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Table of Contents

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Productivity, Smart Specialisation, and Innovation: Empirical findings on EU macro-regions

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Abstract. The paper aims to enrich the discussion on the Research and Innovation Strategies for Smart Specialisation (RIS3) and ongoing development of macro-regions in the European Union (EU). EU macro-regions are defined as geographical related places that are socially, economically, and historically linked and, until now, make a blind spot in the discussion on smart specialisation and regional innovation. While most literature is qualitative, the empirical approach of this paper is to apply a simply pooled OLS-regression with productivity as an independent variable, various exogenous variables on smart specialisation, dummies on EU macro-regions, and time-fixed effects within NUTS2 regions between 2014 and 2019. It can be concluded that smart specialisation has a significant dependency on productivity. The results suggest that regions of a macro-region benefit from each other by co-location. The findings are not perfect for all macro-regions. This raises questions for the development of EU macro-regions, since the EU program policy is targeted towards the European macro-regional level.

JEL classification: O, O47, R11

Key words: productivity, smart specialisation, innovation, European structural and investment funds, macro-regions

1 Introduction

The European Commission has made great efforts to support regions in their social, economic, and institutional growth through Research and Innovation Strategies for Smart Specialisation (RIS3). Smart specialisation represents an innovative policy approach that strives towards positive economic development through the realisation of regional competitive advantages (Gómez Prieto et al. 2019). Its characteristics include a place-based dimension in combination with a bottom-up character through an intensive dialogue between regional stakeholders. Whereas the identification of investment priorities is based on regional evaluation like the so-called Entrepreneurial Discovery Process (EDP). Smart specialisation approach allows for the identification and development of competitive advantages by focusing efforts and resources on regional economic specialisations (priorities), the discovery of knowledge domains, and then focusing regional policies to promote innovation, particularly in these fields of priorities and domains (Gómez Prieto

et al. 2019, McCann, Ortega-Argilés 2013). As the saying goes, all that glitters is not gold – but is smart specialisation glitter or gold? And which regions do benefit?

Romão (2020) considers economic specialisations and technology influencing economic growth. This is where the financing of innovation projects in the regions comes in. S3 channels funding and Research and Development (R&D) investment into specific priorities and domains. This prioritisation in S3 should increase the competitiveness of the regions in terms of income and prosperity. Marques Santos et al. (2021) confirmed that R&D and innovation subsidies, such as smart specialisation, resulted in a positive effect on regional productivity, and smart specialisation generated additional regional effects. However, the influence of smart specialisation strongly depends on the type of region (e.g., Prognos, CSIL 2021, D'Adda et al. 2018).

In this context, Pagliacci et al. (2019, 2020) underlined the relevance of interlinking smart specialisation with macro-regional strategies to differentiate geographical areas and regional types. A macro-region is an integrated geographical area which is related to its neighbouring EU and non-EU regions in the same geographical area (European Commission 2021e). Although macro-regions are not a new concept in European regional policy, a gap remains when it comes to the integration of macro-regions into smart specialisation theory and practice. This is even more acute as the European Commission regards macro-regions as "highly relevant in delivering the EU priorities" (European Commission 2020, p. 3), for instance in the context of the Green Deal or the European Digital Strategy. Macro-regions are thus a high priority in EU policy due to neighbourhood policy, common history, historical roots, and path dependency, as well as a connecting geographical element ("Baltic Sea", "Alps") (McMaster, van der Zwet 2016). However, to our knowledge there are no statistical-econometric studies on the effects of macro-regions on the involved territories. In this regard, it is hypothesized that smart specialisation, with its secondary conditions, is positively related to the productivity of a region, as assumed by previous research, and can, as a result, provide an impetus for development. Moreover, it is assumed that macro-regions benefit from each other by co-location, path-dependency, and historical interrelation.

Afterall, gaps in research on smart specialisation remain. These rank from interregional cooperation, particularly on the level of macro-regions, to the analysis of productivity effects of different kinds of specialisation. Derived from this motivation, the authors hope to enrich the ongoing discussion on RIS3 and macro-regions in respect to the following questions: (1) How does smart specialisation contribute to economic development, here productivity, and (2) to what extent is there a connection between the EU's perspective of macro-regions and their actual performance on productivity?

The authors have chosen a quantitative approach to analyse the concept of macro-regions. Since the current analyses of cross-border regions and macro-regions primarily include qualitative research, an empirical approach was more promising to complement the existing literature. The subsequent analysis focuses on the dependence of tested variables and their expected values between smart specialisation operationalised by proxy and control variables such as on research domains and on sectoral specialisation on the one hand and productivity on the other. Using a sample of 212 NUTS2 regions, the article presents a model that studies the relation and the impact of different factors on economic productivity in European NUTS2 regions. A regional macroeconomic view is more specific than an approach from the EU27-states since economic activity, interaction, and the approach of the innovation region can be found in the regions. It is examined how NUTS2 regions have developed in the period between 2014 and 2018 and, ideally, which regional innovation accounts they have pursued. The model supplements data concerning the regional economic accounts and statistics on innovation measures, such as European structural and investment funds. The empirical approach applies a simply pooled OLS-regression with productivity as the independent variable and various exogenous variables on operationalised smart specialisation measures that include time-fixed effects.

The paper is structured in the following way: a brief overview of the literature on smart specialisation and regional development is presented in Section 2. The third section describes the selected variables and explains the methodology of the empirical approach, followed by the results of the applied econometric analysis (Section 4). Section 5 discusses

the limitations of the empirical strategy and briefly discusses the results.

2 Literature in brief: Smart specialisation and regional development

Regional prosperity and competitiveness are found to rely on determinants such as productivity and innovation, which need to be addressed to realise sustainable regional growth. This is of particular interest in Europe, which aims towards regional cohesion in terms of income and productivity (Landabaso 1997). Not only the recent economic crisis but also global challenges such as climate change or digitalisation require regions to find new sources of sustainable productivity growth (Tuffs et al. 2020). In this context, R&D as well as innovation-related activities play a role as drivers of regional productivity (Foray et al. 2011). The European policy approach to exploit the opportunities of regional innovation is called smart specialisation. Smart specialisation as a concept was introduced as a response to the increasing productivity gap between Europe and the United States (Barca 2009). Extending from the analysis of an expert group that recommended focusing on regional innovation, smart specialisation was promoted shortly after as an official policy of European structural policy and established as an ex-ante-conditionality for structural funds in the programming period of 2014-2020. This explains the success and coverage that smart specialisation has achieved in Europe and in other parts of the world (Kruse, Wedemeier 2021). Moreover, research on smart specialisation has increased over the last decade (Janik et al. 2020).

The strategy for Europe 2020 and beyond is defined by developing an individual and regional Smart Specialisation Strategy (S3) (Lopes et al. 2018). One of the relevant considerations behind the original S3 approach was that innovation leader regions in a specialisation primarily invest in the invention of a general-purpose technology (GPT), while the moderate innovator regions follow the co-invention aspect of a technology investment. Smart specialisation is therefore not about being specialised in a certain high-tech sector. Addressing the issue of specialisation in the R&D invention and its link to sector activities is particularly crucial for the regions that are not innovation leaders (Foray 2018). For the respective regions, it is more relevant to focus on GPT's potential by the aspect of co-invention of applications. For example, the relevance of R&D for smart specialisation is highlighted by Capello, Lenzi (2013), although empirical analysis shows that different forms of regional innovating should be considered.

Smart specialisation is one of the key instruments of the European Commission to push forward the development of EU regions. The concept of smart specialisation can be summarised as the recognition of the uniqueness of regions and their economic structures. This place-based policy assumes that each region should come up with its own development strategy based on its strengths and characteristics (Di Cataldo et al. 2022). As opposed to traditional cluster policy, smart specialisation not only focuses on already existing strengths but aims towards identifying and facilitating the regional development of sectors with promising technology and market outlook to open new domains of regional competitive advantages. This identification is based on a process of regional stakeholder involvement and entrepreneurial discovery (Foray 2013, Navarro et al. 2014, McCann, Ortega-Argilés 2016, Vezzani et al. 2017, Di Cataldo et al. 2022). Considering the key role of R&D and innovation in developing competitive advantages, the according policy of smart specialisation involves strengthening regional innovative capacities (Foray 2013). By doing so, the specialisation on certain economic domains or sectors makes it possible to benefit from economies of scale, scope, and spill-over effects in knowledge production and application (Foray et al. 2011). While cluster policy implies a focus on a limited number of clusters, smart specialisation aims towards diversification which can be assessed to be successful in the previous European programming period of 2014-2020 (Marques Santos et al. 2021).

Balland et al. (2019) emphasised the problem in the course of the S3 implementation and policy foundation that the quantitative and qualitative monitoring is neglected. More statistical-empirical measurements are required to circumvent the challenges. However, data availability poses a major threat to the analysis as data referring to interregional interaction are scarce. As Eurostat does not provide trade statistics on a regional level,

most of the research focuses on patent data and other quantitative measurements (Gianelle et al. 2014, Basile et al. 2016, Mitze, Strotebeck 2018, Ye, Xu 2021, Balland, Boschma 2021). This one-sided approach gives rise to a certain bias in research results as patents refer to research-intensive technological sectors and do not cover basic economic activities. Moreover, patent analyses mostly rely on the same databases such as REGPAT, so that research on interregional cooperation suffers from a limited perspective (Strumsky et al. 2012). It is important to also consider qualitative measures like the innovation biography and entrepreneurial discovery processes for long-term strategies (Hassink, Gong 2019). McCann, Ortega-Argilés (2016) underline the mix of qualitative and quantitative factors in the European approach. They are convinced that a one-sided analysis would be biased. For them, the current European approach can make an important connection between institutions, entrepreneurs, and policymakers.

A challenge that particularly affects the European Union is the homogeneity of the industry. Regions are specialised in the same high-tech industry and therefore, the workforce owns a similar knowledge of capital. For a long time, the innovation strategies were based on a national and not EU-wide level. The actual challenge is to diversify the industry to realise learning effects and innovation (Hassink, Gong 2019). In this context, the relevance of interregional cooperation is increasingly recognised in the literature on smart specialisation (Hassink, Gong 2019, Tuffs et al. 2020, Esparza-Masana 2021). The idea of interregional learning effects that could stimulate the recombination of knowledge and open new development paths was already formulated by Foray et al. (2009) when the smart specialisation concept was created. However, it took years for interregional cooperation to become a focus of attention for the knowledge productivity of regions (De Noni et al. 2017). Balland, Boschma (2021) show empirically in a study on 292 NUTS-2 regions in Europe that an interregional focus has a positive effect on the probability of regions diversifying, particularly in peripheral regions. One explanation is found in regional complementarities of economic domains of specialisation. The authors provide an indicator for partnering strategically in the context of S3. Insofar, the idea of interregional learning effects is statistically derived as solid evidence. However, the number of interregional co-investment projects has remained limited since the introduction of smart specialisation (Larosse et al. 2020). Results from Müller-Using et al. (2020) suggest that strengthening interregional cooperation and establishing support programs can facilitate the innovative ability and competitiveness of SMEs. Based on these findings, the European Commission supports regions on NUTS2 level to cooperate with each other to exchange innovation strategies by S3 platform tools such as the R&I Regional Viewer (European Commission 2021e).

An important field of interregional cooperation is super-regional groups of regions. The idea of cooperation across regional borders is already established in cross-border regions and cross-border regional innovation systems (Lundquist, Trippl 2011, Makkonen et al. 2016, Trippl 2010). The concept of "Euroregions" as a tool of promoting regional integration has been an important cornerstone after a long journey of promoting cross-border cooperation in Europe since the 1960s (Lina, Bedrule-Grigoruta 2009, De Sousa 2012). The analysing literature on cross-border regions, however, is mostly based on case studies and interviews as qualitative rather than quantitative analytical tools (Miörner et al. 2018). An additional perspective is provided by the concept of macro-regions. Here, the focus is broadened to not only cover regions sharing a common border but larger groups of different regions, independent of their respective nation state. Macro-regions are based on the recognition that a bundle challenges are too large for regions to address so that larger groups of like-minded regions are considered when it comes to cooperation in these fields. The concept of macro-regional strategies is still relatively new in Europe, having been developed in the programming period 2007-2013 (Pagliacci et al. 2019). The first implementation dates back to 2009 with the development of the EU Strategy for the Baltic Sea Region (EUSBSR) (Dubois et al. 2009). This transnational strategy was divided into three objectives that represent the key challenges of the Baltic Sea Region (BSR), namely saving the sea, connecting the region, and increasing prosperity (Leino 2020). This challenge-driven innovation has made the BSR macro-regional strategy a role model for the development of further joint (macro-regional and trans-European) strategies

(Uyarra et al. 2014). In combination with the targets of smart specialisation, this scale-up process is expected to help less-developed regions by climbing in value chains and new path-creation based on interregional innovation ecosystems and networks (Mariussen et al. 2016). This will be achieved by exploiting complementarities and synergies among the members of the macro-regions, which gives the concept of interregional cooperation a new stimulus in European policy. Since the macro-regional approach is still relatively new, literature on the topic remains to be scarce, particularly the evaluation and monitoring on macro-regional level related to smart specialisation implementation (Gerlitz et al. 2020).

The productivity effects of smart specialisation and macro-regional strategies are of particular interest at this point as Pagliacci et al. (2019) outlined with a focus on EUSALP. Preliminary studies have been conducted by Pagliacci et al. (2019) who underlined the relevance of interlinking smart specialisation with macro-regional strategies. Regarding the analysis of regional productivity, Romão, Nijkamp (2017) have analysed how regional systems of innovation influence the competitiveness, measured as gross value added (GVA) of tourism destinations in Europe. Thereby, i.e., employment, turnover, or investments have been treated as explanatory variables. A more recent study by Romão (2020) additionally considers economic specialisations and technology-related indicators when analysing the effect on economic growth and employment. Other studies have analysed the relationship between employment growth and relatedness and complexity (Davies, Maré 2019). Marques Santos et al. (2021) confirmed that the implementation of R&D and innovation subsidies, such as smart specialisation, resulted in a positive effect on regional productivity and that smart specialisation generated additional regional effects. A first approach to evaluate the relationship between R&D intensity and specialisation on the labour productivity of a region was conducted by Pisár et al. (2018). The authors found a positive correlation between R&D activities and certain specialisations such as services and manufacturing on labour productivity while specialisations in agriculture, forestry, or fishing are associated with lower regional productivity – as expected from the nature of said activities. Also, the relevance of R&D for smart specialisation is highlighted by Capello, Lenzi (2013).

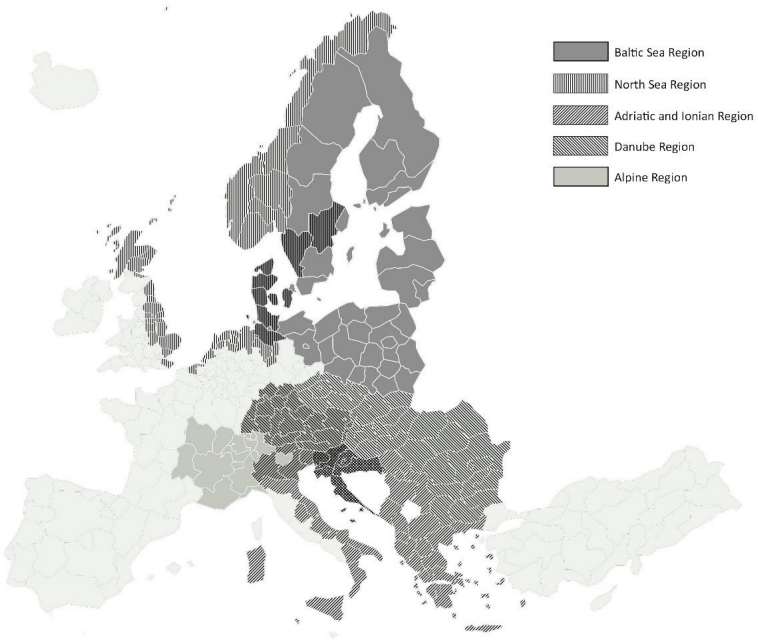
However, several research gaps remain. These rank from interregional cooperation in smart specialisation, particularly on the level of macro-regions, to the analysis of productivity effects of different kinds of specialisation. The lack of appropriate quantification of smart specialisation (Balland et al. 2019) is addressed, while also contributing to the discussion of updating the European smart specialisation concept in the next programming period (2021-27). Marques Santos et al. (2021) analysed NUTS2 regions of Portugal for evaluating the smart specialisation program. In their research, they compared the ex-ante period of the European Union's program (2007 – 2013) with the period after the implementation of S3 (2014 – 2020). Because of the complexity and correlation of influencing factors, the main challenge was to quantify the cause-effect relationship. In their findings, they emphasised the positive effect of Research, Development, and Innovation (RDI) funds on regional productivity and the acceleration of the effect due to other innovation subsidies.

3 Methodology: Measuring the impact of technological activities and innovation on smart specialisation

Derived from this motivation, the authors strive to contribute to the ongoing discussion on RIS3 and macro-regions with following research questions:

(1) How does smart specialisation contribute to economic development, here productivity, and (2) to what extent is there a connection between the EU's perspective of macro-regions and their actual performance on productivity?

Therefore, the authors proceed as follows: First, the geographical scope is defined, and the single NUTS2 regions of Europe are assigned to the macro-regional areas. The procedure is described in Section 3.1. The data is then discussed in more detail in Section 3.2. The variables are selected by following the logic of developing Smart Specialisation Strategies (S3). Section 3.3 then describes the empirical strategy.



Source: own elaboration

Figure 1: European macro-regions

3.1 Geographical scope

A macro-region is defined as an integrated geographical area that is related to its EU and beyond regions in the same geographical area (European Commission 2021e). The first implementation of a macro-region dates back to 2009 with the development of the EU Strategy for the Baltic Sea Region (EUSBSR). Since then, three more macro regional strategies have been established in the EU: the Danube region (EUSDR, in 2011), the Adriatic and Ionian Sea (EUSAIR, in 2014), and the Alpine region (EUSALP, in 2016). The four macro-regions involve 21 EU (Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, the Netherlands, Poland, Romania, Slovenia, Slovakia, Sweden) as well as 8 non-EU countries (Albania, Montenegro, North Macedonia, Norway, Russia, Serbia, Switzerland, the United Kingdom) and show some degree of regional overlaps (European Commission 2020, Pagliacci et al. 2019, Tursie 2015, Gänzle 2016, Gänzle et al. 2018). This limitation must be considered when reviewing the results, there may be distortions in the analysis and interpretation of the data sets. In the following analysis, we complemented the official list by countries of the North Sea Region (NSR), which lacks the formal status of an EU macro-region but still constitutes an institutionalised geographical entity with its own INTERREG program and organisations such as the North Sea Commission. A map of macro-regions in the EU that are addressed in the scope of this paper is presented in Figure 1.

To conduct the analysis at the level of European macro-regions, dummy variables for the macro-regions of the Baltic Sea Region, North Sea Region, Alpine Region, Adriatic-Ionian Sea Region, and the Danube Region were assigned to the NUTS2 regions. We fitted the regression with the European macro-regions with a categorical variable to analyse whether, on average, productivity is associated with the European macro-regions.

3.2 Data

Several proxy and control variables are occupied to empirically investigate the impact of smart specialisation. While the paper attempts to analyse the smart specialisation policy framework in terms of its impact on regional productivity, measuring it empirically is challenging. For this purpose, the individual quantitative components for determining

an S3 are recorded to evaluate the regional smart specialisations. (Balland et al. 2019, Kruse, Wedemeier 2021): sectoral specialisation (i), research and innovation (ii), economic openness (e.g., trade export) (iii), and funding (iv). The variables for determining the regression can be selected based on these components. However, there were no control variables for regional openness due to data availability (e.g., trade, FDI) on the NUTS2 level. In addition, the location quotients (LQ) can only record the degree of specialization of the regions and thus reflect their concentration or, vice versa, their diversification. The regional employment concentrations are reflected in nine sectors and approximate the prioritisation within the region. This will provide the technical link to the S3 policy of the regions; the prioritisation is one of the components for developing a S3. In the end, the measurement is only an approximation. For a more detailed approach, see Varga et al. (2020), albeit with the paper's research question of examing industry concentration, knowledge spillover, and impact modelling of smart specialisation. Similarly, the use of the innovation variables reflects a broad approach in our model to measuring regions' innovative capacities and does not reflect their underlying dynamics.

However, unless otherwise stated, primarily Eurostat data were applied in the empirical analysis (in that case, data from the European Structural and Investment Funds (ESIF) were used). The Eurostat and ESIF data ensure a high data quality and replicability of the analysis. The data were collected for EU and non-EU countries by Eurostat; the database for the subsidies is also harmonised data. The authors have used a wide range of data in the period (of the EU-program) 2014-2019. This timeframe was selected since the EU strategy program S3 was implemented in 2014. For reasons of data harmonisation, the research ends in 2019 since more recent data were not available for all data points.

1. The first step in the data set compilation was to determine the location quotients of the employment data in order to provide information on the sectoral specialisation of the regions (variable *lqagr*, ..., *lqart*). The location quotients were calculated by applying the following formula:

$$LQ_{j,t} = \frac{e_{j,t}/E_{j,t}}{E_{j,t}/E_t}$$

   where $LQ_{j,t}$ is the vector of location quotients for sector j in the regional economy in year t, $e_{j,t}$ is the employment in sector j in the regional economy, e is defined as the total employment in the local region, $E_{j,t}$ as the employment in sector j in the national economy and respective year, with E being the total employment in the national region. If the location quotient takes on values above 1.0, employment in a particular industry is represented above average. In contrast, a value below 1.0 indicates below-average specialisation. Values of more than 1.5 indicate that a region is highly specialised in a particular industry (Varga et al. 2020).

   A short look at the descriptive statistics shows that sectoral specialisation within the NUTS2 regions is characterised by large differences in the minimum and maximum values. When observing the average specialisation, these differences are harmonised by the amount of data, so that the values indicate an above-average specialisation of the regions in the selected employment areas.

2. The data of the Regional Innovation Scoreboard were considered (variable *innovationscore*) to measure approximatively the research and innovation domains of NUTS2 regions. This annually collected data assesses the innovation performance of European regions based on selected indicators that consider topics such as human resources, digitization, finance, ICT, willingness to cooperate, innovation activity, and environmental awareness (European and Regional Innovation Scoreboards 2021).

3. To include political investments in the macro-regions of Europe, a variable on European Structural and Investment Funds (ESIF) was added to the data set (variable *investment*). The ESIF fund structure has five areas: research and innovation (i), digital technologies (ii), supporting low-carbon economy (iii), and transformation (iv) such as supporting small businesses (v). The funds consist of the

European Regional Development Fund (ERDF), the European Social Funds (ESF), the Cohesion Fund (CF), the European Agricultural Fund to Rural Development (EARFRD), and the European Maritime and Fisheries Fund (EMFF) (European Commission 2021b).

4. Further controls for size (variable *density*) are used. The variable controls for specific geographical differences in size, for example for urbanization and periphery.

NUTS 2 regions were ranked and split into three groups. According to this GDP per inhabitant subdivision, the amount of the allocations is made via the European Structural and Investment Funds. The lower the GDP per inhabitant, the higher the allocation of funds. They follow this subdivision (European Commission 2021d):

- less-developed regions (where GDP per inhabitant was less than 75% of the EU average)
- transition regions (where GDP per inhabitant was between 75% and 90% of the EU average)
- more-developed regions (where GDP per inhabitant was more than 90% of the EU average)

The variables were included in the data set to control for the level of GDP and its development status of NUTS2 regions. The categorical variables can take values between 1 to 3 (variable *dev*).

The number of observations consists of 1,696 NUTS2 regions in Europe. As can be seen in Table 2, the number of 1,484 NUTS2 regions can be assigned to European macro-regions. This corresponds to a share of 87.5%. As shown in Table 2, both the variables were used to assign NUTS2 regions to European macro-regions (variables *EUBSR*, *NS*, *EUSALP*, *EUSAIR*, *EUSDR*). Likewise, missing values for individual indicators and time series were not added. We will now show how the use of descriptive statistical characteristics creates an overview of the data set used in the rest of the study. It should be mentioned that the created data set consists of both categorical and numerical variables (see Table 1).

The ratios and frequencies of the variables used in the entire data set serve as suitable statistical ratios. The mean, minimum, and maximum values of the numerical variables are presented in Table 2.

3.3 Empirical strategy

The authors conducted a simple ordinary least squares regression (OLS) with gross value added as independent variables to motivate the research question and eventually, present a more elaborate multiple ordinary least squares regression model that controls for other factors.

The empirical strategy is to consider a stepwise regression of modelling fitting to motivate the research question. The strategy is to build a model process for proofing model uncertainty and to correct for reflections. First, the relationship between productivity and gross value added is calculated:

$$lnprod_{i,t} = a + b_1 lngva_{i,t} + \epsilon_{i,t} \tag{1}$$

Productivity in region i and year t is thereby explained by the respective region's gross value added and an unobserved error term $\epsilon_{i,t}$ by region and year. The hypothesis is that productivity might be driven by other factors which are correlated with gross value added. First, this postulates that regional productivity can be further explained by the region's innovation level. To this end, a model describing the relationship between the innovation index and regional productivity is estimated. In the following, a simple linear regression function is assumed:

$$lnprod_{i,t} = a + b_1 lngva_{i,t} + b_2 innovationscore_{i,t} + \epsilon_{i,t} \tag{2}$$

Table 1: Overview of variables, by data type

Numerical Variables
• Gross value added at basic prices (*gva*)
• Total employment (*totalempl*)
• Employment, agriculture, forestry, fisheries (*agri*)
• Employment, industry excluding construction (*ind*)
• Employment, construction, and building (*constr*)
• Employment, trade, maintenance, transport, hotels, and restaurants (*trade*)
• Employment, information, and communication (*info*)
• Employment, provision of financial and insurance services (*finance*)
• Employment, real estate, and housing (*realest*)
• Employment, professional, scientific, and technical activities, other business activities (*sciencetech*)
• Employment, public administration, defense, education, health, and social services (*admin*)
• Employment, arts, entertainment and recreation, other service activities, private households, extraterritorial organisations, and bodies (*art*)
• Regional Innovation Scoreboard (*innovationscore*)
• GPD per capita (*gdppc*)
• Yearly actual investment on the ground from EU structural and investment funds (*investment*)
• Population density (*density*)
Categorical variables
• Baltic Sea Region (*EUBSR*)
• North Sea Region (*NS*)
• Alpine Region (*EUSALP*)
• Adriatic-Ionian Sea Region (*EUSAIR*)
• Danube Region (*EUSDR*)
• Development of regions (*dev*)
• Time dummies (*yearid*)

Source: Eurostat (2021a,b,c,d,e,f,g), European Commission (2021a,c,d), European and Regional Innovation Scoreboards (2021)

Productivity might be driven by additional factors that are potentially correlated with gross value added and a region's innovation score. Introducing location quotients for each sector, region, and year accounts for this. The LQ measures the regional specialisation of employment and is therefore an integral part of an S3 analysis. The next specification is based on the following regression formula:

$$lnprod_{i,t} = a + b_1 lngva_{i,t} + b_2 innovationscore_{i,t} + \boldsymbol{b_3 lq}_{i,t} + \epsilon_{i,t} \tag{3}$$

Here, $\boldsymbol{lq}_{i,t}$ represents the vector of location quotients for each region and year, with $\boldsymbol{b}_3$ being the vector of corresponding coefficients.

To understand the impact of EU payments to the regions, the model is extended by estimating a multiple linear regression of the following form:

$$\begin{aligned} lnprod_{i,t} \quad = \quad & a + b_1 lngva_{i,t} + b_2 innovationscore_{i,t} + \boldsymbol{b_3 lq}_{i,t} \\ & + b_4 investment_{i,t} + b_5 investment_{i,t} dev_{i,t} + \epsilon_{i,t} \end{aligned} \tag{4}$$

$investment_{i,t}$ does not represent the sum that was paid out of different funds to the region in a certain year, but rather the sum of money that has been estimated to have been invested by the regions on-the-ground based on a large simulation. This allows for a comparison of the effectiveness of EU structural fund payments across regions without having to consider any inefficiencies that might occur in the process of using the granted sums for on-the-ground investments. It is also considered to be interesting how EU payments affect less developed regions, so the effect of the actual investment on the ground in the regions each year in interaction with an economic development dummy is

Table 2: Descriptive analysis of variables

Variable	n	Mean	Min.	Max.	Year
nuts2	1,696	106.5	1	212	2014-2019
gva	1,199	48,523	1,125	659,678	2014-2019
lqagri	1,355	1.283	0.0206	9.921	2014-2019
lqind	1,445	0.992	0.175	2.307	2014-2019
lqconstr	1,447	1.027	0.309	2.197	2014-2019
lqtrade	1,463	1.015	0.641	2.280	2014-2019
lqinfo	1,308	0.905	0	3.262	2014-2019
lqfinance	1,351	0.896	0.168	3.372	2014-2019
lqrealest	838	1.375	0.199	5.220	2014-2019
lqsciencetech	1,455	0.917	0.184	2.061	2014-2019
lqadmin	1,463	1.043	0.411	2.335	2014-2019
lqart	1,449	0.927	0.269	2.237	2014-2019
innovationscore	1,696	91.95	0	191.6	2014-2019
investment	1,045	1.778e+08	1.087e+06	2.434e+09	2014-2019
density	1,242	308.8	3.400	6,513	2014-2019
eusbsr	1,484	0.208	0	1	2014-2019
ns	1,484	0.113	0	1	2014-2019
eusalp	1,484	0.137	0	1	2014-2019
eusair	1,484	0.175	0	1	2014-2019
eusdr	1,484	0.241	0	1	2014-2019
gdppc	1,187	0.0271	0.00354	0.0906	2014-2019
dev	1,187	1.776	1	3	2014-2019
year	1,696	2,018	2,014	2,021	2014-2019
yearid	1,696	4.500	1	8	2014-2019

estimated in the next step. This accounts for the effect of on-the-ground investments in less economically developed European regions.

Additionally, a population density variable for each region and year to control for urbanization and agglomeration effects is introduced. Moreover, the vector $macroregion_i$ contains five dummy variables accounting for the different European macro-regions, with $\boldsymbol{b}_6$ being the vector of corresponding coefficients. Due to missing data, the number of observations drops from roughly 1,200 in the first specification to only about 500 in the last. This is caused by missing employment data for certain sectors and regions. Lastly, an ID *yearid* for each year is introduced to account for variation over time. The final model specification is given by:

$$\begin{aligned} lnprod_{i,t} \quad = \quad & a + b_1 lngva_{i,t} + b_2 innovationscore_{i,t} + \boldsymbol{b_3 lq}_{i,t} \\ & + b_4 investment_{i,t} + b_5 investment_{i,t} dev_{i,t} + b_6 density_{i,t} \\ & + \boldsymbol{b_7 macroregion}_{i,t} + b_8 yearid + \epsilon_{i,t} \end{aligned} \tag{5}$$

Even though the data is constructed as a panel, a pooled OLS regression has been chosen for several reasons. Firstly, the Hausman test indicates that a fixed effects model should be used. However, it is also interesting how belonging to a specific macro-region influences the productivity of a certain NUTS2 region. Macro-region dummies do not have any variation over time, so they would have dropped from the model. More importantly, it is not possible to group all NUTS2 regions according to their membership in a macro-region, as some regions belong to as many as three macro-regions. Moreover, the analysis also aims to explore the effect of the interaction between economic development and structural investments, which can be easily done in an OLS model and interpreted. The application of an interaction term and its positive significance indicates that the effect of one predictor variable is of different values. There is no singular effect of investments, but it depends on the interaction with the development status of the region.

Moreover, a central issue is that the specified model has heteroskedastic standard errors. Transformations have been conducted on some of the variables to ensure the linear specification is correct. However, the Breusch-Pagan test for heteroskedasticity still yields a statistically significant result, motivating the choice to employ robust standard errors to account for this issue.

Multicollinearity could also be a concern due to the relatively large number of variables included in the final model specification. For example, it is plausible that the innovation score is highly correlated with the location quotients. To this end, pairwise correlations between the variables have been checked to ensure that correlations between the independent variables are less than 0.5 and additionally to make sure the model is not overly complicated or overfitted. For instance, the business demographics variable was dropped because it was highly correlated with gross value added. After additionally calculating variance inflation factors (VIF) for the independent variables, the location quotient for the industry sector had to be dropped since this variable has a variance inflation factor of over 20 across all specifications.

4 Results

The regression results will now be presented and discussed. The chosen explanatory variables predict as much as 88.9% of the outcomes in log productivity, indicating that our model as outlined in equation (5) fits the data well.

In the first specification, a 1% increase in a region's gross value added leads to a modest average increase of 0.33% in productivity. As more variables are included in the model, the increase drops to 0.11% in the final specification. A region's innovative capability significantly increases log productivity across all specifications – more concretely, the increase of one point in a region's innovation score translates to an average statistically significant increase in its productivity by approximately 0.41% in the full model compared to 0.96% in the second specification. While this seems like a small effect, it is worth looking at an example. In 2014, the region of Yugozapaden in Bulgaria had an innovation score of 37.75. The same region managed to increase its innovation score to 52.64 by 2020, which is an increase of about 15 points. According to the model, productivity in Yugozapaden has increased by 6.15% within only six years due to higher innovation in a general sense when all else is equal. The Innovation Score has also been applied, in a descriptive way, by Pagliacci et al. (2019) in the context of smart specialisation in macro-regions.

Specialisation can also have a positive impact on productivity. For instance, a 0.1 increase in the location quotient for the information and communication sector of any given region leads to an approximate increase in productivity by 7.4%. Likewise, a 0.1 increase in the location quotient for the public administration, defence, education, health, and social services sector increases productivity by approximately 52.6% on average. Interestingly, a 0.1 increase in the location quotient for the arts, entertainment and recreation, other service activities, private households, extraterritorial organisations, and bodies sector leads to an increase in productivity of about 15.1%.

The results regarding the effect of investments from EU funds are not as straightforward though. When looking at the interaction between on-the-ground investments and economic development, it can be observed that being classified as a less-developed region leads to a virtually non-existent effect of investment on productivity. This is also the case for transition regions. Even though the coefficient is not statistically significant, since the different types of EU structural and investment funds (ESIF) are either targeted at improving infrastructure in underdeveloped and transition areas (CF), at promoting human capital and employment (ESF), and at supporting rural regions (EAFRD) as well as a balanced economic development of the EU overall (ERDF). For this reason, transition and less-developed regions are usually allocated a higher share of EU payments. Therefore, not only would it be expected that the payments in general have a positive impact on productivity, since there is more room for improvement in these regions in comparison to more developed ones, but also a disproportionately large effect of investments on productivity. One probable reason for this result is found in the applied data. When

looking at the investments made in only less-developed regions and plotting them against log productivity, a large range of investments becomes apparent. While the mean is at around €229 million in each region, there are outlier regions with investments as high as nearly €2 billion that have roughly the same productivity, driving the respective coefficient nearly to zero. Additionally, investments have a lagged effect on productivity that goes beyond the short run. Running the regression (model 5) with a lagged investment variable (one year as well as two years) does not change the effect substantially. Productivity in year t is also not substantially more highly correlated with investments made in $t-1$ (-0.0939) or $t-2$ (-0.1114) than with investments made in t (-0.0827).

Population density also has a negligible effect on productivity. There is great heterogeneity in the density levels of regions with similar productivity levels. Some of the most productive regions are not very dense, such as regions in Northern Europe.

Belonging to a specific macro-region translates to higher average productivity. When all else is equal, being a part of the Adriatic-Ionian Sea Region on average increases productivity by approximately 11.7%. Interestingly, being a member of the Baltic Sea Region or the Danube Region on average decreases productivity by approximately -19.6% and -13.9%, respectively. While these results could be driven by the similarity or heterogeneity of the NUTS2 regions that make up a macro-region in the data set as well as the fact that the number of observations varies from one macro-region to the next (which range from 168 observations for the North Sea Region to 357 observations for the Danube Region). Further analyses are required to be able to statistically explain these differences between macro-regions (see Section 5). The regression results from the previously outlined specifications are in Table 3.

5 Conclusion

To empirically analyse the role of smart specialisation, various proxy and control variables are included in the model by the authors. There are components involved in evaluating a regional intelligent specialisation: sectoral priorities (i), research and innovation domains (ii), economic openness (e.g., trade export, FDI) (iii), and funding (iv). Eurostat data in the period (of the EU-program) 2014-2019 were used to create a panel to ensure high data quality and replicability of the analysis.

In relation to the hypothesis, it can be concluded that smart specialisation - here operationalised by the components of a S3 by the sectoral prioritisation of employment concentrations, Regional Innovation Scoreboard indicators, and funds on structural transformation and innovation (ESIF) such as further regional conditions as population density – has a statistically significant impact on the productivity of a region and can thus provide impetus for further development. This is in line with previous studies on productivity effects, for instance by Marques Santos et al. (2021) who analysed Portuguese regions in that regard. By analysing regions in Slovakia and the Czech Republic, Pisár et al. (2018) found that both an appropriate infrastructure and research-related factors have a positive impact on regional productivity.

In addition, it was questioned whether there is a connection between the EU's macro-regions and their actual performance on productivity. In linkage to this question is the assumption that regions of a macro-region benefit from each other by co-location, path dependency, and common historical interrelationship. More important, however, is that a considerable part of the EU program policy is targeted towards the European macro-regional level and the monetary transfers take place within this framework. In this respect, the categorisation into macro-regions is relevant, even if the spatial effects of co-location should be specified within a spatial model (see also Section 2). The correlation between productivity and macro-regions differs in result. Being a member of the Adriatic-Ionian Sea Region on average increases productivity, whereas the results for the Baltic Sea Region or the Danube Region lead in the analysis to a decrease of productivity. The diversity of structural patterns on NUTS2 level in the different macro-regions was described by Pagliacci et al. (2019) who categorised regions in clusters. The categorisation followed the indicators of income level, population density, and economic specialisation and revealed that macro-regions, although being characterised by shared challenges, show a certain

Table 3: Regression results

	(1)	(2)	(3)	(4)	(5)
lngva	0.331***	0.0676***	0.119***	0.121***	0.112***
	(19.77)	(4.64)	(7.88)	(8.22)	(6.65)
innovationscore		0.00958***	0.00520***	0.00308***	0.00413***
		(39.75)	(12.04)	(6.40)	(8.72)
lqagri			-0.0277	-0.0155	0.00729
			(-1.80)	(-0.88)	(0.39)
lqconstr			-0.0574	-0.0636	0.0831
			(-1.23)	(-1.26)	(1.75)
lqtrade			0.0104	0.00427	0.0423
			(0.17)	(0.07)	(0.68)
lqinfo			-0.130***	-0.0170	0.0740*
			(-4.09)	(-0.55)	(2.08)
lqfinance			0.100**	0.00173	-0.0393
			(2.92)	(0.05)	(-1.14)
lqrealest			-0.0261	-0.0482*	0.0120
			(-1.40)	(-2.57)	(0.64)
lqsciencetech			0.248***	0.109	0.0537
			(4.32)	(1.75)	(0.90)
lqadmin			0.711***	0.612***	0.526***
			(12.81)	(11.38)	(10.29)
lqart			0.328***	0.217***	0.151***
			(11.49)	(5.99)	(3.86)
2.dev#c.investment				9.95e-11	2.28e-10
				(0.78)	(1.73)
3.dev#c.investment				2.90e-11	9.67e-11
				(0.46)	(1.63)
density					-0.0000698*
					(-2.01)
eusbsr					-0.196***
					(-6.48)
ns					0.0457
					(1.87)
eusalp					0.0338
					(0.97)
eusair					0.117***
					(4.14)
eusdr					-0.139**
					(-2.96)
yearid					-0.00291
					(-0.51)
const	7.362***	9.226***	7.928***	8.592***	8.537***
	(40.97)	(64.07)	(40.70)	(44.61)	(40.44)
Observations	1199	1199	654	530	530
R-squared	0.357	0.668	0.831	0.861	0.880
F-statistic	390.9	1233.4	441.4	.	.

Notes: dependent variable: lnprod, t statistics in parentheses: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

level of internal differences when it comes to income or specialisation patterns as well as differences between the macro-regions. Areas in Southern and Eastern Europe are particularly expected to have serious difficulties when it comes to identifying their specific smart specialisation, which also represents a challenge for the macro-regions (Pagliacci et al. 2019, Varga et al. 2020). Explanations could be provided by the different state and private institutions, in the sense of the varieties of capitalism and institutions. Moreover, the political and economic integration of macro-regions took place over different periods of time. Although the countries of the eastern EU member states joined the EU in the years 2004 and 2007, the EU-integration process is still ongoing. In addition, the macro-regions of the eastern EU member states are also part of the European neighbourhood of non-EU countries, which increases the heterogeneity between the countries and their regions within the macro-regions. A limitation is that the study did not observe the role of these institutional (and political) capabilities. Weak institutions could negatively impact innovation (Rodríguez-Pose, Di Cataldo 2015). The Iron Curtain still lies as a cutting edge from the past, covering various European regions, including directly through some of the macro-regions. Germany, for example, is still divided when it comes to entrepreneurship

and knowledge domains (Fritsch 2004, Fritsch, Storey 2014). The same can be assumed for many overlapping areas of macro-regions. Future focused case studies of individual EU macro-regions could be helpful to try to understand the synergies (or not) between the S3 specialisation within and between the overlapping macro-regions.

A limitation is that a certain endogeneity problem exists. According to the macro accounting, there is a certain degree of dependence between productivity and GVA. They are not fully independent. In order to control for this effect, we regarded a certain structure of a panel and added time and regional variables. Lagging independent variables, e. g. a period, were not added due to the specific structure of the data set. Further limitations include that the potential of smart specialisation is approximately solved by operationalising different heterogenous variables. Third, the number of observations is limited to the observed program period 2014-2019. Last, but not least, further research should include variables for regional openness, which need to be integrated to fulfil all components of a Smart Specialisation Strategy (S3). Due to data availability, it was not feasible to control for regional openness, using for instance regional trade data on the NUTS2 level. Moreover, the components of a S3 applied in the here used model do not fully reflect the nature of a S3 in practice. For example, the regional employment concentrations in nine sectors do not reflect the prioritisation decisions within a regional strategy. This approach has to be chosen due to the availability of data. Far more variables would have reduced the degree of freedom with simultaneously limited regional observations. However, the research method chosen is an approach to the question of the connection between productivity, smart specialisation, and innovation. At the same time, this paper points to the need for further research on the empirical findings on EU macro-regions and their limitations.

The result shows that smart specialization is more than glitter to give regions a growth boost, but it is not the sole 'golden' solution of regional development. To conclude, the analysis shows that additional research into the definition and meaning of European macro-regions and their spatial functionality is needed. The importance of interlinking smart specialisation with macro-regional strategies is given: The European Commission considers macro-regions as highly relevant to fulfil the EU priorities within the new programme period and beyond. The Smart Specialisation Strategies (S3) of the EU-member (and non-EU member states) are the instruments to achieve the ambitions aims of the Green Deal and further EU policy goals. Macro-regions provide the territorial and programming framework for this. In this respect, smart specialisation is a cornerstone of European structural and innovation policy. In the end, the European macro-regions are above all a political order, a framework for project planning with a budget, but it is also the design of a neighbourhood policy.

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A Blockchain-Based Welfare Distribution Model for Digital Inclusivity

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Abstract. An unprecedented rate of technological advancement, compounded by the COVID-19 pandemic, has expedited our transition to a fully digitalised society. Traditionally, digital inclusion focuses on an individual's ability to connect to and access information from the internet. The adoption of novel technologies such as artificial intelligence and blockchain is little distinguished in the literature from internet accessibility. While these digital solutions present novel opportunities, they may also perpetuate or exacerbate the existing hurdles faced by digitally excluded localities. However, these technologies could also be used to tackle the digital divide. Inspired by the design of Bitcoin, the current study offers a conceptual blockchain-based welfare model that adopts a two-pronged approach to enable the fair distribution of capital and resource allocation across the UK regions. The model offers transparency over institutional processes and improves their trustworthiness while preserving privacy. At the community level, the model assumes the application of economic incentives in order to promote digital inclusivity and stimulate cooperation and competition within local cultures. By mobilising both public institutions and communities, such a holistic model would assist the flow of information between the supply and demand side of the regional economy. This approach may not only help to dissolve the welfare losses arising from the digital divide, but also improve social well-being in all regions.

1 Introduction

The emergence of Industry 4.0 technologies (I4T) such as artificial intelligence (AI), blockchain and big data has marked the onset of a Fourth Industrial Revolution (Liao et al. 2017, Lu 2017, Popkova et al. 2019). The digitalisation of public services in healthcare and welfare has facilitated remote access to key support services during the COVID-19 pandemic. By utilising digital technologies for the delivery of these vital services, the impact of a lack of human capital diminishes, ultimately leading to an increase in a population's welfare (Grigorescu et al. 2021). I4T offers great promise for regional growth opportunities in terms of knowledge production and innovation (Balland, Boschma 2021). Yet there is a substantial risk that these benefits may only become a reality for digitally literate localities (Coldwell-Neilson, Cooper 2019). The literature on regional divergence and polarisation (Martin et al. 2016, Storper 2018, Venables 2020) suggests that the widespread adoption of digital technologies is likely to compound the existing digital divide that arose from the Internet. Given that the key drivers of the digital divide mirror structural social inequalities, technological innovations in the public sector threaten to reinforce social inequalities and further isolate disadvantaged groups who rely upon

support services (Robinson et al. 2015). In other words, the digitalisation of the public sector poses a tangible threat to the welfare of those on the periphery of the digital revolution due to regional and socio-economic disparities.

Our research question is as follows: can a welfare data management system be created using the cutting-edge technologies of the Fourth Industrial Revolution that ensures the digital inclusion of all groups in society? Surveying the literature on I4T and management systems, there have been numerous studies investigating the use of AI (Oke 2008, Zawacki-Richter et al. 2019, Benbya et al. 2021, Collins et al. 2021). However, the debate in mainstream and regional economics has focused largely on firms, employment and consumer behaviour (Frey, Osborne 2017, Tubadji et al. 2021, Hidalgo 2021), with little attention paid to the use of AI for welfare management (Oravec 2019, Vinuesa et al. 2020). Additionally, there has been only partial recognition of the use of blockchain technology for management systems, primarily in the context of identity and digital rights management (Faber et al. 2019, Chen et al. 2019). Studies on the application of blockchain technology in social welfare have largely been limited to its use as a digital payments platform for the issuance of benefits and philanthropic donations (Li et al. 2018, Hsu et al. 2020), with the UK government also commissioning a study for a blockchain-based welfare payments system (Walport 2016, Barber 2016).

At the time of writing, we have identified a gap in this stream of literature: a welfare data management system that utilises the transparency, auditability and accountability of blockchain technology. In this paper, we describe how the integrity of data stored on a public blockchain such as Bitcoin combined with the economic incentives underlying its security model can offer significant promise when implemented in a digitalised welfare management system. Incentive mechanisms are necessary to ensure that such a system is fully inclusive for all classes of society and stimulate action by communities and institutions so that they can collectively support the social welfare of digitally excluded individuals. Our conceptual model aims to spark further research to address this gap in the literature through digital inclusion policies enacted at the micro- and macro-level, whereby the latter is realised through the integration of the Bitcoin blockchain with the management of welfare records, and the former uses the micro-incentives inherent to the Bitcoin network to demonstrate how the technology can be used to narrow the digital divide. It is important to note that the paper is written from a technical point of view, as an open letter of invitation to economists and welfare specialists to contribute and elaborate upon the open questions around designing an appropriate incentive structure to handle individual participation in the welfare model.

The structure of the paper is as follows: Section 2 will present a review of the literature on digital inclusion and the effect of I4T in regional economics on the socio-economic development of people and places. Section 3 will focus specifically on the state of the social welfare system in the UK and how it relates to the digital divide, with particular reference to regional and socio-economic disparities. Section 4 will provide an overview of Bitcoin fundamentals and Section 5 will present our conceptual model of a blockchain-based management system that promotes digital inclusion in the welfare services provided by the state. Section 6 will offer some discussion, while Section 7 will conclude the paper. An Appendix is provided for more information about the UK welfare system.

2 Literature Review

Digital inclusivity is a term that is traditionally ascribed with Internet accessibility. Since the rise of I4T, related terms such as digital divide, digital literacy and digital inclusion have adopted a myriad of definitions in political, media, and academic discourse (Jaeger et al. 2012). In the most general sense, the digital divide refers to a division pertaining to digital technologies, which arises from disparate access to hardware, software, or digital infrastructure (Bertot 2003). It is influenced by factors relating to age, region, socio-economic status, and disability (Helsper 2008). Digital literacy is a term that extends the notion of accessibility to one of utility i.e., the ability to utilise digital technologies and services effectively (Gilster 1997). It is a measure of one's digital skills and information literacy; the ability to locate, evaluate and use digital information (Thompson 2008).

The term may also encompass media literacy i.e., one's ability to create and absorb content (Hobbs 1998, 2010). Lastly, digital inclusion refers to the design of strategies and policies that narrow the digital divide and solve the problems arising from digital illiteracy (Jaeger et al. 2012). These policies often target demographics such as ageing populations (Olphert et al. 2005) or people living in rural areas (Correa, Pavez 2016).

Several research studies have highlighted a strong macro-level correlation between the digital divide and the social gap from class-divided societies (Helsper 2008, 2012, Parsons, Hick 2008, Mariën, Prodnik 2014, Mervyn et al. 2014, Robinson et al. 2015). According to Mervyn et al. (2014), the link between social exclusion and the digital divide reflects a "dichotomous disparity" between those that are digitally included and those that are not. Despite the statistically significant association with socially disadvantaged groups, policy-makers tend to adopt a user-centric, micro-level approach to digital empowerment (Helsper 2008). Micro-level policies take a bottom-up approach to address the challenges faced by individuals and are often enacted by local organizations or communities. An example of a micro-level digital inclusion policy is the provision of training and education to support digital literacy (Mariën, Prodnik 2014). Given that digital exclusion occurs for a number of reasons (Correa, Pavez 2016), user-centric policies allow inclusive strategies to be tailored to each individual according to their needs. However, micro-level policies fail to consider how social inequalities resonate to digital inclusion, nor do they take into account the causes of structural disempowerment at the macro-level (Mariën, Prodnik 2014). Public policy interventions at the macro-level adopt a top-down approach to tackling broader social issues. Such policies are intrinsically informed by economic growth. For example, public institutions may address the large-scale mechanisms of digital and social exclusion through wealth redistribution using social welfare support services (Mariën, Prodnik 2014). While it is arguably in the economic interest of the government to invest directly or indirectly in technological infrastructures that enable the digital empowerment of its citizens (Sharma et al. 2022), macro-level policies lack the individualistic approach needed to reach marginalised groups in society (Madon et al. 2009).

In their analyses of case studies from developing countries, Madon et al. (2009) outlined four key processes that can aid the institutionalisation of digital inclusion projects designed to support vulnerable individuals: the first relates to acceptance by the community that the project is targeting; the second is to stimulate valuable social activity and gain traction with relevant social groups; the third involves securing viable revenue streams that ensure the sustainability of the project; and the final process is to enrol government support. These four processes highlight the complementary roles that public institutions and local communities play in broadening the reach of digital inclusion initiatives. At the micro-level, the importance of local community action is evidenced by the success of projects led by and for its people (Phahlamohlaka et al. 2008). At the macro-level, the importance of institutional engagement is evidenced by the success of projects that align with political development (Madon 2005) alongside the inevitable failure of those that do not seek government backing (Roode et al. 2004).

Whether at the micro- or macro-level, the efficacy of a digital inclusion project is partly dictated by the cultures prevalent within a locality or region. Culture is defined by the attitudes and modes of thinking that the local population has strongest affinities for (Tubadji 2020). As a result, local cultures influence decision-making at the individual and institutional levels due to inherent biases that permeate through society. The existence of unconscious biases may thus perpetuate the prejudices that contribute to a social divide (Alesina, Giuliano 2015, Guiso et al. 2006, 2009, Tubadji 2020). Given the highly interconnected relationship between social and digital exclusion, it may be possible for welfare institutions to adopt a unified strategy in tackling digital exclusion since it is their responsibility to address socio-economic issues. A question therefore emerges around whether the culture of welfare institutions can be practically changed to become more inclusive. In a 1944 study entitled 'An American Dilemma' (Myrdal 2017), the Swedish economist and sociologist Gunnar Myrdal described discrimination arising from unconscious biases dating back to the early 1900s as the underlying reason for the dynamics of ethnic and racial conflict in America today. The American sociologist,

Professor Robert Merton, expanded on this view by describing the "tragic circle of the self-fulfilling prophecy" in which society's fears and falsities are perpetually reinforced "only in the absence of deliberate institutional controls" (Merton 1948). In other words, Merton claimed that the only way to break the perpetual reinforcement of unconscious biases is by enacting appropriate institutional change.

The proliferation of I4T is likely to further exacerbate regional and socio-economic disparities. According to regional diversification literature (Hidalgo et al. 2007, Neffke et al. 2011), regions are more likely to develop technologically based on their existing technological activities due to a key driver of specialisation – the so-called principle of relatedness (Hidalgo et al. 2018). As identified by Hidalgo (2021), policies that exploit this principle are likely to benefit from the diffusion of knowledge spillovers and an increase in economic complexity within a given region i.e., the accumulation of knowledge and expertise based on the collective human, social and physical capital in the economy. In the UK, the economic complexity related to technology is comparatively higher than other countries in Europe (Balland, Boschma 2021). Yet there remain significant regional disparities across the nation due to regions of high and low economic complexity (Mealy, Coyle 2022). Given the strong positive effect of relatedness on the probability that a region specialises in a new I4T, it is recommended that public policy interventions target regions with related I4T capabilities to perpetuate knowledge spillovers to adjacent regions (Balland, Boschma 2021). The literature suggests that relatedness also helps dampen the effects of labour displacement by allowing the workforce to exploit cognitive and technological proximities, in addition to geographical and cultural forms (Hidalgo et al. 2018).

Based on the above streams of literature, there is a distinct need for a holistic digital inclusion strategy in which both public institutions and local communities are mobilised into action. This combination of community and institutional action may also enact the cultural change needed to make society more inclusive as a whole. By exploiting the principle of relatedness, policy-makers can maximise the impact of community support to promote collective learning within localities and increase knowledge diffusion across regions in an effort to minimise the regional disparities arising with the Fourth Industrial Revolution. In the next section, we will outline the framework within which our digital inclusion policy will be developed by looking into the scale of digital exclusion across the UK with respect to regional trends, how recent global events have impacted high risk communities, the allocation of capital to the welfare system and digital inclusion, and issues arising from new digital welfare systems.

3 UK Welfare System

3.1 The Landscape of Digital Exclusion

A consortium coordinated by the Lloyds Banking Group and the Tech Partnership has led to the development of an essential digital skills (EDS) framework (Department for Education 2019), which categorises the basic digital skills for life and work into communicating (e.g., sharing information online), handling information and content (e.g., using a search engine), transacting online (e.g., buying items or services), problem solving (e.g., verifying sources of information online) and being safe and legal online (e.g., identifying fraud or cybercrime). In the UK Consumer Index, Lloyds Bank (2018) used the EDS framework to map regional variations across the UK population. The study found that Wales had the lowest proportion of basic digital skills (19% of the population has zero EDS) while the South East of England had the highest (only 5% of the population has zero EDS).

The Office for National Statistics (2018) survey on the scale of digital inclusion across the UK revealed that a growing number of citizens interact with public authorities and services online e.g., by obtaining information from Government websites, or downloading and submitting official forms (Figure 1). While the survey also revealed an overall decline in the percentage of non-internet users (defined as those who have never used the internet or last used it more than 3 months ago) across all UK regions from 2012 to 2018, it also revealed the regional disparity in internet use, with Northern Ireland having the largest

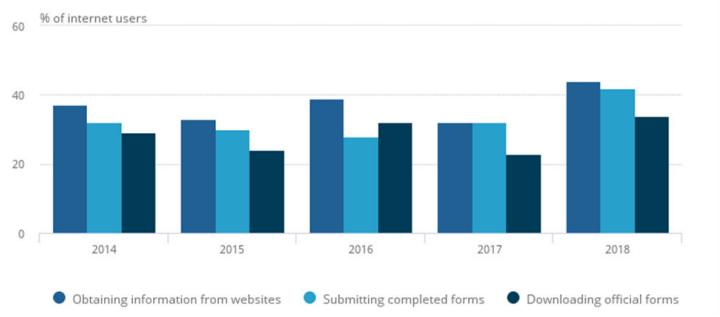

Figure 1: A survey on the percentage of internet users by type of interaction demonstrated that the internet is increasingly being used to interact with public authorities or services (Office for National Statistics 2018)

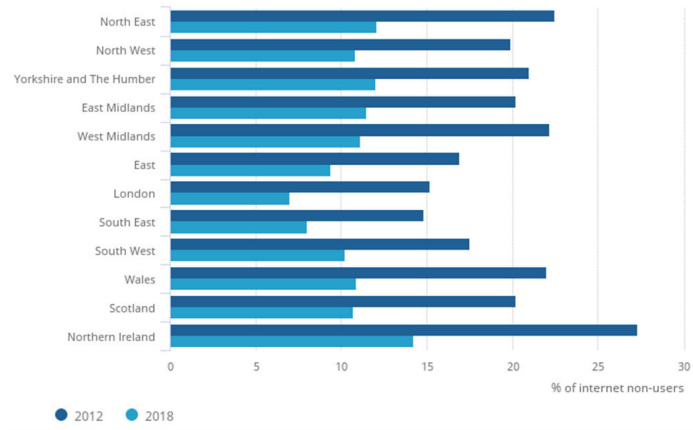

Figure 2: A survey on the percentage of internet non-users in the different UK regions revealed existing regional variations yet an overall decline from 2012 to 2018 (Office for National Statistics 2018)

percentage of non-internet users, followed by the North East of England (Figure 2).

In 2019, the start of a series of UK lock-downs to control the spread of coronavirus during the pandemic led to many individuals becoming completely isolated, further exacerbating the existing digital divide (Baker et al. 2020). The UK Consumer Digital Index 2020 found that 7% of those surveyed could not use the internet as much as they would like to during lock-down because they did not have someone to help them, while 55% of respondents claimed that technology could not replace key services they they needed in their daily lives. The report also found that 37% of the UK workforce lacked the basic skills to stay safe and legal online, while 36% of respondents did not understand the importance of staying safe online. A survey by the insurance company Aviva found that 20% of respondents suspected that they had received fraudulent correspondence relating to coronavirus (Baker et al. 2020) as a growing number of COVID-19 scams were reported in the form of phishing emails and fake Government emails containing links that steal personal or financial information.

Children from lower income households were also at a disadvantage as schools transitioned to remote learning over lock-down. An Ofcom survey conducted between January and March 2020 found that children from 9% of the surveyed households did not have access to a laptop, desktop PC or tablet (Ofcom 2020). A Sutton Trust survey in April 2020 (Cullinane, Montacute 2020) found that children from disadvantaged backgrounds were less likely to participate in online lessons, with only 23% of deprived schools having an existing online platform for remote learning compared to 60% of private schools. Nations with existing infrastructures on digital inclusion were shown to have better ed-

ucation policy responses across the UK. Wales acted quickly by leveraging their existing infrastructure to support policymakers and schools in repurposing existing stocks of laptops and wireless routers, which were delivered to disadvantaged pupils by the end of May 2020. England's response was comparatively slower, with digital equipment being distributed in mid to late June 2020. Device roll-out was the slowest in Scotland and Northern Ireland, where distribution was completed by or after the end of the school term (Sibieta, Cottell 2020). Home schooling over lock-down also raised awareness into data poverty as many households struggled to pay for their increased data usage with many pay-as-you-go customers being forced to chose between data and food (Lucas et al. 2020).

3.2 Capital Allocation

Benefit claimants in the UK have struggled to make ends meet during the pandemic due to historical cuts on benefits (Department for Work and Pensions 2021) and welfare funds (Keep 2022) that together restrict the amount any individual can claim. The benefit cap was introduced in 2013 to limit the amount of Government spending by limiting the total amount of benefits that can be claimed per person. The cap was intended to incentivise people to return to work by disincentivising welfare dependency. However, many individuals have avoided the cap by claiming Working Tax Credit or benefits not affected by the cap (UK Government 2022). The welfare cap was subsequently introduced in 2014 to further limit the total amount that the Government can spend on social security benefits and tax credits per year. In 2016, the benefit cap was tightened further, a measure that was found to unfairly penalise single parents that are reliant on benefits but cannot return to work (House of Commons 2017). The Department for Work and Pensions (2017) released statistics showing that for every child whose parents had returned to work, eight other children were left living in worse conditions. Thus the caps are widely viewed as an ineffective incentivisation scheme that punishes the vulnerable and encourages dishonest behaviour.

The 2021 UK Budget (Norman 2021) announced by the Chancellor of the Exchequer, was an opportunity for the Government to allocate capital to the welfare system and address the growing digital divide, which directly impacts those individuals reliant upon welfare support. The Chancellor stressed that "for businesses, certainty matters", yet the Budget received criticism for the lack of welfare certainty it offers to low-income households (Tims 2021), with no measures taken to permanently reverse restrictions on benefit claimants. With respect to digital inclusivity, the Budget outlines a three-year £295 million Help to Grow Digital scheme for 100,000 small and medium-sized businesses to grow and become more efficient.

However, this scheme is only suitable for those that already possess basic digital skills, thus further alienating the digitally illiterate. The new online job finding support service also marginalises those with limited or no internet access. Thus the Budget fails to account for communities at the extreme end of the digital inclusion spectrum i.e., the nine million people in the UK that cannot use the internet without help (Milner 2021).

3.3 Digitalising Social Welfare

In a United Nations (2019) report, poverty and human rights expert Philip Alston warned that governments around the world that are automating social welfare systems need to "alter course significantly and rapidly to avoid stumbling zombie-like into a digital welfare dystopia". Alston expressed his concern over governments automating key welfare functions with inadequate transparency, accountability and due diligence. After representing numerous individuals poorly affected by automated decision making of public benefits, Professor Michele Gilman – the Venable Professor of Law at the University of Baltimore School of Law – has also called for more transparency into how automated welfare systems function to establish accountability and to ensure that the design of such systems are based on honest incentives (Gilman 2020).

The Welfare Reform Act 2012 introduced several notable changes to the UK welfare system (Department for Work and Pensions 2022). The most controversial of these was

the introduction of Universal Credit (Human Rights Watch 2020), a *digital by default* social security that according to the government is intended to simplify the benefits system (Cabinet Office 2012). Since 2012, there has been a gradual transition to Universal Credit for claimants of six of the main means-tested benefits and tax-credits (income-based Jobseeker's Allowance, income-related Employment and Support Allowance, Income Support, Housing Benefit, Council Tax Benefit, Child Tax Credit and Working Tax Credit). Universal Credit has been heavily criticised for the minimum 5-week delay to receive a first payment, and the transition to Universal Credit has been directly linked to a notable rise in the use of food banks, primarily by individuals who depend on benefits as their main income (The Trussel Trust 2018). Vulnerable groups that are most impacted by the design and/or operation of Universal Credit include disabled people, claimants affected by chronic health conditions and families with dependent children. Reports by The Trussel Trust (2018, 2019) highlighted that an increasing percentage of food bank referrals were due to an increase in debt as people struggle to meet housing costs and energy bills. The Universal Credit application form has also been heavily criticized for its length and complexity, with many lacking the digital skills to successfully complete their identity verification online. The majority of individuals applying to Universal Credit are those that cannot afford to pay for internet access, yet ironically the form itself can only be accessed online. The Trussel Trust (2018) claimed "People are falling through the cracks in a [welfare] system not made to hold them".

There are many more factors to consider, most of which are not unique to the UK, with respect to the social and economic impact that technology is having on our welfare systems and other aspects of society (see the Appendix for more information). In the UK, the welfare system lacks support for the digitally excluded, lacks transparency in welfare distribution, and lacks incentives to support people truly in need. There appears to be a fundamental absence of information flowing between the supply and demand sides of the UK economy and the examples provided highlight the urgent need for more transparency and accountability in digital welfare distribution methods. Digital welfare systems only work under the assumption that every citizen is digitally included, and that algorithms do not fail. Since neither of these assumptions are valid, the result is that people are not able to trust the welfare system. By logging welfare data in a transparent and auditable database, such as the blockchain, modern welfare systems can more accurately identify people in need of support, in addition to calling out people that are exploiting social welfare. Improving the quality and availability of welfare records could also better inform the allocation of UK capital, and generate long-term economic benefits for communities and public institutions alike.

3.4 Our Contributions

This paper proposes a conceptual model that benefits from the native features of the Bitcoin blockchain to solve the key issues in the UK welfare system by:

1. using community-level participation to ensure that vulnerable individuals are digitally included and can access welfare support,

2. using a transparent and immutable public blockchain to monitor welfare data, and

3. taking inspiration from Bitcoin's incentive model to stimulate local community action and reward positive contributions to the welfare system.

The model uses the blockchain as an auditing tool, which offers a mechanism to establish transparency and data integrity, to ensure that there is sufficient accountability in the welfare system. For digital welfare systems, these features enable fast dispute resolution in cases where IT problems are encountered and/or algorithms fail. Designing a digital welfare system that promotes honest incentives can help establish a fully inclusive welfare state in which technology serves to support the social well-being of all its citizens.

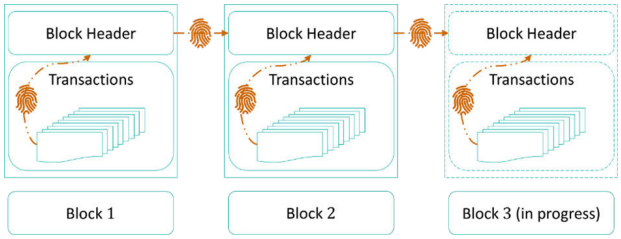

Figure 3: Bitcoin Blockchain Data Structure

4 Bitcoin Blockchain

Blockchain technology enables a public timestamped distributed ledger that benefits from transparency, immutability and auditability. Time-stamping a digital document was initially proposed by Haber, Stornetta (1991) as a method of certification. Their work demonstrated how time-stamps could be linked together in a linear fashion to generate a verifiable chain of authentication, from one document to another. Subsequent developments to this linking scheme entailed replacing the linear list with trees as originally developed by Merkle (1980), which led to more efficient and reliable digital time-stamping methods (Bayer et al. 1993). Blockchain technology has evolved significantly from a peer-to-peer electronic cash system to a global ledger as a service (Song et al. 2021). The technology is most well-known for its implementation in Bitcoin, with a growing number of applications being built upon the Bitcoin SV (2021) blockchain to benefit from its inherent features of data integrity, scalability and security (Bitcoin Association 2021, Tartan et al. 2021, Unbounded Capital 2022).

The ledger records Bitcoin transactions in order, as well as securing any data embedded within each transaction that is published on the blockchain (*on-chain*). One use case of this feature is to replay events and conduct auditing with full confidence in the integrity of the embedded data. The ledger is structured as a chain of data blocks. Each data block contains a block header and a set of ordered transactions. The first transaction in each block (*coinbase transaction*) is used by block producers (*miners*) to collect transaction fees and block subsidies once a successful block is produced and published on the blockchain. The financial gain from coinbase transactions is the incentive for miners to follow the rules (*consensus*). Blocks are chained together by inserting the fingerprint of the previous block header to the current block header. Each block header also contains a fingerprint (Merkle 1989) of all the transactions in that block, as shown in Figure 3. This fingerprint offers the means to verify that a piece of data was entered in the ledger at a certain point in time and prove the integrity of the data (*integrity proof*). Note that these fingerprints do not reveal anything about the data itself. In order to produce a valid block, miners must carry out a process that involves repetitive computations of a mathematical function on different inputs, and which cannot be replicated easily. This process generates the fingerprint of the current block, which is considered as the proof of work for the block. Once a block is produced and propagated through the network, other producers verify the block and its contents. If the block is valid, all miners start the process again by taking the valid block as the previous block, and continuing to build upon the chain of blocks. By virtue of this data structure, any changes to a transaction in a published block renders all subsequent blocks invalid. Thus there would be a necessity to redo the proof of work for all these blocks, which is considered economically unviable or computationally infeasible. Moreover, any misbehaviour can be identified and mitigated as all information about the blockchain and its transactions are publicly available.

In short, it is the combination of data immutability, transparency and the incentive mechanism that collectively secure the Bitcoin blockchain. The conceptual model proposed in this paper utilises Bitcoin as an immutable and transparent ledger, while also taking inspiration from the incentive-driven system inherent to the design of Bitcoin.

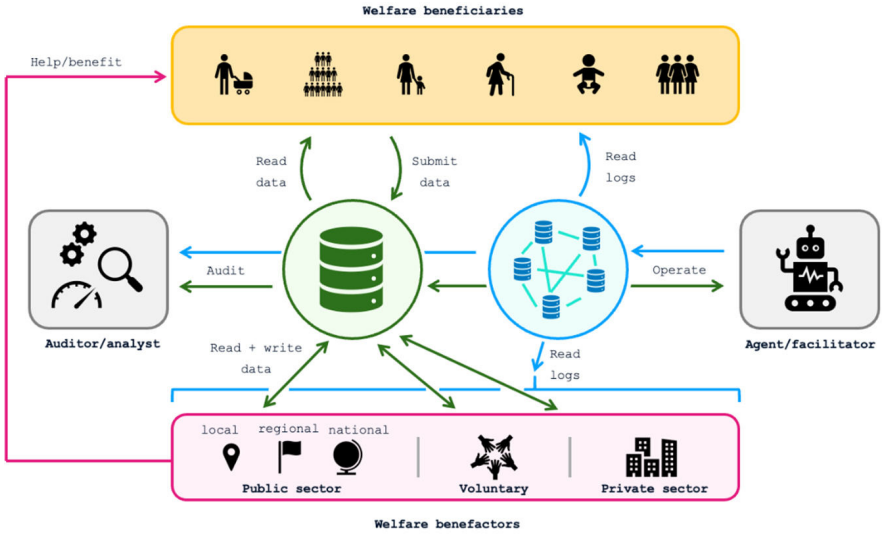

Figure 4: A Bitcoin-based Welfare Management System

5 Bitcoin-based Welfare Management System

The aim of the conceptual model is to implement a Bitcoin-based welfare management system (BWMS) that can address digital inclusion at a local, regional, and national scale. Our approach is to consolidate any existing processes of the incumbent policy-driven *macro-welfare* system by community actions within the incentive-driven *micro-welfare* system. The model is designed based on the following:

1. an incentivisation framework to encourage participation and meaningful action in the welfare system,

2. a state-based monitoring framework to track the status of citizens and regions with a focus on digital inclusion, and

3. a robust digital platform that allows users to interface with a central repository of welfare data anchored by a public blockchain to ensure accountability and trustworthiness.

Figure 4 shows an overview of the BWMS. The system is comprised of four core components and one auxiliary (external) component. The key features of each component are described below with respect to the colours used in the figure.

Core 1: Central Repository [in green]

The central repository aggregates all raw welfare data supplied/submitted by both benefactors and beneficiaries of the system. Examples of welfare data include disability status and socio-economic information derived from an individual's level of education, their employment status, whether they are in receipt of support services such as benefits and social care etc. The use of a centralised infrastructure ensures that the relevant public institutions possess access control over the platform.

Core 2: Blockchain Audit Trail [in blue]

The transparency and integrity of the data exchanged within the platform is ensured using a secure and public distributed infrastructure, the Bitcoin SV blockchain. The blockchain maintains trustworthy logs i.e., fingerprints of the raw welfare data to enable verification of the state of the central repository. The immutable property of data

stored on the blockchain ensures that historical records cannot be tampered with and that an audit trail exists to help identify any attempts of fraudulent behaviour. Using the blockchain to monitor and audit events in the centralised system ensures that the welfare platform can operate securely and at scale. The blockchain audit trail imbues the central repository with integrity proof data that ensures its integrity and can be used in conjunction with the actual data stored in the central repository to audit the entire system. The blockchain audit trail enables auditors to detect malicious users that abuse their privileges thereby mitigating potential security threats to the platform.

Note that the model ensures GDPR compliance by storing all raw database logs in the repository, and by avoiding logging any personally identifiable data on the public blockchain. In other words, private welfare records are notarised but never stored directly on-chain. These precautions are taken to preserve the privacy of UK citizens and to respect their rights to be forgotten.

Core 3: Platform Agent / Facilitator [in grey, right hand side]

The platform agent is the party responsible for running and operating the system in practice. This can include facilitating automated processes (which benefit from the *checks and balances* of a blockchain audit trail), and may also be responsible for creating and maintaining interfaces (not shown) between the other components and parties e.g., web-app, mobile interface, database integrations, APIs. The agent is also responsible for defining and implementing the access control over data.

Core 4: Benefactors [in pink] and Beneficiaries [in orange]

Benefactors are the parties who help to supply welfare data on behalf of citizens and can take meaningful action to improve some aspect of the welfare state (e.g., level of digital inclusion) for one or many citizens. Examples include public institutions such as the DWP, ONS and NHS, private firms and local organisations working in the public and voluntary sectors.

Beneficiaries are all individuals in society; a subset of which will be direct beneficiaries (i.e., that can be reclassified to an improved state of digital inclusion), and the rest are indirect beneficiaries as they are not currently at risk of digital exclusion, but the system monitors for any changes that may put them at risk. This makes the system preventative rather than reactive to people becoming excluded. Note that the welfare benefactors are the platform users, since the beneficiaries are not (necessarily) required to sign up or input their own data.

Auxiliary 1: Auditing and Analytics [in grey, left]

Raw data and events in the repository are periodically audited by a trusted third-party. The auditors are impartial entities that follow regulation, but make use of the blockchain audit trail and associated integrity proofs (i.e. certificates) during the audit. The repository is also accessed by data analysts who analyse the data and derive the current welfare state of citizens in a given region or locality. The states are derived from a set of key metrics, where each state is analogous to a risk register e.g., that assesses whether a local community is at high, medium, or low risk of becoming digitally excluded.

5.1 Monitoring Framework

The monitoring framework uses a state-based contractual approach to track processes taking place in the micro-welfare system. The platform agent facilitates the automation of these processes. These processes can be written into *automated contracts* i.e., contractual agreements between the agent and the benefactor(s) using the platform. An automated contract uses software to facilitate, verify or enforce the negotiation or performance of some or all parts of a contract, and the agent can be viewed as a computer-based algorithm that creates, executes, monitors, and terminates the contract(s). The contract is linked to a set of specific conditions, from which an *initial state* and *final state* are defined, along with a set of *inputs* (e.g., tasks or actions) that must be enacted to fulfil

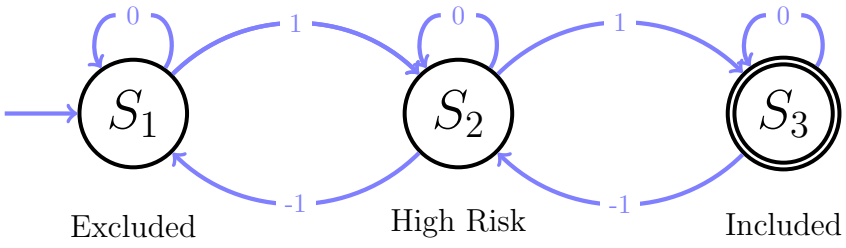

Figure 5: Example state diagram

the conditions and terms of the contract. The blockchain can be used to monitor the current state of the contract to create replayable and auditable trails of historical events in the welfare system. When given one or more inputs, the contract undergoes a *state transition* to the next or final state for any number of intermediate states as outlined by the terms of each contract. The contract is terminated once it moves into an *accepting state*. The contract is deterministic in nature, which means when given a state and an input, there is only one new state (possibly the same as the initial state) that can occur. This allows us to define a state transition table in which the future states for all possible current states and inputs can be specified.

A toy example of an automated contract involves building a garden fence from scratch within a certain time frame. The initial state of the contract indicates that no fence exists, while the accepting state tells us that the fence has been built. A state transition is initiated given a set of pre-defined inputs. The first input tells us that the necessary materials (the fence panels, posts, post supports etc.) have been acquired. The next input tells us that the appropriate tools (power drill, hammer, nails etc.) have been sourced. There may be any number of intermediate states between the initial and final state that accept one or more of these inputs. Alternatively, the contract may require the aggregate of all the inputs to trigger a single state transition to the final accepting state. It is possible that the final state is not an accepting state i.e., the garden fence was not completed or was partially built within the allocated time frame.

An example of a simple state diagram and corresponding transition table for an automated contract are shown in Figure 5 and in Table 1, respectively. In this example, the possible states are defined as $S = \{S_1, S_2, S_3\} = \{excluded, high\ risk, included\}$ where each state in the contract maps to the current welfare state (e.g., with respect to digital inclusion) of an individual, community or region. The initial state S_0, and the final state F, are both defined by the possible states in the finite set S. The contract can be designed to have any number of possible states in S, depending on the computational requirements and desired granularity of the automated contract. For example, two auxiliary states can be included to categorise individuals at low risk and medium risk, giving a total of five possible states in S.

The inputs to the contract depend on the scenario and may take a multitude of forms e.g., a set of tasks successfully completed by different platform users may collectively initiate a state transition defined by a single contract. For simplicity, consider the possible inputs $I = \{I_1, I_2, I_3\} = \{-1, 0, 1\}$, where the input $I_1 = -1$ denotes a negative state change (e.g., a high risk individual becomes digitally excluded), $I_2 = 0$ no state change (e.g., the individual remains high risk), and $I_3 = 1$ initiates a positive state change (e.g., the individual moves from high risk to digitally included). At any one time, the contract is defined by a current state from the set S and a state transition is initiated by one input from the set I. The state diagram in Figure 5 shows the accepting state as $S_3 = included$, at which point the contract is terminated. The agent monitors the work carried out by different platform users for a given contract. Each user submits evidence of their work done to prove that they have successfully completed a task that they have committed to in the platform. The agent translates the inputs from the platform users into an input within the contract to assess whether the terms of the contract have been fulfilled.

Table 1: Example state-transition table

	-1	**0**	**1**
$\boldsymbol{S_1}$	—	S_1	S_2
$\boldsymbol{S_2}$	S_1	S_2	S_3
$\boldsymbol{S_3}$	S_2	S_3	—

5.2 Incentivisation Framework

Over 200 years ago, Adam Smith described the "invisible hand" of self-interest and competition that together guide the market company (Smith, Cannan 2003). Skinner's *principle of reinforcement* led to the incentive theory of motivation, which highlighted the importance of incentives as the primary motivation for action (Skinner 1957). Since then, there have been numerous papers on economic incentives with respect to social preferences (Fehr, Fischbacher 2002, Bowles, Hwang 2008) and the field of regional economics (Bartik 2018, Mitchell et al. 2018).

The Bitcoin network is a free market within which the network operators are economically incentivised to work together on maintaining the network while competing for a financial reward. Inspired by the literature and Bitcoin's use of economic incentives, the BWMS model seeks to incentivise community participation using a combination of gamification techniques and financial / non-financial rewards staked to each task in the platform.

The workflow for the incentivisation framework starts with the agent pricing the input(s) required to trigger a state transition for each contract. This includes each task generated within a user's account that may individually or collectively map to a single input. The financial rewards are scaled to the amount of work required and resultant impact on the welfare system. Disincentives such as financial penalties may optionally be included to control for negative impacts on the welfare system. For example, the agent may introduce a penalty if a user triggers a negative state transition resulting in a diminishing welfare state. Any users identified as committing or inciting fraudulent behaviour are subject to disqualification (i.e., blacklisting) from the platform. Depending on the severity of the incident, information about blacklisted users may be published on-chain taking privacy into consideration.

It is important to note that the current model relies on the assumption that the automated contracts are allocated funds from the UK welfare budget. Each automated contract can be committed to by multiple users, who compete and/or collaborate to initiate a particular state transition in a given region. As a result, a positive state transition should improve the operational efficiency and associated costs of institutional processes, generating a high return on investment and overall cost savings for the welfare system. Such a proposition would at a minimum require some back-of-the-envelope assessments to assess whether or not this expected increase in operational efficiency is enough to finance the policy. Similarly, any non-financial incentives for the public institution, such as improvements in error and fraud detection, reputational gains as well as the trust derived from transparent systems such as the BWMS, would also require quantitative and/or qualitative assessments in order to adequately justify government sponsorship. We therefore invite economists in the field to advise on any methodologies that could appropriately qualify the efficacy of such a proposition, in addition to their views on the ethical connotations associated with the use of welfare funds to incentivise community participation and the type of rewards (monetary or otherwise) that would be socially appropriate to award to benefactors in the micro-welfare system.

5.3 Macro-Welfare System

The model adopts a hybrid approach to digital inclusivity whereby welfare institutions dictate the policies that are enacted at the micro-level by the benefactors (users) of

Table 2: The model workflow for the macro-welfare system

Macro-Level Phases	Workflow
Digital Platform Setup	Generate sector-specific user accounts Grant access control to central repository
Global State Survey	Collect and consolidate primary data Aggregate primary data in repository Analyse primary data to evaluate preliminary global state
Policy Review Period	Analyse all data in repository Audit all data in repository using the blockchain Auditing and analytics results optionally recorded on-chain Enact policy changes to improve overall strategy

the digital platform. At the macro-level, the BWMS workflow entails setting up the digital platform and conducting a preliminary survey to collect primary data in order to establish the 'global' state of the welfare system (i.e., across all UK regions). Following this, a periodic review is conducted to compare and analyse the data retrieved at the macro- and micro-levels, so that the policy can be periodically iterated to improve the overall strategy. Table 2 summarises the macro-level workflow to setup the BWMS. A description of each phase is included below.

Phase 1: Digital Platform Setup

The digital platform (Gansen et al. 2018) is set up by relevant public institutions (e.g., UK Government Digital Service). The platform agent delegates access control over the central repository to the sector-specific user accounts i.e., benefactors of the model. A rulebook for platform users is published on-chain. User accounts are generated in the platform when benefactors successfully enrol to the micro-welfare system. Appropriate identity checks are carried out during enrolment to ensure that users are certified for their selected account e.g., a social worker must prove that they are legally certified to interact with vulnerable members of the community.

Phase 2: Global State Survey

During this policy-driven phase of the model, primary welfare data is collected by relevant public institutions and stored in the central repository. Primary data refers to data acquired by processes in the incumbent macro-welfare system (e.g., via national surveys such as Census, written correspondence, phone calls or home visits) while secondary data refers to data collected by micro-processes in the novel micro-welfare system. Government departments can consolidate siloed datasets by integrating their existing welfare records into the repository. Figure 6 shows examples of the types of datasets added to the repository. Each log includes the source of the information, along with the time, location and mechanism used to acquire the data.

The data is analysed against a set of metrics to assess the current global state of welfare of an individual, community, locality, or region within the UK. The data analytics results are included in a state register and signed off by the auditors for publication in a Bitcoin data transaction. For example, the lower state boundary of the register may correspond to *digitally excluded* while the upper state boundary may correspond to *digitally included*. The on-chain state register acts as a source of data integrity and promotes transparency between all stakeholders (beneficiaries and benefactors) of the welfare system. Key metrics are also indicated in the state register to show how the states were derived. Recall that no personally identifiable information is stored on-chain to preserve privacy.

The repository is managed collectively by the system's benefactors, with oversight from incumbent government agents, and is notarised on the Bitcoin blockchain to prove data integrity. All events in the repository are also logged on-chain to maintain trans-

Figure 6: Aggregate welfare (in blue) and citizenship (in pink) datasets stored in the repository

1. Auditor obtains a data set from the repository (e.g. Internet Connectivity data).
2. Auditor requests logs corresponding to the current version of the data set from the system/agent.
3. Auditor verifies the integrity of the logs:
   (a) Auditor obtains integrity proofs for the on-chain attestations of log entries.
   (b) Auditor verifies integrity proofs of log attestations.
4. Auditor verifies that logs corroborate the current version of the dataset.

Figure 7: Example verification algorithm

parency over access control and to monitor any modifications to the off-chain welfare records. Examples of events in the repository include data entries or modifications such as *insert*, *read*, *write*, *update*, *delete* e.g., 'Table 5: row 16: entry deleted'. Such events may trigger alerts to the data auditors to request verification of some modification. An example of a verification algorithm is shown in Figure 7.

Phase 3: Policy Review Period

Routine data audits are carried out during the policy review period, whereby auditors use the blockchain to verify the logs in the repository and investigate any suspicious events or log entries with the perpetrator(s). Any misbehaviour may be penalised by blacklisting user accounts and disqualification from the platform. Auditing reports consisting of event records and documentation verifying the authenticity of the raw welfare data (though not the private data itself) may be published on-chain. The efficacy of the policy itself is also assessed so that the overall strategy can be adapted and optimised based on empirical evidence. The review entails comparing data collected at the macro- and micro-levels and reviewing the results with key stakeholders.

5.4 Micro-Welfare System

The micro-level phases of the model are defined by the contractual agreement workflow. The role of the micro-welfare system is to provide welfare support at the community level and to consolidate gaps in the primary data to ensure that all individuals are accounted for by the welfare system. Table 3 shows the workflow for the contractual agreement, for which the phases are described below.

Table 3: The contractual agreement workflow for the micro-welfare system

Micro-Level Phases	Workflow
Initial State Survey	Agent initiates state S_0 using primary data. Agent prices positive state transitions (optional rules may be included for punishment i.e., decreasing state).
Intervention Period	Users commit to contract(s) and work on associated tasks. Users collect secondary data in repository.
State Transition Survey	Agent verifies user inputs against secondary data. Agent evaluates current state against expected state (S_0 + inputs = actual output). Agent finalises contract and records outcome on-chain. Agent issues financial rewards or penalties.

Phase 1: Initial State Survey

The platform agent defines the terms of each automated contract using the primary data obtained during the preliminary global state survey by specifying a set of conditions that must be met to initiate a state transition. When a user commits to a contract, tasks are automatically generated in their account based on the resources available to them, with a financial reward indicated alongside each task. A state transition rulebook may be published in a data transaction on-chain that defines the rules of the game for all platform users. The terms of each contract may also be recorded on-chain to insure against any potential instances of dispute resolution, while omitting personally identifiable data to preserve privacy.

Phase 2: Intervention Period

The benefactors may commit to one or more automated contract, after which they commence working on a set of allocated tasks generated in the platform. The work carried out by the benefactor results in the collection of secondary data, which is recorded in the repository and logged as part of the evidence (inputs to the contract) in a bid to win the staked reward. Note that secondary data is also subject to routine audits during the periodic reviews.

Phase 3: State Transition Survey

During the final phase of the automated contract (triggered by a pre-determined date/time), the platform agent starts verifying the inputs against the secondary data populated in the repository by the contract's signatories (the benefactors). The agent evaluates the current state of the contract against the expected (i.e., next or final) state, which is a combination of the initial state and the inputs to the contract. A state transition is triggered if the actual output is equivalent to the expected state. In the case that the expected state is the final state, the agent finalises the contract by terminating it in the platform, recording the outcome of the contract in a transaction on-chain and issuing any rewards (and/or penalties).

In the next section, we walk through a real-world example of a contractual workflow that aims to tackle digital inclusivity in a high risk UK region.

5.5 Example Workflow

The DWP conducts a national survey to analyse the current landscape of digital inclusivity across the UK regions. The output of the survey identifies a rural Welsh village as having a large percentage of individuals at high risk of digital exclusion, and a small proportion of elderly citizens as digitally excluded. The results of the survey are uploaded to a central repository accessible via a digital welfare platform. The platform agent prepares an automated contract "Digital Inclusion of Rural Welsh Village" based

on the survey results, including a set of priced tasks that each require signatories from one or more sector-specific benefactors for the contract to be initiated. The platform sends notifications to notify its users about the new tasks in their user accounts. A number of organisations working in Wales respond to the survey by committing to the tasks under the contract. The tasks are distributed according to two state transitions: from *excluded* to *high risk* ($S_1 \rightarrow S_2$), and from *high risk* to *included* ($S_2 \rightarrow S_3$).

Through this contract, a broadband provider pledges to build new infrastructure in regions where individuals have little or no physical connectivity. The company also lowers their subscription fee for 6 months to support those that face digital exclusion due to data poverty. Individuals residing on the outskirts of the village are less interactive within the local community and as a result, some are not motivated to be digitally included. A local charity therefore commits to a contractual agreement to onboard these isolated individuals, such as via home visits by their local volunteers that have passed the necessary security checks and are qualified in social welfare. The volunteers are able to adopt a more personable approach to motivate individuals that exist on the cusp of society to become digitally included. Collectively, the work carried out by these benefactors triggers a state transition from *excluded* to *high risk* ($S_1 \rightarrow S_2$).

The state transition triggers the start of a new set of tasks for the relevant signatories who committed to the next (and final) state transition in the contract. Namely, a local community centre pledges to organise a series of digital inclusion workshops to support its members in acquiring the foundation-level digital skills outlined by the Essential Digital Skills (EDS) Framework (Lloyds Bank 2020). The workshop needs to be tailored to the local demographic to gain traction with the elderly community identified in the online survey. The community centre reaches out to the local Bingo hall to organise a series of collaborative Bingo nights and educational workshops, since the Bingo hall is known to have a good reputation with the older demographic. The workshops prove to be a success with the 60+ age group, with a high proportion of the community obtaining certification in the basic digital skills that transition them from digitally excluded to the high risk category. Further initiatives to up-skill the community are carried out by the community centre as well as the local library. A successful attendance to a series of workshops hosted by these organisations results in a large proportion of the community obtaining more advanced digital skills that allow them to access online public services that help them transition to a digitally included way of life.

Table 4 summarises the inputs (i.e., actionable tasks) under the themes of *connectivity*, *on-boarding* and *up-skilling* that collectively finalised the terms of the contract outlined by the platform agent in response to the initial survey. The contract is finalised and the relevant benefactors are financially rewarded for successfully completing their respective tasks. The output of the contract is captured on the blockchain and any relevant data collected during the different contract phases is stored in the central repository and reflected in the global state of the welfare system.

6 Discussion

The conceptual model adopts a hybrid approach to policies and the infrastructure within which its policies are executed. In terms of its infrastructure, the BWMS benefits from both the efficiency of a centralised system (the central repository) and the security of a decentralised system (the blockchain). With respect to policy-making, the model unifies macro- and micro-level welfare processes via a digital platform that consolidates the actions taken by local communities and public institutions. At the macro-level, the blockchain ensures the transparency and integrity of private welfare records to foster the development of strategies in which social and digital exclusion are considered in unison. The use of the blockchain technology also ensures greater accountability and auditability in aid of dispute resolution, which is increasingly paramount as the implementation of new digital solutions are further exacerbating the digital divide. At the micro-level, the model aims to incentivise the up-skilling of communities by exploiting the principle of relatedness and rewarding knowledge spill-overs across regions. This in turn bolsters regional economies by tailoring up-skilling initiatives to individual interests and the lo-

Table 4: State transition survey for rural Welsh village

Current State	REGIONAL: STATE TRANSITION SURVEY Digital Inclusion of Rural Welsh Village List of Positive Inputs ($I = +1$)	Next State
S_1	*Connectivity* 1. New infrastructure to create access to broadband in rural regions. 2. Lower broadband subscription fee in areas of data poverty. *On-boarding* 1. Identify isolated individuals. 2. Outreach programme for 60+ aged community members. 3. Foundation-level EDS certification for excluded individuals.	S_2
S_2	*Up-skilling* 1. Outreach programme on access to online public services. 2. Advanced EDS certification for high risk individuals.	S_3

cal cultures within which the contractual agreements are actioned. An appropriately designed incentive structure informed by economists in the welfare sector could result in a variety of automated contracts from which diverse incentives may be realised that also take into consideration the complementary social preferences of different benefactors (Fehr, Fischbacher 2002). An impact evaluation framework, such as that proposed by Todd, Wolpin (2020) for new policy programmes, may be adopted to quantify the impact that the proposed intervention has on digital inclusion, alongside back-of-the envelope assessments to qualify the appropriate means to finance the policy through government sponsorship or otherwise. Todd, Wolpin (2020) uses a discrete choice dynamic programming structural model and compares the results to data from a randomized control trial to ensure the credibility of structural estimations. While state transitions are initially priced by the platform agent, these prices may be dynamically adjusted based on the results from any periodic impact assessments.

The model seeks to be inclusive at all levels and this paper invites contributions from economists to inform the design of an appropriate incentive mechanism to ensure that any individual, group, or organisation is incentivised to enrol as a benefactor. While the issue of how to handle the incentive structure for active participation is a general one that is typical of all welfare schemes, the model uses blockchain technology as a trustworthy, auditable log of welfare records in the macro-welfare system to avoid introducing further challenges around accessibility for the digitally excluded beneficiaries of the micro-welfare system. The incentive mechanism is also critical to ensure diversity amongst the benefactors, which is a fundamental component of policies that aim to support the inclusion of individuals (beneficiaries) from all socio-economic classes. The benefactors may range from community groups, charities and social welfare organisations from the voluntary sector; to healthcare and welfare firms, broadband providers or SMEs from the private sector; and local councils, leisure or community centres, and social workers from the public sector. Community participation is necessary to improve the output from the model. The more community members contributing to the micro-welfare system, the greater the total output and the greater the positive impact on the welfare system. The result is a cohesive and cooperative welfare system in which institutional efforts are simultaneously reinforced by positive community actions.

Despite our aim to develop a model that supports digital inclusion, the generality of our model serves to aid the collection and dissemination of any type of welfare data. Collecting high-quality data for the welfare sector would help to assess the risk of an individual or community becoming socially and/or digitally excluded, with the latter becoming increasingly pivotal in the existing welfare system as more public services become digitalised. The model therefore proposes that information relating to internet connectivity, data poverty, access to online services and digital skills be integrated with a citizen's welfare records. The model also unveils the need for welfare issues stemming from digital

exclusion to be reflected in society's dissatisfaction with public institutions. This is an aspect that is yet to be captured by the current survey from which the European Quality of Government Index (Charron et al. 2019) was derived. However, recent events such as the COVID-19 pandemic have highlighted that digital inclusion will impact society's trust in public institutions. Our conceptual model offers a solution to the issues that prevailed during the pandemic as a means to continuously monitor and improve the digital inclusion of individuals across different regions to ensure the prosperity of the national welfare sector.

The BWMS may also be combined with big data to help make better sense and use of it for policy purposes. The model provides up-to-date, reliable and granular data on the interventions, such as, how effective they are, how long they take, which are popular, what sort of parties (users) are taking them on, and what value provides a compelling incentive. The data is available at community and regional levels, both on a national scale, and could expand to cover a vast range of target issues and interventions. The potential impact of this data, both in terms of research and policy-making is extensive. Moreover, blockchain is one of the few technologies that is appropriate to manage this amount of huge volume, high precision data. The model may help to eliminate the discrimination that societies have historically faced on a self-fulfilling prophecy basis in cases that relied upon self-selection and skill sets. For example, the BWMS could be used to ensure the public provision of education to ensure work for all socio-economic classes, along with the public provision of digital skills that ensure access to any future welfare service that will rely upon big data, while avoiding the biggest danger of perpetuated digital discrimination i.e., the developmental trap.

7 Conclusions

In this paper, we set out to investigate how the new technological revolution can help society and the welfare provision by the state. Our research question was whether the cutting-edge technologies of the Fourth Industrial Revolution could facilitate the creation of a welfare data management system that ensured the digital inclusion of all groups in society. Examining the literature on I4T, we found that little attention was paid to the welfare sector, and there was an over-focus on AI over other technologies. Therein we identified a gap in the literature – a welfare data management system that exploits the transparency, auditability and accountability of the blockchain technology. Our solution to providing a more inclusive welfare state uses a conceptual model that benefits from the data integrity offered by the Bitcoin blockchain, in addition to the transparency, auditability and accountability of the technology. The holistic nature of our model means that incumbent macro-level policies enacted by public institutions are positively reinforced by novel incentive-driven policies enacted by local communities. As a result, the macro- and micro-level processes occur in unison and positively reinforce collective efforts to address the digital divide. The model also ensures the collection of high-quality welfare data at all levels of the welfare system. The data is privately stored in a central repository and secured via a blockchain-based management system. A digital welfare platform unifies this data, allowing benefactors of the system to interface with the system, and incentivises positive community actions using contracts between the platform (institution) and its users.

While our proposed model is not a fully evolved solution, it aims to stimulate research into the benefits of blockchain technology for future public policies for the welfare sector. As the Fourth Industrial Revolution continues to take effect on the world, regional economists may use the model to learn about the importance of data integrity in the development of regions, cities and places. Our proposed use of an incentivisation framework aims to mobilise stakeholders from different socio-economic classes. The source of inspiration for the incentivisation framework was found in the Bitcoin network, which continues to prosper as a free market due to the economic incentives baked into the protocol. We invite specialists in the field to contribute to the design of the incentivisation framework to ensure that it is appropriate for welfare programmes. We recommend that policy-makers adopt a similar collaborative approach to leverage the combined insights

of technical experts, economists and welfare specialists and to ensure that the individuals and groups that its policies target are included within the design process.

Future developments may also involve consideration of other blockchain features that were not deployed in the first instance of the model. The blockchain technology is most well-known for its payments feature. Financial rewards may be issued via Bitcoin transactions, either using a new token system (e.g. a nation's central bank digital currency) or via the blockchain's native token (bitcoin) with due consideration given to the accessibility of the technology to platform users along with the legal implications around government sponsorship of bitcoins. The incentives may decrease in size if the model's welfare system becomes very popular. In this case, a micro-payment system would be needed, which can be achieved via Bitcoin payments due to the low transaction fees in the Bitcoin SV network. Micro-payments are a particularly interesting feature as they could provide a tool to incentivise individuals into interacting with the digital platform, for example by completing micro-tasks on a daily basis. More complex payment conditions could also be created in a Bitcoin transaction, such as using multi-signature transactions where large rewards are involved and shared among multiple platform users. Transacting on the blockchain would also provide more transparency into the issuance of the financial rewards and being able to track and audit the trail of welfare funds. Once the model establishes direct access to beneficiaries that may have initially been socially and/or digitally marginalised, we could introduce interventions that target the beneficiaries directly. In other words, the beneficiaries of the schemes could be inducted to act as benefactors of themselves and their very input to the platform could act as a marker of digital inclusion. This would also improve data verification, since it would be possible to check directly with the beneficiaries whether they feel more digitally capable or whether they use digital technologies more often. Moreover, financial rewards could be issued directly to high risk beneficiaries for taking on and successfully completing tasks that promote their digital inclusion. For example, a micro-payment may be issued if the individual checks a portal on a daily basis, or by keeping their welfare information up-to-date, or signing up to paperless billing, and so on.

In conclusion, this paper provides novel insights into how to disrupt the current paradigm of welfare provision using cutting-edge blockchain technology and invites comments from specialists in the field to develop this research further.

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A Appendix:

A.1 Algorithmic inequality trap

As more businesses start to automate their operations, employment opportunities are growing for the digitally included and diminishing for the digitally excluded. In 2021, the HM Treasury (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/968403/PfG_Final_Web_Accessible_Version.pdf) reported that 5 million UK workers are at risk of becoming "acutely under-skilled in basic digital skills" by 2030. A Harvard Business Review article coins the algorithmic inequality trap as the algorithmic discrimination and bias that is widening the digital gap and exacerbating inequality in the workforce. More specifically, the article refers to a "code ceiling" in which career advancement is stifled for those that rarely interact with human co-workers and are instead managed by algorithms. COVID-19 has acted as a catalyst to this transformation of the labour market, which is increasingly dominated by AI, algorithms, and automation.

A.2 The automation of welfare

Automated decision-making systems based on machine learning, a form of AI, are being widely implemented in welfare systems, with reports (https://theconversation.com/ai-algorithms-intended-to-root-out-welfare-fraud-often-end-up-punishing-the-poor-instead-13-1625) of a digital welfare state spanning the US, the UK, India, Australia and parts of Europe. In the US, large penalties were administered from an automated fraud detection system without human intervention. This resulted in severe consequences for low-income families ranging from evictions, to bankruptcy, homelessness and in some cases, suicide. Moreover, a subsequent state review revealed an algorithmic error from which 93% of the fraud determinations were wrong. In India, a glitch in the world's largest biometric ID database resulted in death-by-starvation for a resident whose subsistence rations were erroneously halted (https://www.reuters.com/article/india-election-starvation-idINKCN1LS0HO).

A.3 Economic effects of digital and social welfare

A study (https://cebr.com/reports/tinder-foundation-and-go-on-uk-call-for-urgent-digital-skills-funding-to-support-government-2020-fast-broadband-for-all-pledge/) by the Centre for Economic and Business Research (CEBR) found that providing basic digital skills to the entire UK population could contribute over £14 billion annually to the UK economy by 2025 due to the potential for increased earnings, better employability and communication, transaction benefits, and time savings. The study also found that training individuals to access online health resources could translate to a potential NHS cost saving of £121 million per year. Research commissioned by the Joseph Rowntree Foundation in 2016 into the economic effects of deprivation found that providing a high level of welfare to keep people out of poverty actually saves money in the long-term (https://www.cashfloat.co.uk/blog/money-borrowing/social-welfare/). They estimated a total cost of £78 billion to the economy collectively arising from the treatment of health conditions (e.g., due to inadequate housing), benefits (i.e., lost tax revenue), education (e.g., free school meals), spending on children services and policing areas affected by deprivation. This is an equivalent expenditure of £1,200 per person in Britain caused by poverty alone.

A.4 Digital inclusion charity in the UK

The Good Things Foundation is a UK-based charity that emphasises the importance of community support for the provision of personalised support for digitally excluded individuals. Research commissioned by the charity found that 75% of adults agreed that every community in the UK needs a place that can offer support with internet skills such as online banking or accessing public services online (http://www.goodthingsfoundation.org/-wp-content/uploads/2021/01/blueprint-for-a-100-digitally-included-uk-0.pdf). A 2020 public poll also found that 61% of people agreed that data access should be recognised as an essential utility, like electricity (http://www.goodthingsfoundation.org/wp-content/uploads/2021/01/blueprint-for-a-100-digitally-included-uk-0.pdf). The charity has worked in collaboration with Nominent, the official registry for UK domain names, to establish a new Data Poverty Lab to ensure that every community in the UK can interact with the digital economy (https://www.goodthingsfoundation.org/what-we-do/news/good-things-foundation-and-nominet-seek-end-to-data-poverty/). Responding to the UK 2021 Budget, the Good Things Foundation has also called for the Government to publicly commit to digital inclusion policies that tackle the digital skills gap and data poverty (https://www.goodthingsfoundation.org/insights/budget-2021-a-missed-opportunity/).

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Territorial Infrastructure Support Index (ISIT): A theoretical and empirical contribution to the analysis of lag zones in Chile

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Abstract. Through a review of the literature on infrastructure, a study of international experiences, expert knowledge, and the elaboration of a Territorial Infrastructure Support Index (ISIT), this paper provides a comparative analysis of the development conditions – regarding infrastructure and services – for the location of productive economic activities, at the regional and provincial level in Chile. The results show contrasts between regions and within them, revealing the state of the current situation for each of the six dimensions: Water, Energy, Telecommunications, Roads, Logistics, and Resilience, as well as for their synthetic indicator ISIT. The results of the ISIT have been contrasted with the recent definitions made by the Government of Chile regarding the definition of lag zones, finding important coincidences at the provincial level that allow validating the ISIT as a tool for the analysis of gaps in infrastructure and equipment for development of economic and productive activities in Chile.

Key words: Infrastructure, region, lag zones and indicators

1 Introduction

The objective of this work is to investigate the possible impacts that infrastructure has on socio-territorial development in Chile, for which it is posed as a question how the gaps in productive economic development are related to the declared lag zones in the country. In particular, an index called Development of the Territorial Infrastructure Support Index (ISIT) is applied, which considers six dimensions: Water, Energy, Roads, Telecommunications, Logistics, and Resilience at a provincial scale and is contrasted with the geostatistical results provided by the information on lag zones.

The hypothesis of this work is that a lag zone is deprived of infrastructure for socio-territorial and productive development, deepening the conditions of isolation and widening the gaps with respect to zones that are provided. Although geographical conditions that isolate a territory are decisive for the definition of a lag zone, we believe that infrastructure represents the opportunity to overcome these conditions and improve the quality of life of its inhabitants and the productivity of their economic activities.

For this purpose, two work objectives are proposed: (1) Analyze and compare the gaps in infrastructure for the economic-productive development existing in the country

in a multidimensional way based on the ISIT; (2) Compare the level of coincidence with the definition of lag zones established by the Chilean state.

First, the article provides some background on the theoretical and empirical framework used, from the review of international literature and working documents of the Chilean state. Then, what characterizes the lag zones is defined and it is explained how the ISIT was elaborated, to subsequently analyze its cartographic representation at a provincial scale and its contrast with the resulting cartography of the lag zones. Finally, some conclusions are delivered that reflect on its scope in terms of decentralization and regionalization in the current context of political and institutional transformations in which the country finds itself.

2 Theoretical framework

The economic literature on infrastructure began with research efforts to explain the positive correlation between infrastructure development and rapid economic growth of the industrial economies (Banerjee et al. 2020). Agénor (2010) suggests that an increase in the share of public spending on infrastructure leads to a steady high growth state. This is because infrastructure affects the production and public services such as health and, therefore, labor efficiency.

In this direction, different authors have argued that infrastructure reforms geographic connectivity and contributes to the agglomeration of economic activities (Fujita, Krugman 2004). Likewise, infrastructure reduces costs and trade flows, thus positively influencing economic development (Cohen 2010). Therefore, prosperity and regional growth depend primarily on the indirect effects of infrastructure (Chen, Haynes 2015).

Recent studies have shown that infrastructure provides the necessary services that support economic growth by increasing the productivity of labor and capital, thereby reducing production costs and increasing profitability, output, income, and employment. (Zolfaghari et al. 2020). Additionally, it is increasingly recognized that infrastructure plays a vital role in promoting growth and reducing poverty in under-developed countries (Gramlich 1994).

Empirical evidence on regional inequality and investment in infrastructure has shown, for example, that improving road infrastructure can help increase labor force participation to reduce income inequality (Calderon, Servén 2004). Similarly, other types of infrastructure, such as communications, drinking water, and electricity networks, can promote income growth in rural sectors and reduce the gap between rural and urban areas (Wan, Zhang 2015). Similarly, Straub (2008) points out that investment in infrastructure directly affects the increase or decrease of the gaps between rich and poor regions within the same countries.

Based on these facts, governments, institutions, and the research community recognize the importance of infrastructure in economic and territorial development. However, the distributional effects of infrastructures have not been sufficiently explored (Wan, Zhang 2015), revealing that one of the main problems is the unequal distribution of infrastructure provision in the territories (Zhang et al. 2017).

The infrastructure is relevant to connect all kinds of territories, especially those lagged or with peripheral conditions. These zones usually are isolated from other zones because of physical and human factors (Farole 2013, Hanks 2011). In other words, they are separated from the leading zones and circuits both physically and economically (Brad et al. 2015). The infrastructure represents a critical opportunity for improving lagging conditions, allowing more accessibility to and from the lag zones.

In the case of Chile, although there has been significant increase of infrastructure development in recent decades, some gaps continue to be observed in the form of regional inequalities, quality of local infrastructure, and the population's exposure to negative externalities derived from economic growth (OECD 2017), such as the contamination, and decrease of hydric resources due to the mining industry. Additionally, it is still necessary to overcome existing infrastructure deficiencies (MOP 2007) and contribute to a more homogeneous distribution of their provision, particularly in terms of roads, telecommunications, and water reserves. In this sense, the Ministry of Public Works

(2007) indicates that it is necessary to increase the country's competitiveness, improve the population's quality of life, and concentrate public investment in sectors and territories where social profitability[1] is higher, with social and territorial equity. This vision is inserted in the Infrastructure Director Plan 2010-2025.

Chile is a unitary and centralized country, (OECD 2017), in particular, concerning the issues of decentralization and public investment, Orellana Ossandón et al. (2021) argue that when clear and transparent rules do not regulate the criteria that control the allocation of these types of public investment, they do not have a significant impact on the final result. Additionally, the distribution of territorial infrastructure in Chile is dominated by non-programmatic logic, in which the politicians in charge of the distribution make use of discretion to improve their electoral results (Orellana Ossandón et al. 2021). Chile's subnational investment in infrastructure is mainly framed in transportation and public works, decided centrally by the sector ministries (OECD 2017).

Faced with this situation, one of the main challenges faced by political systems to advance towards sustainable urban development, lies in defining established technical criteria that direct the thematic and geographical prioritization of public investment in territorial infrastructure on standards of territorial equity or economic efficiency (Orellana Ossandón et al. 2021). This is necessary to counter possible relationships between election results and public investment spending, as has happened in Greece, where ruling parties have tended to reward constituencies that return them to power (Rodríguez-Pose et al. 2016).

In the same way, it is crucial to value private investment. According to the Critical Infrastructure for Development Report (2018), developed by the Chilean Chamber of Construction, more than 60% of the total investment in infrastructure for the next decade requires the participation of the private sector. In fact, 32% could be provided entirely and directly by the private sector if the correct incentives and institutional frameworks are created, and another 29% could be provided under a mixed regime (with public and private financing) (CChC 2018).

Studies in line with the Keynesian vision show a complementarity between public and private investment, arguing that this effect is because public investment is generally limited to goods and services that the private sector will not produce in optimal quantities (Ouédraogo et al. 2020). In this sense, public investment in infrastructure tends to complement private investment because it facilitates the implementation and realization of investment plans by private agents (Martinez-Lopez 2006). Along the same lines, Abiad et al. (2016), using a simulation model, highlighted that increased public investment increases production, both in the short and long term, and increases private investment.

3 Marginal territories

The advanced marginality is concentrated and isolated in delimited territories. It is often associated with territorial stigmatization from the outside and inside (Wacquant 2007). Also, there is a loss or dissolution of the "place" itself because of the physical and socioeconomic conditions, which disadvantage the territory resulting on dependency over other territories (Tort 2003). In this line, the functional relationship between a center and its periphery determines the marginality of the region because they are distant, dependent, and different (Ferrão, Lopes 2004 in Vecchio 2022).

They are distant in a physical and/or in an economic view, where rural and non-productive territories, for example, are left aside from infrastructure development and financial flows. Also, they are dependent because of the lack of labor markets and a sustainable commerce of goods and services in the territory. Finally, they are different because of their own conditions of disadvantage which make them unattractive. Territorial marginality is related to a specific space and location, including the participation, or its lack thereof, in the economic dynamics (Vecchio 2022). There is often an absence

[1] It refers to a project evaluation and prioritization criterion that Chile has used to allocate public resources since 1975, which compares investment at social prices with the number of direct beneficiaries impacted by the project, pointing to purely economic issues and not the beneficiary end (society)

Table 1: Percent of susceptible districts to be lag zones by region in Chile

Region	Total number of district	Number of susceptible districts	Percent of susceptible districts in the region
Arica y Parinacota	4	0	0.00%
Tarapacá	7	3	42.9%
Antofagasta	9	7	77.8%
Atacama	9	3	33.3%
Coquimbo	15	8	53.3%
Valparaíso	38	4	10.5%
Metropolitana de Santiago	52	12	23.1%
Libertador General Bernardo O'Higgins	33	7	21.2%
Maule	30	10	33.3%
Ñuble	21	8	38.1%
Biobío	33	15	45.5%
La Araucanía	32	9	28.1%
Los Ríos	12	6	50.0%
Los Lagos	30	17	56.7%
Aysén Del General Carlos Ibáñez Del Campo	10	6	60.0%
Magallanes Y De La Antártica Chilena	10	5	50.0%
TOTAL	345	120	39.0%

Source: SUBDERE, 2022

of institutions that could benefit the inhabitants or promote new developments through investment in infrastructure. Some of these territories do not have a minimum population which justifies the investment from a cost-benefit perspective. Eventually, this ends in a vicious circle where marginality remains.

Marginal territories are related to the concept of accessibility. This concept has produced a paradigm shift in various research fields, from transportation studies to digital human interactions, as well as in multiple disciplines such as engineering and geography, to name a few (Greco 2018). Accessibility is understood as the potential to access a specific activity. Said potential depends on the ease or difficulty of reaching different points in space and the level of attractiveness or magnitude of the opportunities. In other words, it implies integration over the space of possibilities, weighted by the ease of interaction (Miller 2018). In this sense, due to their peripheral nature, marginal territories lack this potential due to the difficulty of access due to lack of means (infrastructure) and low attractiveness. Investment in infrastructure in these territories tends to be considered inadequate to cover their demand because their population is small and dispersed, making it difficult to justify this investment (Vitale Brovarone, Cotella 2020).

In the case of Chile, an adequate approximation to define this condition of marginal territories is possible from the definition of what, from the field of public policies, is called "lag zones". According to the Subsecretaría de Desarrollo Regional (SUBDERE), it refers to the existence of territories that live in conditions of lag with respect to the country average, for which the program proposes to reduce social and economic gaps prioritized participatively by the public and private actors of each lagging territory. The methodology for defining lag zones considers the district[2] as a unit of territorial analysis. Among the analysis variables that it contemplates are: level of isolation due to geographic or climatic conditions or availability of connectivity infrastructure; travel time to education and health facilities; travel time to services (financial institutions, among others). Table 1 shows the percentage of districts in each region that are susceptible to be classified as lag zones.

4 Approach of the research and methodological application

This work poses as research question: To what extent are the existing gaps in infrastructure for economic-productive development related to the condition of lag zones in the

[2]District is the smallest territorial unit in administrative political terms in Chile.

country? For this purpose, it is maintained as a working hypothesis that, although the lag zones determined by public policy in Chile are limited to aspects related to factors related to the level of isolation of human settlements in terms of connectivity, access to health, education and services, there is a close relationship between endogenous factors (geographical and climatic) with exogenous factors (public and private investment in infrastructure) which together explain the existing gaps between Chilean regions.

4.1 Development of the territorial infrastructure support index (ISIT)

Public and private investment decisions that favor the economic and social development of the country, expanding the geography of opportunities, require indicators that allow establishing the pre-existing conditions of the territory as a source of resources and supporting activities. Thus, based on the report on Critical Infrastructure for Development 2018-2027 prepared by the Chilean Chamber of Construction (CCHC), we carried out a detailed and systematic analysis of investment requirements in fourteen critical sectors for sustainable development in Chile, including water resources, energy, telecommunications, interurban roads, urban roads, airports, ports, railways, logistics, public spaces, hospitals, prisons, education, and resilience.

Subsequently, we organized workshops with Chilean infrastructure and land planning experts to collect recommendations on infrastructure measurement. Also, we reviewed international experiences at a subnational scale (whether regional or interurban) about measuring and comparing aspects related to critical infrastructure for the development of the economic-productive system of a country, such as the Index of Logistics Performance of the World Bank, logistics observatories and indicators of regional integration of Economic Commission for Latin America and the Caribbean, the World Competitiveness Index developed by the International Institute for Management Development Competitiveness Center, among others.

Concerning this, there is a need to exploit, for example, the potential of accessibility indicators as a support tool in infrastructure planning tasks aimed at efficiency and territorial cohesion (Ortega et al. 2014). Likewise, the medium or long-term investment plans, which include indicators of infrastructure gaps and focus on a territorial basis, could play a key role in moving towards a territorially inclusive country (Orellana Ossandón et al. 2021). In addition, a system of indicators highlights territorial inequalities (e.g., greater or lesser coverage of drinking water) and the existing elements that support local communities' social and economic development (Vișan 2019). Other authors, such as Sherval (2009), also point out that constructing a quantitative indicator for specific territorial contexts, (like urban and rural territories), is crucial to guide decision-makers in distributing public subsidies for disadvantaged regions.

Based on the review of various experiences in the development of indicators (Steiniger et al. 2020), such as the System of Indicators and Standards of Urban Development (SIEDU)[3], Rural Life Quality Indicators System (SICVIR)[4], and Urban Quality of Life Index (ICVU)[5], we elaborated the Territorial Infrastructure Support Index (ISIT). The ISIT refers to the territorial aptitude relative to network infrastructures and services for the development and competitiveness of the various activities of the national economic-productive system at the provincial level. Based on the indicators systems mentioned above, we established six dimensions of the ISIT: water, energy, telecommunications, roads, logistics, and resilience. Each one is briefly explained below:

- Water; provision, and coverage of drinking water and sewerage in urban and rural areas, as well as rainwater.
- Energy; related to the provision in the territory of electricity, fossil fuels, and the use of renewable energies.
- Telecommunications; coverage, and quality of fixed and mobile telephone services, and internet in urban and rural areas.

[3] https://www.ine.cl/herramientas/portal-de-mapas/siedu/
[4] https://www.ine.cl/herramientas/portal-de-mapas/sicvir
[5] https://estudiosurbanos.uc.cl/documento/indice-de-calidad-de-vida-urbana-icvu-2021/

- Roads; coverage, and quality of the interurban road infrastructure network on primary and secondary roads.

- Logistics; coverage, and proximity of equipment and services required to support economic-productive development in the territory.

- Resilience; provision of equipment and services to respond to exposure to socio-environmental risks.

For example, on issues of water resources, Ali et al. (2020) developed a regional drought indicator, which provides sufficient evidence for establishing effective drought mitigation policies and early warning strategies. In the case of Chile, the main objective of investments associated with water resources for the next decade is to have infrastructure works that allow the progressive supply of all kinds of demands, both for drinking water service and for environmental, ecological, and productive uses (CChC 2018).

Regarding energy development, Yang et al. (2020) suggest that an effective infrastructure investment strategy could optimize the reallocation of energy resources (e.g., more finance on renewable energies instead of carbon or oil), promote coordinated development between regions, and reduce regional development inequality. Likewise, investment in energy infrastructure can improve social welfare for the poor people's demand for vital energy resources, such as gas and electricity (Li et al. 2018). Also, Gunnarsdóttir et al. (2020) argues that sustainable energy development is a political objective that requires solid indicators. Often, indicators emphasize the economic impacts of energy developments (Allan et al. 2014, Black et al. 2014, Lekavičius et al. 2019) and little or no recognition of environmental or social impacts.

It is essential to highlight the telecommunications infrastructure's role as a driver of GDP and the greater demands for data traffic expected in the future. Although Chile presents high penetration values for residential and mobile internet in the regional context, the country reaches only 70% of the average mobile internet penetration in OECD countries (CChC 2018). Internet access is a challenge in Latin America and the Caribbean, requiring continuous and specific public policies to achieve universal coverage (Serebrisky, Suárez-Alemán 2019).

Concerning these last three dimensions, the input-output matrices[6] illustrate, for example, that water resources, electricity, and telecommunications are used in the production process of almost all sectors, while transport is a transversal input to all of them (Zolfaghari et al. 2020). Indeed, improvements in transport infrastructures positively impact regional development and significant repercussions on the economy and affect many processes (Ortega et al. 2014).

Transport infrastructure is a vital social and economic resource and provides access to current economic and social opportunities (Richardson 2005). Investment in the construction and maintenance of transport infrastructure is enormous, and its repercussions can be seen in all areas of society (Hildén et al. 2004). Regarding this, the road infrastructure supply for better mobility and transportation performance is generally used as an indicator and can be measured from four perspectives: state of the pavement, traffic capacity, safety, and accessibility (Alavi et al. 2016, Dong, Huang 2015, Song et al. 2020). In terms of interurban roads, the importance of roadways in the entire national infrastructure is evident. The geographical configuration of Chile and the scarcity of road alternatives in many parts of the territory means that inland highways and roads take a leading role in the transportation networks of people and goods (CChC 2018).

Logistics is considered the necessary infrastructure to make the freight transport value chain more efficient (CChC 2018). The needs at the national level are associated with improving the efficiency in the treatment of cargo and the transitions between means of transport, following the complete value chain of the merchandise, from its origin to its destination (CChC 2018).

[6]input-output matrices of the central bank of Chile, available at https://si3.bcentral.cl/estadisticas/-Principal1/Excel/CCNN/cdr/excel.html.

4.2 ISIT Selected Variables

The selection of variables to calculate the ISIT involved a procedure that combined two stages. In the first stage, we preselected around 70 indicators distributed in the six dimensions based on national (SIEDU, SICVIR, ICVU) at a territorial scale superior to the city scale or international (OSD, OECD) measurement experiences (Steiniger et al. 2020), published studies, and expert knowledge through interviews and a workshop with members of the infrastructure committee of the Chilean Chamber Construction (CChC). In a second stage, 43 indicators were selected (see Annex 1), based on three critical considerations: availability of official sources to prepare the ISIT periodically and obtain comparable results for the Chilean case, geographical and climatic conditions[7] of each province to make a valid relative comparison, always making sure that each indicator has the 56 provinces.

Further information on the indicators (including all ISIT dimensions with 8 Water dimension indicators, 6 Energy indicators, 5 Telecommunications indicators, 7 for Roads Network indicators, 8 Logistics indicators, and 9 Resilience indicators) is available in the Annex 1. The calculation formula, the institutional source, and the update year are established for each indicator by dimension.

4.3 Indicators by dimensions and synthetic indicator

For the elaboration of the ISIT, from the 43 indicators and their six dimensions, a Principal Component Analysis (PCA) was applied to enable the construction of a synthetic indicator for each dimension evaluated in the ISIT (Shahabi et al. 2012).

Before performing the PCA, all the variables will be normalized between 0 and 100. In addition, the scale of those variables whose original value scale is negatively or inversely proportional to good support of the territorial infrastructure was inverted. Therefore, 0 is considered the minimum or least favorable value for all variables, and 100 is the maximum or best value for supporting the territorial infrastructure.

Each Principal Component (CP) obtained from the analysis is a linear combination of all the indicators, where each one obtains a specific coefficient or weight (eigenvalue). The analysis yields several CPs equal to the number of indicators, and where each CP explains a certain percentage of the total variance.

To generate indicators by dimension, the weights obtained in the PCA are reduced to a single coefficient per indicator. First, the absolute value of each indicator's weight in each dimension, relative to each PC, is multiplied by the percentage of the variance that explains said PC. This process is repeated for each indicator, considering the CP values (see equation 1). After obtaining a single coefficient per variable, a cut-off value (benchmark) is established to select the indicators that make up the final index. The criteria for choosing the cut-off value will be discussed at the work table; however, as an initial criterion, it is suggested to select a benchmark that leaves a minimum of 2 to 3 variables per area. Then, all those indicators with coefficients higher than the benchmark are chosen.

$$Cv_{\,comp1} = PVar1_{\,comp1} * \%S^2_{var1} \tag{1}$$

where

$comp1$ ... Component 1,
Cv ... Final Variable Coefficient,
$PVar1$ ... Variable Weight 1,
S^2 ... Variance.

Subsequently, for the final calculation of each dimension, the coefficients obtained are scaled for the selected indicators to add up to 100 in each area. Then, the provincial values of each indicator (previously normalized) are multiplied by the coefficient and added by dimension. Therefore, the province that has the maximum score in all the indicators of a dimension will have a score of 100 in that dimension.

[7] Some indicators are available only for coastal zones or specific climatic zones (presence of vegetation, among other characteristics).

Table 2: Population and area distribution by region in Chile

Region	Population	% Population	Surface	% Surface
Arica y Parinacota	226,068	1.3%	16,873	2.2%
Tarapacá	330,558	1.9%	42,225	5.6%
Antofagasta	607,534	3.5%	126,049	16.7%
Atacama	286,168	1.6%	75,176	9.9%
Coquimbo	757,586	4.3%	40,579	5.4%
Valparaíso	1,815,902	10.3%	16,396	2.2%
Metropolitana	7,112,808	40.5%	15,403	2.0%
O'Higgins	914,555	5.2%	16,387	2.2%
Maule	1,044,550	5.9%	30,296	4.0%
Ñuble	480,609	2.7%	13,178	1.7%
Biobío	1,556,805	8.9%	23,890	3.2%
Araucanía	957,224	5.4%	31,842	4.2%
Los Ríos	384,837	2.2%	18,429	2.4%
Los Lagos	828,708	4.7%	48,583	6.4%
Aysén	103,158	0.6%	108,494	14.3%
Magallanes	166,533	0.9%	132,297	17.5%
TOTAL	17,573,603	100.0%	756,097	100.0%

Source: Own elaboration, according to INE data, 2022

4.4 Classification for comparative analysis

Given that there is no possibility of comparing the ISIT with any national or international reference that would allow recognizing specific standards in some dimensions, four levels were determined; High, Medium-High, Medium-Low, and Low, based on the results obtained from the statistical processing itself. So then, the territorial aptitude of the ISIT or some dimension would be:

HIGH (dark green) : When the indicator by dimension or synthetic for a province is above the average plus mean standard deviation. $x > \bar{x} + \sigma$

MEDIUM-HIGH (light green) : When the indicator by dimension or synthetic for a province is between the average plus the mean, standard deviation, and the average. $\bar{x} < x < \bar{x} + \sigma$

MEDIUM-LOW (light brown) : When the indicator by dimension or synthetic for a province is between the average and the average minus the mean, standard deviation. $\bar{x} - \sigma < x < \bar{x}$

LOW (dark brown) : When the indicator by dimension or synthetic for a province is below the average minus the mean, standard deviation. $x < \bar{x} - \sigma$

The results for each dimension and the ISIT are represented cartographically, a question that allows observing the differences between regions and within them, showing the contrasts that exist to make the location of some economic-productive activities more feasible depending on what affects them in each dimension.

5 Analysis of results

The regions that conform to the continental territory of Chile present an uneven distribution in terms of their surface and demographic terms, as can be seen in Table 2, organized from north to south.

To better visualize the contrasts existing in the country, in demographic and territorial terms, Table 2 shows that while the Metropolitan region concentrates 40,5% of the population, it only occupies 2,0% of the continental surface. In contrast, the Magallanes

region only concentrates 0,9% of the population and occupies 17,5% of the national territory. Regions such as Antofagasta in the north and Aysén in the south present the same pattern as Magallanes.

The latter reinforces the centralist and unitary character of the Chilean state, as can be seen in Graph 1 were, from north to south, between the regions of Valparaíso and Biobío (5 regions of 16 regions), 73,5% of the population is concentrated, only occupying 15,1% of the national territory. It is crucial to point out that in the OECD report on Chile (OECD 2017), it is stated textually, "Chile has opted for a mixture of two models: on the one hand, a liberal economic model that relies on the ability of the market to distribute resources and tends to limit public intervention. And, on the other hand, a 'centralist model of political administration' is understood as a way to maintain stability, protect national unity, and contribute to economic efficiency and social redistribution. This model places Chile in a unique situation compared to other OECD countries, with low total public spending (as a percentage of GDP) as well as a low level of subnational spending (as a percentage of total public spending)" (p. 8).

The combination of models has made it possible to develop exports focused primarily on the primary sector, with an estimated US$50 billion in exports. This sector is mainly concentrated in mining (50,8%), fruits (9,4%), forestry (7,1%), and aquaculture (6,5%). Mining activity is concentrated in the northern area and the rest are located in the country's southern area, while in the Metropolitan region where the country's capital is located, the commerce and services sector prevail far above the percentage of the population with just over 70,0%.

6 ISIT provincial results

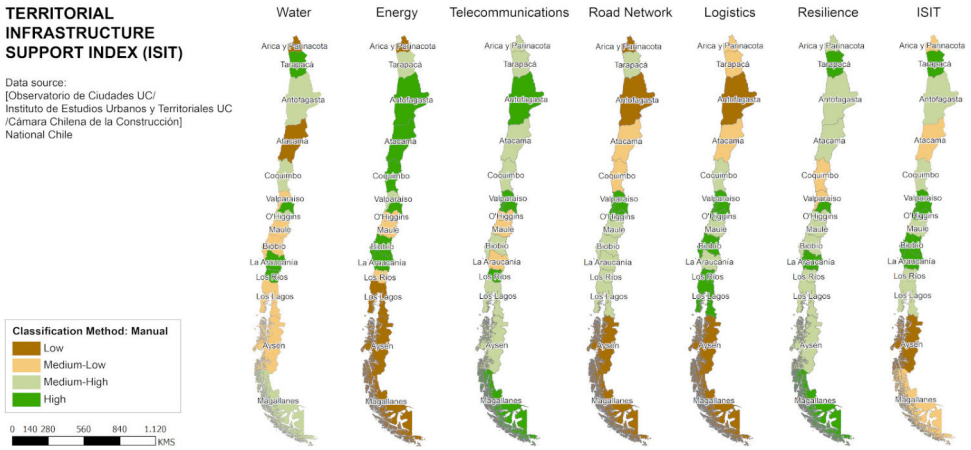
The results of the preparation of the ISIT are presented below, considering two scales of analysis; interregional and intraregional. The interregional analysis allows comparing the ISIT and its dimensions between the different regions of the country. And, the intraregional analysis will enable us to verify the existing contrasts within each region from the results that are represented at the provincial level.

6.1 Interregional Analysis

The interregional analysis is shown in Figure 1, where the results obtained for each region are presented, once applied in PCA and selected the 25 indicators that express the most significant variance, considering a distribution of water with three indicators, energy with four, telecommunications with four, roads with five, logistics with five and resilience with four.

In general, the interregional maps show that the different dimensions of the ISIT in the central macro zone of the country are more favorable compared to the north and south of the country, particularly concerning the southern zone (regions of Aysén and Magallanes), in contrast to a High and Medium-High level of territorial aptitude for the Metropolitan region in almost all dimensions, exceptionally in the telecommunications dimension. Then, the Biobío, Valparaíso, and La Araucanía regions present results with a High and Medium-High level in all their dimensions, although with a greater tendency towards a Medium-High level of territorial aptitude and other Medium-Low. The rest of the regions of the central macrozone, such as the O'Higgins and Maule regions, mainly present a territorial aptitude at a Medium-High level. Both also show a low level in the telecommunications dimension.

Figure 1 also shows a significant level of contrast between dimensions in the extreme north of the country. On the one hand, while the energy dimension is presented with an excellent territorial aptitude, especially in regions with a significant presence of large copper mining such as Tarapacá at the Medium-High level, Antofagasta and Atacama at the High level, which has promoted private investment in terms of development, the supply and diversification of energy sources, mainly through solar and wind energy. And, on the other hand, in the roads and logistics dimensions, territorial aptitude is presented at a Low and Medium-High level, most likely due to the high concentration



Source: Own elaboration, 2022

Figure 1: Interregional comparison by dimension of the ISIT

of the population in its regional capitals and the low level of development of its smaller cities without good alternatives for transportation of workers to mining sites.

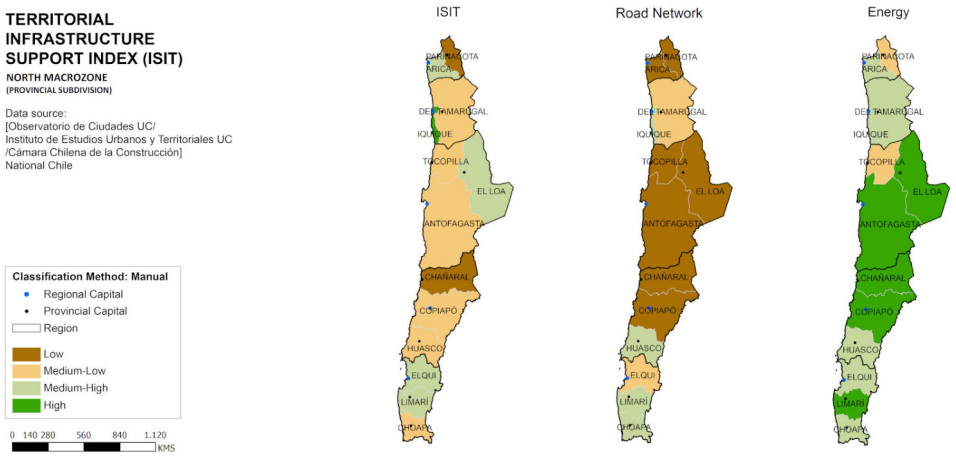
And, in the extreme south, from Los Ríos Region towards the southern zone, the regions show a deterioration in most dimensions, where they mostly reach a Low or Medium-Low territorial aptitude, except for the telecommunications and water dimensions. Figure 1 also shows the characteristics of a territory with rugged geography from the region of Los Lagos to the south, making surface connectivity especially complex in Aysén and Magallanes. In addition, it is an area with historically low population occupation. These two regions cover a third of the country's continental surface but only account for 1,5% of the national population.

Lastly, the ISIT, as a synthetic indicator that results from the average of the six dimensions, shows that only the Metropolitan and Valparaíso regions reach a High territorial aptitude. This situation deteriorates towards the north, reaching a low ISIT level in the Arica and Parinacota Region. In contrast, to the south between the O'Higgins and Los Ríos regions, a Medium-High territorial aptitude predominates, then the Los Lagos, Aysén, and Magallanes regions present an ISIT at Low level. In conclusion, in interregional terms, the country presents critical imbalances in infrastructure and equipment for economic-productive activity that limits its growth and economic development potentials, already warned by the OECD (2017) report and other similar studies.

6.2 Intraregional Analysis by Macrozone

Based on the interregional results, this section reviews the results obtained at the provincial level, considering an analysis based on macro zones. Four macro zones will be considered: The North (regions of Arica and Parinacota, Tarapacá, Antofagasta, Atacama, and Coquimbo); the Central North (Valparaíso, Metropolitana, and O'Higgins), the Central-South (Maule, Biobío, Araucanía, and Los Ríos), and the South (Los Lagos, Aysén, and Magallanes). The intraregional analysis is conducted from north to south for the 55 provinces defined in the continental territory.

The presented analysis shows the contrast between those dimensions where there is greater contrast in the results. That is, where provinces tend to be concentrated in a Low or Medium-Low aptitude versus that of a more favorable dimension, where the provinces are concentrated in the High and Medium-High levels. Likewise, the result of the synthetic index obtained by the provinces of each respective macrozone is presented.



Source: Own elaboration, 2022

Figure 2: ISIT of provinces of the northern macrozone

6.3 Analysis of Provinces of the Northern Macrozone

Figure 2 shows the results by province of the five regions that belong to the northern macrozone. Of all the provinces that conform to this vast territory, only the province of Tamarugal in the Tarapacá Region achieves an ISIT at the High level. However, the province of Iquique, which is in the same region, only reaches the Medium-Low level. For the other regions, the ISIT shows an important contrast between the Arica and Parinacota Region provinces but less prominent between the Regions of Antofagasta, Atacama, and Coquimbo.

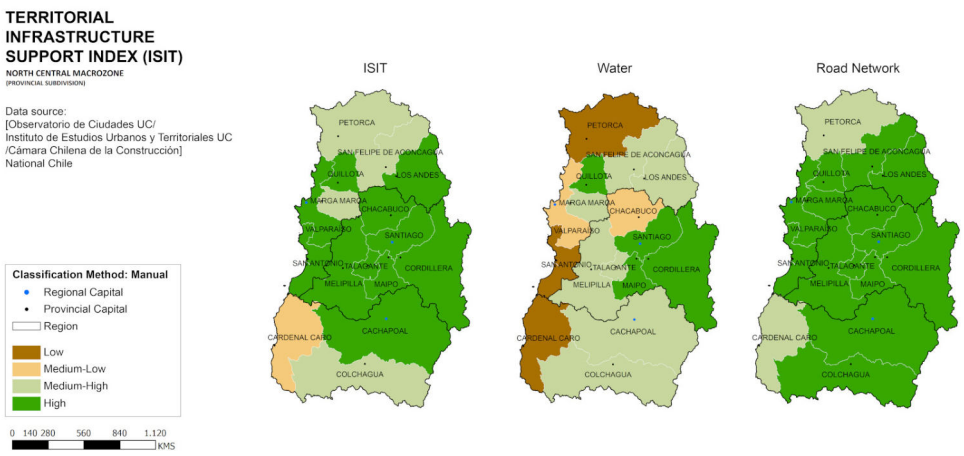
This contrast also shows a significant disequilibrium between dimensions. For example, the Antofagasta region has a good energy performance, derived from mining activity, but poor connectivity, considering the distances. The opposite occurs in the province of Tamarugal, where the indicators are more homogeneous among the different dimensions, allowing the province to stand out with the best overall infrastructure indicator.

6.4 Analysis of Provinces of the Central-North Macrozone

Figure 3 shows how all the provinces of the Metropolitan Region have a High ISIT level, being the only case among all the regions of the country. While in the case of the Valparaíso region, there are contrasts among its seven provinces, where Petorca, Marga-Marga, and San Felipe de Aconcagua reach an ISIT at a Medium-High level, the rest of the provinces have High levels. And, in the case of the O'Higgins region, there is a greater diversity of situations concerning the ISIT, because while the province of Cachapoal reaches a High level, the province of Colchagua obtains Medium-High and the province of Cardenal Caro obtains Medium-Low.

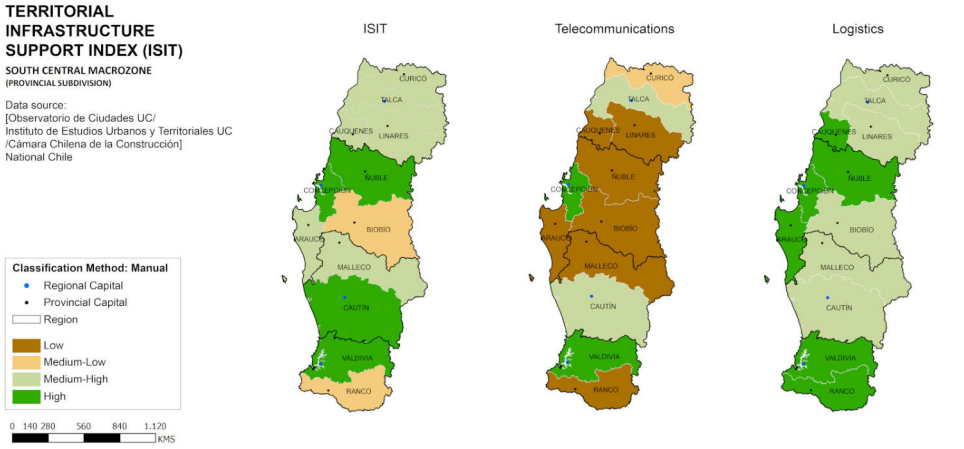
Then, the greatest contrasts between provinces by dimension in the case of the central-north macrozone are in the water dimension where a greater number of provinces obtain Low and Medium-Low levels, particularly in the province of Petorca and San Antonio in the region from Valparaíso and in the Cardenal Caro provinces in the O'Higgins region. Now, although there are provinces with a High and Medium-High level in territorial aptitude in the water dimension, it is crucial considering that the province of Santiago, Maipo, and Cordillera, contain 40,0% of the country's population. There are also provinces in the Medium-Low levels such as Valparaíso and Chacabuco.

In contrast to the previous dimension, in the roads dimension, this macrozone presents its best territorial aptitude, since except for Petorca and Cardenal Caro, which reach a Medium-High level, the rest of the provinces obtain a High level in this dimension. It must be considered that the three regions (of central-north macrozone) that make up



Source: Own elaboration, 2022

Figure 3: ISIT of provinces of the central-north macrozone



Source: Own elaboration, 2022

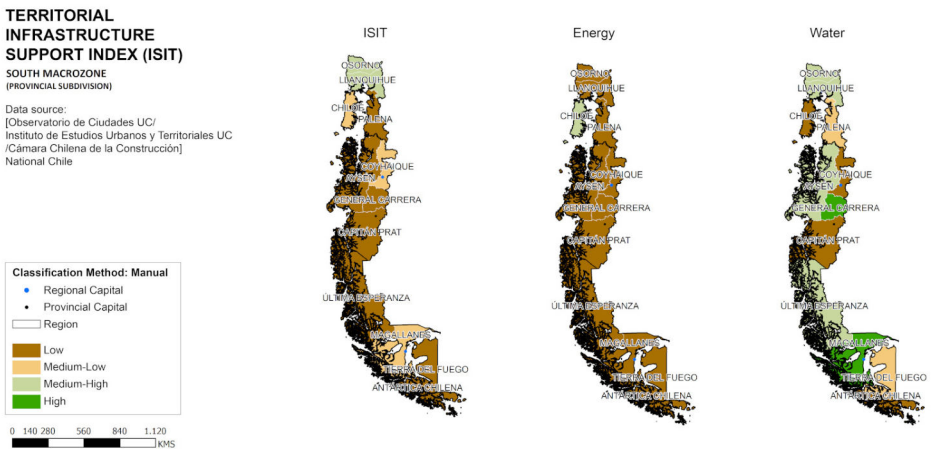
Figure 4: ISIT of provinces of the central-south macrozone

what for this study we have defined as the central-south macrozone, it covers only 6,6% of the country's territory. However, it contains at the same time 56,0% of the country's population, a territory where there are also ports located in the provinces of San Antonio and Valparaíso, that move slightly over 50,0% of the country's cargo, as well as the main international airport in the province of Santiago.

6.5 Analysis of Provinces of the Central-South Macrozone

In Figure 4, the results are positive, given that the ISIT presents most of the provinces in the High and Medium-High level in terms of territorial aptitude, where only the province of Biobío in the Biobío Region and the province of Ranco in the Los Ríos region reach only a Medium-Low level. Maule region's homogeneity in the ISIT is particularly noteworthy, and the greatest contrast is in the Los Ríos Region.

The Telecommunications dimension is where this macrozone presents the fewest advantages, as shown in Figure 4, and more significant contrasts within the regions that comprise it. The most remarkable contrast occurs in the Biobío region given the fact that while the province of Concepción reaches a High level, the other provinces reach a



Source: Own elaboration, 2022

Figure 5: ISIT of provinces of the southern macrozone

Low level. The Los Ríos region holds the same level of contrast. And, in the case of the Maule and Araucanía regions, the contrasts are lower; however, it also accounts for regions where telecommunications do not reach the same coverage and quality standards.

In contrast, the logistics dimension for this central-south macrozone is where the results are most favorable since all the provinces reach a High or Medium-High territorial aptitude, the Los Ríos region is the only region with all provinces at High level.

6.6 Analysis of Provinces of the Southern Macrozone

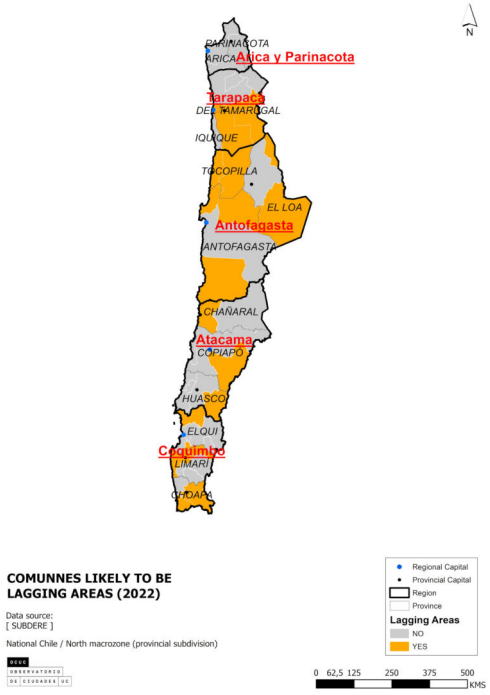
The ISIT for the southern macrozone shows in Figure 5 that the provinces mostly reach a Low level in their territorial aptitude, except for the provinces of Osorno and Llanquihue, which reach a Medium-High level. As noted above, the ISIT shows a greater precariousness in infrastructure and equipment for the Aysén and Magallanes region provinces. It is essential to highlight the interconnected electrical system and the main road reaching the north to the border with Peru, to the south end in Puerto Montt, Llanquihue Province, Los Lagos Region.

When analyzing the most significant contrasts between dimensions, in the southern macrozone, the dimension that presents the worst results is energy, as shown in Figure 5, where all the provinces present a Low level, except for the province of Chiloé (Insular territory of Los Lagos region). The previous shows that in this dimension, there is also a high level of homogeneity between provinces.

Lastly, although there are essential contrasts between provinces in the water dimension for the southern macrozone, it is also the best dimension in terms of results. This question is logical considering it is an area where higher levels of rainfall are recorded, however, there are significant deficiencies in drinking water and sewerage services, and a storage deficit.

7 ISIT analysis regarding lag zones

The lag zones can be considered as marginalized territories, being possible to contrast the results obtained in the maps obtained from the ISIT with the results shown in Table 1. Thus, in the case of the northern macrozone, made up of four regions; Arica and Parinacota, Tarapacá, Atacama, and Coquimbo, which account for 34,4% of the country's surface (see Table 2), where the lag zones are concentrated mainly in the Antofagasta (77,8%) and Coquimbo (53,3%) regions. In the case of the Antofagasta region, where the communes present an ISIT at a low or medium-low level, it coincides with the character of a lag zone of the communes of the province of Tocopilla (see Figure 6), and reaches



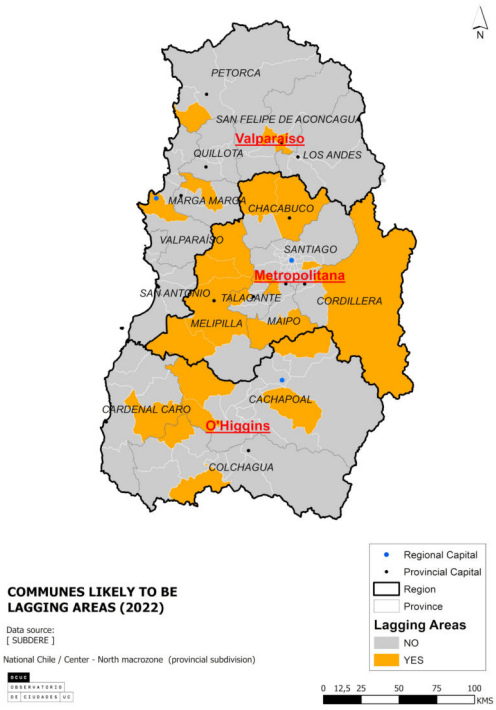
Source: Own elaboration, SUBDERE, 2022

Figure 6: Lag zones by district and province of the northern macrozone of Chile

16,7%. of the surface of the country, only below the Magallanes region (see Table 2). And, in the case of the Coquimbo region, the ISIT result coincides with the communes of the Choapa province. In the case of the Atacama region, where the percentage of lag zones reaches 33,3% of the communes, the coincidence is partial in the case of the province of Chañaral, with only a significant contrast, and in the case of the province of Tamarugal, which shows an ISIT at a High level, while 2 of 5 communes are considered lag zones. In conclusion, the result of the ISIT reaches an important but not total coincidence with respect to the definitions of lag zones.

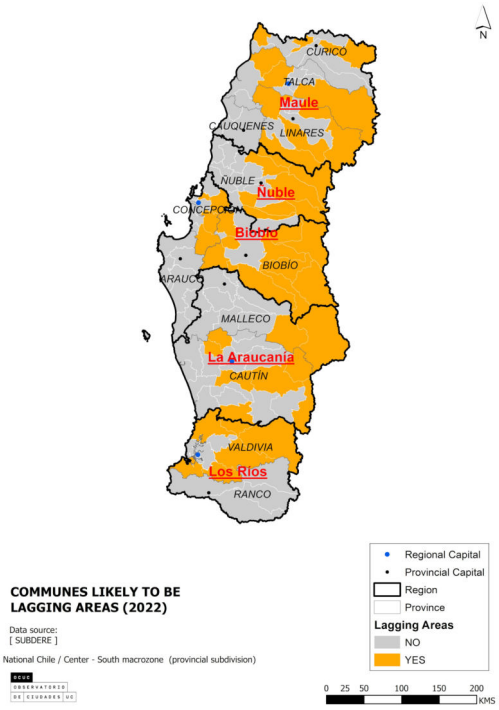
In the case of the central-north macrozone, made up of the Valparaíso, Santiago Metropolitan and Libertador General Bernardo O'Higgins regions, the ISIT results are the same for almost all the provinces (see Figure 3 compared to Figure 7), because the percentages of communes likely to be considered lag zones do not exceed 25,0% for the three regions, being the lowest percentages of all the country's macro-areas. Additionally, it should be considered that this southern macrozone contains 56,0% of the country's population (see Table 2), but the lowest percentage of the country's surface (6,4%). In conclusion, there is a high coincidence between the results obtained from the ISIT with respect to the declared lag zones.

Now, for the case of the regions of the central-southern macrozone, made up of the Maule, Biobío (includes Ñuble), Araucanía, and Los Ríos regions, where 25,1% of the country's population is concentrated (Table 2), the Los Ríos region reaches 50,0% of districts that can be declared as lag zones and then the Biobío region with 45,5%, concentrates the highest percentages (see Table 1). In contrast, the Araucanía region presents the lowest percentage with 28,1%. When comparing these results with those obtained by the ISIT (see Figure 4 compared to Figure 8), it coincides that the provinces of Biobío in the region of the same name and the province of Valdivia in the Los Ríos region, where districts are concentrated as lag zones, present a medium-low level of ISIT. With regard to the rest of the regions, although there are districts that can be declared lag zones, they do not exceed 40,0% of the total number of districts. In conclusion, the result of the ISIT reaches an important but not total coincidence with respect to the definitions of lag zones.



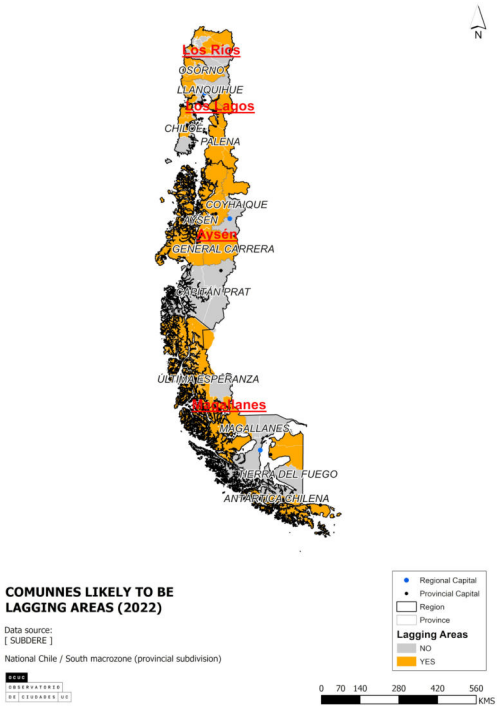
Source: Own elaboration, SUBDERE, 2022

Figure 7: Lag zones by district and province of the central-north macrozone of Chile



Source: Own elaboration, SUBDERE, 2022

Figure 8: Lag zones by district and province of the south central macrozone of Chile



Source: Own elaboration, SUBDERE, 2022

Figure 9: Lag zones by district and province of the southern central macrozone of Chile

And, finally, regarding the results compared to the southern macrozone that integrates the regions of Los Lagos, Aysén, and Magallanes, where only 6,2% of the country's population is concentrated in a total area of 38.2% of the country, a territory characterized by a very low density, particularly in the two extreme regions, where the vast majority of the provinces are likely to be declared as lag zones (see Figure 9). Table 1 shows that among the three provinces, more than 50,0% of communes are in this condition, being particularly high in the Aysén region with 60,0%. This result coincides with that shown by the ISIT (compare with Figure 5), where all the provinces of the Aysén and Magallanes region are at a low or medium-low level. In conclusion, there is a high coincidence between the results obtained from the ISIT with respect to the declared lag zones.

7.1 Conclusions

The ISIT constitutes the first effort in Chile to develop a multidimensional tool to analyze and contrast the state of the infrastructure and equipment needed for the economic and productive development of the country. Chile maintains a political-administrative structure of regions defined in 1974 during the military dictatorship, where later, since the return of democracy in the early 1990s, the reforms in terms of political, administrative, and fiscal decentralization have been insufficient, leaving the country with the lowest level of fiscal decentralization among the OECD countries (OECD 2017) with weak public policy attributions for elected authorities at the regional level (Orellana Ossandón et al. 2020). The latter emphasizes Chile's condition as a unitary and centralist country (OECD 2017), where decisions regarding public investment have concentrated the development of infrastructure and equipment in the central macrozone, mainly where more than two-thirds of the country's population live.

Notwithstanding the previous, Chile's export model, that has enabled participation in international markets, is concentrated in primary and secondary activities located in the north and south of the country, where the ISIT accounts for the existing deficits and high contrasts within the regions themselves. At the same time, this work has made it

possible to demonstrate that the results obtained through the ISIT fit the definitions and identification of lag zones in Chile, where the highest levels of isolation and socio-territorial gaps are concentrated in the extreme north and south of the country. testing the hypotheses.

The ISIT, based on geographical, climatic, and demographic considerations, allows to establish that each region and province has more significant advantages and disadvantages at the national level, to facilitate the location of economic and productive activities. At the same time, it reveals crucial contrasts between regions and within them. From this perspective, this study and its results contribute to visualizing the country's challenges in terms of infrastructure and equipment to reach a development threshold that allows solving the current socio-territorial inequalities in Chile.

The results of this work are consistent with the theoretical and empirical background presented, in relation to the fact that the stock of infrastructure in its different dimensions is decisive in the existing gaps in terms of territorial development in our country, especially in what it says in relation to the connectivity networks associated with some specific dimensions of the ISIT (Roads, Telecommunications, and Logistics, mainly). In particular, the lag zones that are close to the concept of marginal territories for the Chilean case, turn out to be the determining infrastructures in terms of accessibility to public and private goods and services for a significant number of urban and rural localities scattered throughout the national territory.

Regional governors have recently been elected for the first time and the significant demands for greater decentralization on decisions on public investment, planning, and management of their territories, are all aspects that are possibly going to be included in the country's future constitution, a document which will be subject to voter's approval or rejection in September of this year. Therefore, the contribution of this study and its results are transcendent because it seeks to establish an integral – and up-to-date – diagnostic of the infrastructure conditions on the continental territory.

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A Appendix:

Table A.1: List of indicators

DIMENSION INDICATORS	DESCRIPTION
Water	
Drinking water coverage	Percentage of provincial population with drinking water coverage
Sewerage coverage	Percentage of population with sewerage coverage
Total Population by rural drinking water (APR in Spanish)	Relationship of the total provincial population with respect to the number of APR
% Beneficiaries over Rural Population	Percentage of APR beneficiaries with respect to the total population
Annual rainfall deficit	Average annual rainfall of the last four years compared to the historical average
Concessioned urban area	Sanitary concession surface with respect to the provincial urban area
Coverage of operational territories	Area operational territories with respect to the provincial surface
Average water price	Water price per m^3 [No Peak (winter)]
Energy	
Price Benzine 93 Octane	Average price per liter of gasoline 93
Price Benzine 95 Octane	Average price per liter of gasoline 95 octane to the consumer
Price Oil	Average price of oil to the consumer
Total power generation	Sum of energy capacity available by province (Biomass, hydroelectric, wind, thermal and solar)
% Self-Generated Power	Percentage of self-generated power (biomass, wind, solar), with respect to the total power
Electrical Substations	Number of substations SIC/SING/SEM/SEA
Telecommunications	
Successful start calls	Percentage of Successfully Established Calls
Successful term calls	Percentage of Calls Completed Successfully
Fixed networks	Number of Fixed Network connections per thousand inhabitants
inhabitants per telecommunications antenna	Number of inhabitants per telecommunications antenna
Internet connection	Number of Internet connection per 1,000 inhabitants
Road Network	
% Double carriageway paved network	Percentage of dual carriageway paved network
% Paved main network	Percentage of main network paved
% Paved secondary network	percentage of paved secondary network
kms on intercity motorway	Distance to interurban highways, from the centroid or point with the best connectivity in the province
Paving network with respect to surface	Paved network with respect to the provincial surface
mins to intercity highway	Time (mins) to interurban highway, from centroide or point with better connectivity in the province

continued on the next page

Table A.1: List of indicators (continued)

Dimension Indicators	Description
Total network with respect to operational area	Provincial road network with respect to the operational area
Logistic	
Territorial coverage by Post Office (Hás)	Post offices with respect to the provincial area
Coverage of Service Stations (Hás)	Service stations with respect to the provincial surface
Territorial coverage branches of the State bank (Hás)	Banco Estado branches with respect to the provincial area
Distance to airport network (kms)	Distance (kms) to airport network, from centroide or point with better connectivity in the province
Distance to airport network (minutes)	Time (mins) to airport network, from centroide or point with better connectivity in the province
Distance to maritime terminals (kms)	Distance (kms) to maritime terminals, from centroide or point with better connectivity in the province
Distance to maritime terminals (min)	Distance (mins) to maritime terminals, from centroide or point with better connectivity in the province
Distance to service stations (kms)	Distance (kms) to service stations, from centroide or point with better connectivity in the province
Resilience	
% Area risk erosion	Percentage of the territory with Risk of Erosion class Severe or Very Severe
Average isolation hours	Average access (hours) to provincial capital
Kms of average isolation	Average distance (km) to provincial capital, from centroide or point with better connectivity in the province
Primary health distance (kms)	Average distance (km) to Primary Health centers, from centroide or point with better connectivity in the province
Distance to primary health (min)	Average distance (min) to Primary Health centers, from centroide or point with better connectivity in the province
Territorial coverage of Carabineros de Chile (Hás)	Carabineros barracks of Chile with respect to the provincial surface
Disaster Recurrence	Sum of the number of disasters per year (fire, landslides, tsunamis, volcanic activity, storm surges, floods, seismic activity)
Local coverage of the company of firefighters (Hás	Fire companies with respect to the provincial surface
Population per aérodrome	Provincial population with respect to the number of aerodromes

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Defining marginality in the periurban areas of Quito: A descriptive approach based on empirical and spatial data

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Abstract. In Latin America, marginality is a complex phenomenon involving various geographically significant factors, including the critical, physical, social, and human aspects. Bouldering areas of cities are often excluded from infrastructural interventions and social policies. In the case of Andean countries such as Ecuador, marginality affects not only rural lands but also in-transition areas between different geographical regions, as in the case of mountainous and coastal zones. These regions are characterized by a wide range of natural resources and climate conditions, and because of their diversity and relative proximity to the major cities, they offer potential for sustainable development. Nonetheless, the lack of infrastructure affects the accessibility of these periurban areas and critically limits their interaction. Drawing on these elements, the paper seeks to investigate whether periurban areas can be considered marginal and what tools can depict an encompassing image of local marginality, stressing its advantages for the local community. Following this idea, the paper focuses on the case of Lloa, a large rural parish in the Metropolitan District of Quito (DMQ), to determine which criteria can better capture its marginality, considering it as a periurban in-transition area. The paper suggests a cross-discipline methodology to push the limits of the field through the review of a significant body of literature and a thorough qualitative and quantitative analysis of the case study. Finally, the paper emphasizes the inadequacy of the current forms of planning to effectively define the marginality of periurban areas as a whole in the region by reflecting on the case study and through an analysis of the existing land use plans.

Key words: marginality, Metropolitan District of Quito, landscape, periurban

1 Marginality: Not a simple issue in Quito

1.1 The multidimensional urban problems in Quito

The dynamics of migration among countries, as well as between rural areas and cities, are particularly pronounced in Latin America. For instance, Ecuador experienced significant internal migration movements in the last decades and took in a sizable population from

Venezuela, which was experiencing a political and socioeconomic crisis at the time (Malo 2021). This circumstance is influencing how the city will look, which has undergone rapid and contested urban growth in recent decades (Carrión, Erazo Espinosa 2012). According to numerous studies (Carrión, Erazo Espinosa 2012, Cruz Cabrera et al. 2016, Durán Saavedra et al. 2016, Martí-Costa et al. 2016), the growth of the city led to the emergence of a sizable number of marginal sectors that frequently developed through invasion processes and impromptu constructions. The Moncayo administration, in force from 2000 to 2009, attempted to implement a series of reactive and extraordinary actions to deal with the problem. The city authority put into effect an urban plan designed to regulate these informal settlements. However, Quito still has a lot of inequality because of numerous ongoing, historic urban issues and current sociospatial challenges.

There are numerous ways to comprehend urban inequality in Quito. The city, for instance, includes dangerous clusters whose vulnerability leads to social isolation and natural hazards, among other issues (Bracchi et al. 2020, Durán Saavedra et al. 2016, Martí-Costa et al. 2016, Torrijo et al. 2020). These clusters are made up of periurban villages that are currently socioeconomically underdeveloped and lack access to goods and services. Lloa, a periurban parish in Quito, seems to fit the aforementioned description. Indeed, it has exceptional natural resources and a distinctive landscape, which includes different ecosystems in a few kilometers of extension; it is also very close to a crowded and dense portion of the city. However, despite being located in a very touristy area due to the presence of the Pichincha Volcano, it is a critically undeveloped parish with a severe shortage of infrastructure and transportation. The mild regulatory framework governing the development of periurban areas exacerbates this dual nature and reinforces the marginality of this sector.

1.2 The current theoretical scenarios in the region

Vulnerability and occasionally poverty are common characteristics of Latin American cities. As evidenced by the literature (Hardoy, Pandiella 2009, Tavares, Betti 2021), this circumstance could lead to a complicated dynamic of marginality (Hardoy, Pandiella 2009, Tavares, Betti 2021).

The researchers contend that, despite a debate on spatial and economic focuses (Sabatini 1981), this concept has multiple starting points (Alonso 2019), including poverty and spatial (Nun 1999, 2010, Quijano 1972), socioeconomic, political, and cultural factors (Gutiérrez, Sáez 2018, Oliven, Salazar 1981), as well as environmental ones (Perlman 2019). In Latin America, marginality frequently carries a negative connotation for contested areas or territories, which instead struggle to highlight the positive aspects of their settings and cultures (Horn et al. 2021). However, a recent work published by Horn et al. (2021) describes a multidimensional and multi-scalar scenario of disputed territories in Latin America. In essence, the culture-based co-production of territories offers an antithetical idea of habitat to the hegemonic culture of the neoliberal urban development model. It redefines the parameters of equity, marginality, and (under)development. This approach from Horn et al. may encourage other domains of spatial analysis and valuation to consider marginality as a multidimensional concept and complicated issue (Horn et al. 2021). Therefore, the paper explores the scenario of marginality in Quito since it validates several variables from the literature while also introducing new spatial elements stemming from the local landscape value. As a result, this work employed the landscape units idea, as defined by geographer Emma Pérez-Chacón Espino as "a conceptual and methodological tool that has its origin in the intersection of two different disciplinary requirements: one that derives from the consideration of the landscape as a complex territorial system, and therefore linked to the need to establish a scientific reading of the territory; and another that arises from the requirement to respond to the operational challenges of territorial planning, since, at least in appearance, the natural environment is no longer considered exclusively as a mere support for economic activities" (Pérez-Chacón Espino 2005, p. 124). Moreover, Anne Winston Spirn argues that "successful resolution to urban problems must integrate all these dimensions: social, economic, environmental, and aesthetic. Given limited resources, cities can no longer afford to address these issues separately. [...] We must seek common solutions to social, economic, cul-

tural, and environmental problems" (Spirn 1994, p. 165-166). Thus, this paper aims to analyse a specific case study utilizing a multidimensional method that involves the physical component as well as the socioeconomic and demographic elements. Likewise, the Autonomous Community of Catalonia in Spain produced a first prototype of a landscape catalogue in 2006 (Generalitat de Catalunya 2006, Nogué i Font et al. 2016, Sala i Martí 2010), focusing on the definition of landscape atlases based on previous international experiences. Furthermore, this tool requires the authorities in charge of approving partial territorial plans to incorporate the catalogue's indications. Moreover, since this approach is simple enough to apply in a variety of situations, this strategy has been employed throughout Europe and, more recently, Latin America, where governments have begun to take important landscape qualities and aspects into account in urban planning.

1.3 The landscape-based approach

Marginality in Quito could be described through a landscape-based approach, that considers the value of the context as a sum of processes "both natural and cultural: the patterns they produce are juxtaposed, interwoven and overlain" (Spirn 1994, p. 17). Its physical geography confirms relationships of influence between the natural and artificial elements, as well as links to urbanisation and the socioeconomic process of inequality (Carrión, Erazo Espinosa 2012, Martí-Costa et al. 2016). Given the case study, it is worth mentioning that in ecology, the ecotone – the boundary between two different ecosystems – is considered a transition area where two communities collide and integrate (Solomon et al. 2010), as well as a location with high biodiversity and richness. This idea reveals a perspective on marginality that is more positive and at odds with socioeconomic thinking. Urban policies and socioeconomic concerns are largely ignored in this ecological concept, which focuses primarily on the natural environment. However, its contribution is crucial to comprehending what marginality currently means in Latin America. Therefore, the landscape approach encourages a balanced study of this complex system, as it offers specific methods, such as landscape units, that combine natural elements with anthropogenic and planning issues, thus indirectly taking sociological criteria into consideration. Landscape means a complex whole, a spatial, temporal, and ethical reality at the same time (Venturi 2004). The European Landscape Convention defines landscape as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (Council of Europe 2004, p. 2). This definition has also been adopted by the Latin American Landscape Initiative (LALI), which is currently in charge of promoting the appreciation, management, protection, and sustainable planning of the Latin American landscape. Due to its complexity, the landscape is made up of numerous dimensions, including material, perceptual, and symbolic ones. These dimensions interact with one another to define the characteristics of a particular landscape.

1.4 The focus of the paper

The case of Lloa discloses potential strengths in marginal locations, owing to its border position, underpopulated urban tissue, and non-highly growing demography. These planning issues enhance the relevance of landscape units as they reveal the intrinsic values of the marginal landscape, make an assessment of its current condition, and develop a set of landscape quality criteria and actions to support it. As a result, the perception of marginality raises the question of how to characterize local conditions and provide a framework for researching marginality as a multidimensional urban state. The research hypothesizes that, despite the negative values given by literature, marginality might be understood and conceived as a beneficial circumstance when landscape values insist on studied places.

2 Marginality: What does Latin America have to say?

2.1 Introduction

In Latin America, the concept of marginality is an important academic topic (Perlman 2019). Many scholars from various disciplines have emphasized the term's relationship with the urban context for decades (Doré 2008, Jaume 1989, Quijano 1972, Sabatini 1981), as this concept involves several cultural, political, and economic elements (Oliven, Salazar 1981) as well as spatial meanings (Gutiérrez, Sáez 2018, Perlman 2019). The theoretical framework of this study was developed on the basis of Latin American literature in order to have a thorough understanding of local knowledge and culture (de Sousa Santos 2015).

2.2 The Latin American theories of marginality

A vast body of researchers (Alonso 2019, Doré 2008, Jaume 1989, Nun 1971, Quijano 1972, Sabatini 1981) investigate the evolution of the topic based on the urban dynamics of this region. These elements are quite distinct yet complementary to one another, and they have a direct impact on the growth of a city.

Nun (1971) and Quijano (1972), for instance, addressed the connection between marginality and the issue of poverty and inequality in a city. Quijano described marginality as a socioeconomic phenomenon, highlighting the role of the neoliberal system in the establishment of two polar opposites, the "hegemonic nucleus" and the "marginal pole". He refers to individuals or small groups who are excluded from the main system as well as from the economic and productive fringe of society because the neoliberal system in Latin America excludes a society with limited economic resources and a low level of education. Another approach to marginality is to measure access to commodities and services, which, in the case of centralised governance, limits the empowerment of peri-urban people and does not provide alternatives to the marginalized condition (Quijano 1972). Quijano (1972) and Nun (1971, 1999, 2010) construct the centre-periphery dualism based on a cluster's location within or outside the city, implying that individuals located further away from the city are more vulnerable to marginalization. Instead, some academics go on to Sabatini's (1981) concept, which has recently been supported by Perlman (2019) and others, that defines the marginal population as part of the city's economic system. Moreover, Sabatini argues that "there does not seem to be a situation of absolute and global exclusion or social marginality, as posited by the theories of marginality. What there is, is a dialectic between rejection and integration" (Sabatini 1981, p. 65). For that, the evolution from a socioeconomic, political and cultural marginality (Oliven, Salazar 1981) to a more enhanced concept of marginal environment (Gutiérrez, Sáez 2018, Perlman 2019, Sabatini 1981) overcomes the "ecologist" limit, establishing a non-linear relationship between economically marginal areas and deteriorated urban sectors (Sabatini 1981). Sabatini's suggestion to include the concept of context in the debate of marginality marks a significant shift in the Latin American theoretical framework. Although the key focus of his speech is habitat or housing, he expresses a fundamental idea: the marginal environment is defined by a lack of goods and services, a lack of neighbourhood facilities and network services, and little or no access to urban employment and service centres, all of which describe the urban context of the area.

Perlman ratified in 2019 the concept of context, stressing how marginality in Latin America is deeply linked to urban poverty as well as to an unfavourable environment described by three aspects: insecurity in the occupation of the territory, the quality of the construction, and therefore its instability, which can disappear suddenly; the third element of precariousness is the mobility of the population, which reflects the first intuition of marginality as an effect of migration (Park 1928). The precariousness that Perlmann describes then configures a panorama of fast sociospatial evolutionary cycles.

2.3 Marginality as multidimensional topic

Several studies describe the overlap of different kinds of risks and hazards, from climate change (Romero Lankao, Qin 2011) to poverty and exclusion (Hardoy, Pandiella 2009), and the impact of the COVID-19 pandemic on this fragile situation (Kesar et al. 2021, Tavares, Betti 2021) in the Andean cities. Hence, it is not possible to define marginality as a purely socioeconomic and policy issue, as some studies show how the study of marginality has generated other crucial themes, such as social exclusion (Enriquez 2007), informality (Doré 2008), peripheries and precariousness, poorness, contested territories (Chu et al. 2016, Horn et al. 2021), and urban vulnerability (Alguacil Gómez et al. 2014, Rebotier 2012). The contested territories in Latin America reflect a patchwork of conflicts (Clare et al. 2018, Horn et al. 2021, Perlman 2019, Sisson 2021) and point to a more comprehensive understanding of marginality in this area.

Multidisciplinary approaches spanning both regional and local scales can better address an encompassing definition of marginality (Alguacil Gómez et al. 2014, Hardoy, Pandiella 2009, Romero Lankao, Qin 2011). They describe the complexity of marginality through a multidimensional framework that brings up a theoretical point of view that highlights numerous variables, including the socioeconomic topic, public policy, and housing. The socioeconomic perspectives and spatial elements of the landscape (as an "environmental" macro-system) will be scrutinized in the case study to support or contradict the theoretical question.

3 Quito: A metropolitan district with a huge and multifaceted marginality

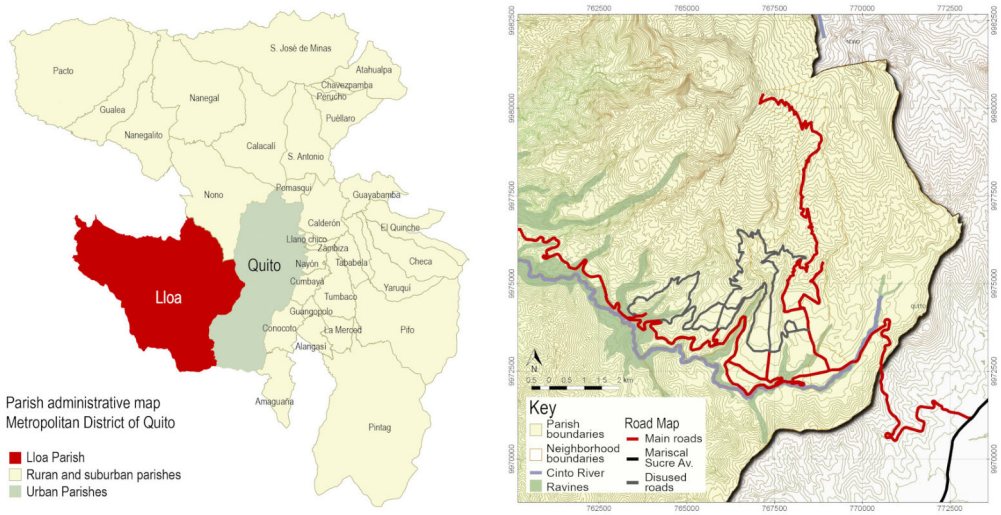
3.1 An overview

Ecuador is a very biodiverse country with 24 provinces that consist of four different climatic zones. Three of them, Sierra, Costa, Amazonía, describe the continental territory, while the fourth one is about the Galapagos archipelago. Nevertheless, due to the volcanic origin of current landscapes and geography, many in-between territories are not specifically defined, and for urban planners, they are perceived as marginal. In other words, these regions' understanding is extremely underdeveloped, likely as a result of their slow urbanisation and consequently low speculative interest. Furthermore, the definition and regulation of marginal areas are plagued by a number of serious problems, as shown by the current regulatory framework. The Metropolitan District of Quito (DMQ) is made up of 33 rural and 32 urban parishes, along with sizable in-transition areas; thus, its situation reinforces the critical issue. This highlights how important it is to comprehend marginality from a variety of perspectives, including those related to geography, planning, and policy, among others.

3.2 The case of Lloa

A very explanatory example of diversity is the rural parish of Lloa in the Metropolitan District of Quito (DMQ) (Figure 1). Lloa is the largest rural parish in the DMQ, and it occupies an altitude range from 1.800 to 4.786 m.s.n.m. (GADP de Lloa 2019) with a diversity of landscapes and ecosystems. In fact, it has a wide variety of natural resources (Figures 3 and 7), climate futures (Figure 7, Table 1), and therefore landscape units that represent economic and tourism potentialities that are not exploited since the existing infrastructure allows limited access to the sites of interest. It covers 545 km^2 and makes up 20% of DMQ. Lloa combines geography, biodiversity, and population to create a tourist destination where they can choose from a variety of activities, from sports and recreation to those more in-line with their surrounding natural and gastronomic environment. As a result, Lloa has enormous potential for natural and tourist attractions that could modernize the idea of marginality.

The parish can only be accessed via two routes, both of which are vulnerable to landslides and weather hazards (Figures 1, 2, and 7), while inter-parish transport is scarce and limited. Moreover, only private vehicles are able to reach the internal areas. Because of these circumstances, many of the nearby natural attractions are probably unknown to both tourists and Quito residents.



Source: Google Earth and OpenStreetMap
Notes: Elaborated by N. Rodríguez

Figure 1: Lloa in the Quito Metropolitan District. Source: Lloa Development Plan and Land Use Planning (GADP de Lloa 2019); main and abandoned roads

The lack of public transportation in human settlements like farms, villages, and other productive and tourist destinations forces people to organize their transportation through an ad hoc network without the benefit of any formal agreements. There are only three carriageways that pass through the parish. The Virgen del Cinto monastery, a recognized religious landmark, is located along the two routes that connect Chillogallo and Magdalena, two neighborhoods in Quito's south. The connection with Chillogallo is considered a first-order street, while the connection with Magdalena is a second-order street. Because both streets are not directly connected to the main Quito street network, access to Lloa is made more difficult. A third-order street runs through Chiriboga village and connects Lloa to Santo Domingo de los Tsachilas province. Hence, Lloa could be classified as a parish with poor connectivity, mobility, and accessibility because the quality of the three infrastructures in terms of dimension, maintenance, and use is subpar.

As in the recent story of Quito (Carrión, Erazo Espinosa 2012), the periurban location should imply a rural area in transition to an urban tissue; however, despite its proximity to the city, Lloa is rural in both landscape identity and social aspects. In fact, it is economically and socially excluded from mainstream processes. Moreover, by ignoring their sociospatial complexity, urban policies and planning strategies exacerbate this widening divide. According to the Development Plan and Land Use Planning (PDOT) of Lloa (GADP de Lloa 2019), the area under study is delimited in the north by the parish of Nono and the canton of San Miguel de los Bancos; in the south by the canton of Meja; in the east by the DMQ and in the west by the cantons of San Miguel de los Bancos and San José de Minas (Province of Santo Domingo de los Tsáchilas). Its territory has a clear vocation as an urban green nucleus, i.e., a "space with a high degree of naturalness and a good state of conservation adjacent to the city" (CEA 2014, p. 17). Similarly, in the land use of Lloa (Figure 3), according to the PDOT, the ecological protection zones correspond to 42.7% of the total area, while the natural resource areas correspond to 52.4% of the total area (GADP de Lloa 2019). Further, its boundaries even touch the province of Santo Domingo, a district between Sierra and Costa, that is located at an altitude of only 500 meters above sea level (Figure 7), which emphasizes the geographical and landscape variety of the area. The northeastern part of the parish, which has the most varied landscape, is where urbanised areas are located, accounting for less than 1% of the total area, according to the Agriculture and Livestock Ministry (MAG). The urban consolidated tissue of DMQ is also closest to this area of Lloa. Therefore, Lloa

Source: PDOT of Lloa (GADP de Lloa 2019)

Figure 2: Main road network

could be referred to as an "in-transition" parish, which describes the shifting from one region's landscape and culture to another.

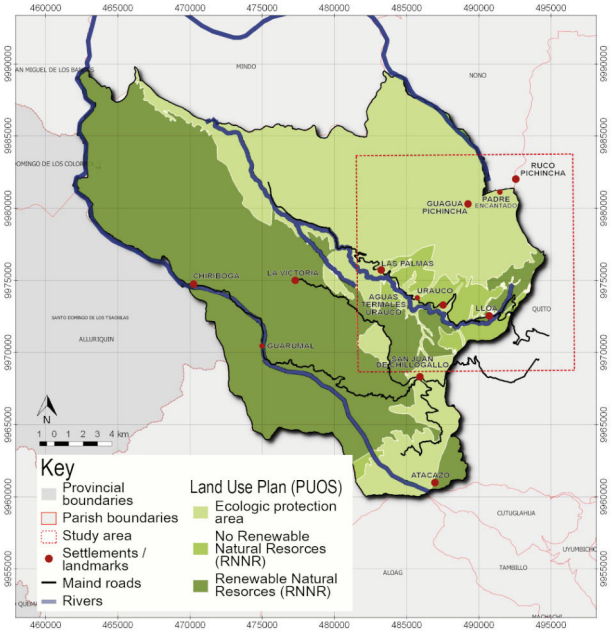
Lack of goods and services in Lloa is another way to describe the condition of marginality. For instance, only 36% of urbanised areas have access to potable water, despite being one of the district's primary water suppliers (GADP de Lloa 2019). The rest of the populace risks their health by using water from ditches or rivers. Only 34% of the parish, mostly in the centre, has sewage infrastructure, which creates another health risk because most waste is dumped into septic tanks or, in the worst-case scenario, directly into ditches or streams. The garbage collection service has 40% coverage, so there should be critical issues with dumping and contamination. Contrarily, the parish is rated as having a moderate level of public lighting (70%) and electricity (77%); however, this could indicate that the dispersed neighbourhoods are underserved (GADP de Lloa 2019).

The entrance to Lloa from Quito is marked by the Metropolitan Park "Chilibulo-Huayrapungo", a popular destination for recreation among Quito residents. Nevertheless, a few courtyards and neighbourhood parks reveal a critical issue about public space in the urbanised areas of Lloa. The parish also has a low level of connectivity: only the parish head and the surrounding neighbourhoods are moderately served and connected to the city, and the roads get worse the further the passenger travels from the city. The only paved infrastructure is the Lloa-Palmira collector, despite its imperfect state. The other two collectors that lead to the Chiriboga and La Victoria sectors have a longer earthen roadbed. This critical circumstance is increased by the annual rainfall values that range between 835.10 mm and 1500 mm and an estimated annual average of 177 rainy days (GADP de Lloa 2019), as well as temperature that can reach 0°C. Therefore, the sector is highly affected by the risks of landslides, with severe consequences for accessibility. Further, volcanic threats (very common throughout the country) significantly increase the latter problem in the event of an evacuation.

4 Methodology: Discovering landscape values in marginalized areas

4.1 General framework

This research has an empirical approach with a narrative focus; it does not provide a general definition of marginality but instead makes an effort to weave a multidisciplinary



Source: Land use and occupation plan (2015)
Notes: elaborated by Nadia Rodriguez

Figure 3: Land use map

statement around a specific local notion of marginality. This empirical dialogue between disciplines contributes to enhancing the range of parameters on marginality and further leads to a new definition of the topic and a cutting-edge local planning approach. The authors offer a three-stage analysis to accomplish this. First, this work presents an archival and desktop critical analysis and focuses on Latin American scientific publications since the local academic interpretation of the topic shapes a specific concept of regional marginality.

4.2 Sociospatial methods and tools

This first step is accomplished by conducting a thorough review of the literature on Latin American theories of marginality and contrasting it with observations of the actual situation on the ground, which results in the paper's opening insight and the Latin American academic definition of marginality. The second step is to dive into a specific case study and use descriptive spatial analysis to show how marginality is defined there and what the potentialities of the location are. This step is developed through two analytical tasks: the first one focuses on an official statistical survey delivered by the National Institute of Statistics and Census (INEC 2010), and the second one is based on proving that statistics are supported by citizens. To gather first-hand qualitative data from residents or local stakeholders, a specific ad hoc questionnaire was distributed to the community. The fieldwork analysis also includes 50 interviews conducted over the course of one fieldwork week with local residents. The questionnaire is divided into four sections, the first of which aims to confirm and verify the statistical information gathered by INEC. The next set of items pertains to the working and educational environments, and the third phase is concerned with determining whether a person is a permanent or transient resident, as well as with local businesses and income levels. The final inquiries centre on the assessment of tourist potential and the degree of commitment of the locals. For instance, a series of inquiries have been made to determine which local opportunities could be developed and which priorities have been identified. In order to achieve this, questions are inserted to help measure the ranking of landscape and tourist resources as perceived by each interviewee.

The paper proposes (third step) the use of the landscape approach (Pérez-Chacón Espino 2005) as a tool to review the actual, local situation matched with the socioeconomic findings of the area in order to fully comprehend the values of the space and its conceptual implications. Using ArcGIS software, the final task entails conducting a geographical analysis with the goal of identifying marginal landscape features in the given area. In this instance, the categorization and evaluation of Lloa's landscape have been defined using the methodology outlined in the Catalan landscape catalogues (Nogué i Font et al. 2016).

According to Nogué i Font et al. (2016), the catalogues were designed as a tool to support the implementation of landscape policies in territorial and urban planning, and especially as an instrument to protect, manage, and order the landscape in Catalonia. The catalogues are based on the concept of landscape as a complex and integrated reality of natural, artificial, and cultural aspects. They assume the definition of the Council of Europe Landscape Convention, according to which "landscape" means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors (Council of Europe 2004). Four phases have been defined for the definition of the landscape catalogues: (i) identification and characterization of the landscape; (ii) landscape assessment; (iii) definition of landscape quality objectives; and (iv) establishment of proposals for criteria and actions. The definition of landscape units is part of the first phase and is aimed at identifying the distinctive features of a portion of territory, that is, recognizing those natural elements, cultural (tangible and intangible), and visual elements that distinguish a given landscape from another (Nogué i Font et al. 2016). The variables used to define landscape units must take into account the territory's dynamics, historical context, points of view, perceptions, and land use rather than just the physical and structuring aspects of the area. The definition of landscape units in the Lloa territory has taken each of these variables into account.

The process carried out in this study does not define an integrated system of criteria and actions; rather, it aims to show that Lloa's negative condition of marginality due to its socioeconomic shortcomings could be "balanced" by the high value landscape that the study shows. Clearly, this could be ascertained or specified at the moment in which the value of the landscape begins to be considered a necessary variable in territorial and urban planning. The landscape study has been applied by identifying general geographical features of Lloa and, based on them, employing two analytical criteria: biophysical and anthropogenic. The former involves the analysis of elements that visually highlight two natural components of the landscape: the biotic, which means flora and fauna, and the abiotic, which describes non-living elements such as climate aspects, hydric resources, and geologic data. The produced maps were created using shapefiles from the Quito municipality's open data (datos abiertos de Quito) and INEC shapefiles, which are accessible from a public website. In order to wrap up the analysis, a visual-basin plug-in has been used to map the visual values of particular landscape clusters in the area under study. The three phases offer a fresh perspective on the concept of marginality in Latin America and present a novel paradigm of it in Quito.

5 Social approach: Are people from Lloa marginalized?

5.1 Desktop analysis

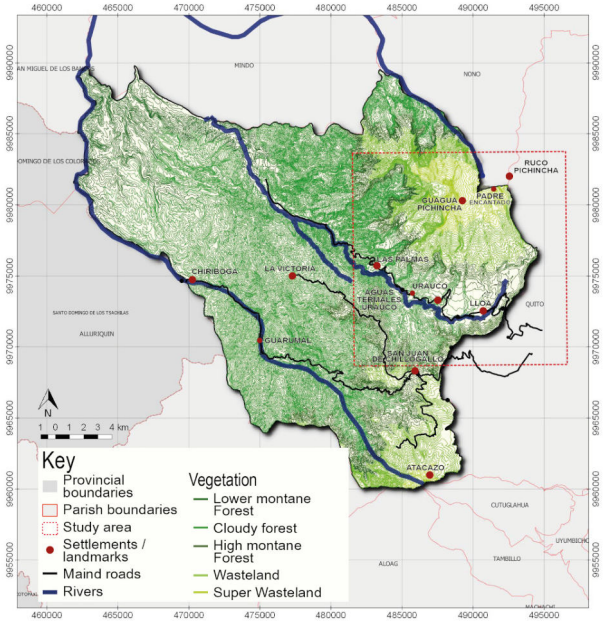
An archival analysis of the socioeconomic situation in Lloa brings the following results. The parish consists of a low-income community with huge precariousness. For instance, official data from INEC (2010) show that 80% of people belong to the population of working age (PET), so this has decreased since 2001 (82%), confirming that the young population is leaving the parish. Indeed, although there is a population growth rate of 0.5%, 58% of the inhabitants are adults (19 to 64 years old), and the age group between 35 and 64 years old is the majority, which indicates that young people are leaving Lloa. Regarding the presence of local economic activities, the economically active population (PEA) compared to the economically inactive population (PEI), denotes a 7% growth of the PEA and a decrease in the PEI, which shows that, despite the conditions, the villagers take advantage mainly in the primary sector, as 52% of the inhabitants are

dedicated to activities such as agriculture, livestock, forestry, and fishing, compared to 11% of industries and 37% of services (GADP de Lloa 2019). Therefore, in Lloa, the average family is supported by jobs in the primary sector. However, due to the health and economic crisis in Ecuador stemming from COVID-19, the census scheduled for 2020 will be published in 2023. Hence, because of this census and the resulting lack of real-time information, empirical field work has been done through conducting interviews with local villagers who voluntarily agreed to be part of the research.

5.2 Interview analysis

Gender equality is confirmed, with 54% of respondents being men and 46% being women, according to the 50 interviews conducted in Lloa. Additionally, the predominant age group continues to be between 35 and 64 years old, which supports the issue of young people migrating. Further, 66% are employed in agricultural activities, 24% in the commercial sector, and barely 10% in the construction industry. Data on the types of work that parishioners do were gathered in order to better understand their way of life: 70% of those polled admitted to having a part-time, independent job related to farming, such as cultivating or selling crops in Quito or at the parish head's weekend fair. Furthermore, a significant portion of people sell their own goods; 60% of those surveyed are business owners, with 83% of them based in Lloa and 17% outside the parish. There is a direct correlation between these variables and the level of income per household, with an income per household ranging from one (50%) to two (30%) basic wages. As a result, most of them are uninsured (63%), i.e., they are not affiliated with the Ecuadorian Institute of Social Security (IESS). Furthermore, the type of work people do affects whether they live in Lloa frequently or permanently, with 27% of people visiting the parish only for work and 50% making it their primary residence. It was also found that most of the people (63%) have lived for more than five years in the current residence (private accommodation), and 58% of the polled form households with more than five people.

Natural elements (40%) and gastronomic offerings (21%) are thought to be the most significant aspects of Lloa's potential and priorities. Recreational activities (horseback riding, trekking, fishing, and mountain biking) follow with 18%, rural travel routes with 13%, and finally cultural and religious issues with 8%. A question was also raised about the parish of Lloa's potential as a tourist and landscape destination. People categorically state that the area has potential for tourism, which demonstrates that Lloa also has a high level of resident relevance and appropriation. Furthermore, 13% of those polled gave priority to the creation of new jobs (13%) or businesses (16%), which has raised concerns about the industry's unstable employment conditions. On the other hand, only 10% stated public spaces as their primary need. However, the request to improve other services, like public transportation and travel agencies, received the most pertinent response (21%). This reflects the subordination of business and tourism issues to Quito. The earlier responses support the interest in landscape potential. A question has therefore been posed about community-based tourism, and 33% of users claim to know what it entails while 62% are unaware of it. To ensure that everyone understood the idea completely, it was explained to them all, and 90% of respondents said they would be willing to participate in or benefit from such a project. This corroborates earlier assertions about the importance of the landscape and supports the notion of community-based landscape development. This information, along with statistical data, demonstrates that Lloa is regarded as a location with significant natural resources and tourist attractions that are connected to the major urban centres. The people who live there are aware of this potential and eager to use it. However, they believe that receiving technical support is essential to gaining empowerment and creating a long-term strategy that enables them to achieve their goals.



Source: DMQ open data 2016
Notes: Elaborated by Nadia Rodriguez

Figure 4: Plant cover

6 A spatial analysis: Is marginality a negative concept in the local context?

6.1 The basic spatial information

The parish of Lloa has been studied as a territorial area of interest from a spatial perspective, with the goal of describing the landscape. The spatial analysis started collecting the basic spatial information of Lloa. The open-access repositories return relevant parish information. First, spatial data on land use, natural resources (plant cover), hydrographic maps, and relief maps were obtained. Furthermore, the road map and Lloa's urban settlement are geo-referenced. The data were then processed using ArcGIS to produce relevant information such as territorial profiles, landscape units, and a visual basin map. Moreover, the basic spatial information was used to develop the Landscape Value Evaluation Matrix, an empirical tool that complements the Landscape Unit catalogue.

6.2 Landscape Units of Lloa

After the spatial analysis of Lloa, the study focused on detecting the specific features of the case study in order to delineate different landscape units. Nogué i Font's methodology was used to conduct the landscape analysis, with a particular emphasis on the biophysical and anthropogenic criteria. This study supports the existence of five ecosystems that are influenced by altitude, flora, and fauna (Table 1, Figure 4). This variety of ecosystems results from the parish's varying slope, which leads from a dry climate typical of the mountains to a humid climate typical of the coastal zone. The water system, which shapes the Blanco River sub-basin (a portion of the Esmeralda River basin), is yet another abiotic component. According to the Lloa PDOT, the Mindo River, Cinto River, and Soloya River are the three major rivers that join to form the Blanco River. These rivers receive water from other rivers as well as from several ravines that are created by the Guagua Pichincha's slope. The PDOT acknowledges a total of 22 micro-watersheds (Figure 5).

According to Nogué i Font et al. (2016), anthropogenic criteria are used to describe the presence of humans in a given area of the landscape and include factors like population, land use, dynamics, history, and aesthetics. Urban settlements in Lloa have no relevant

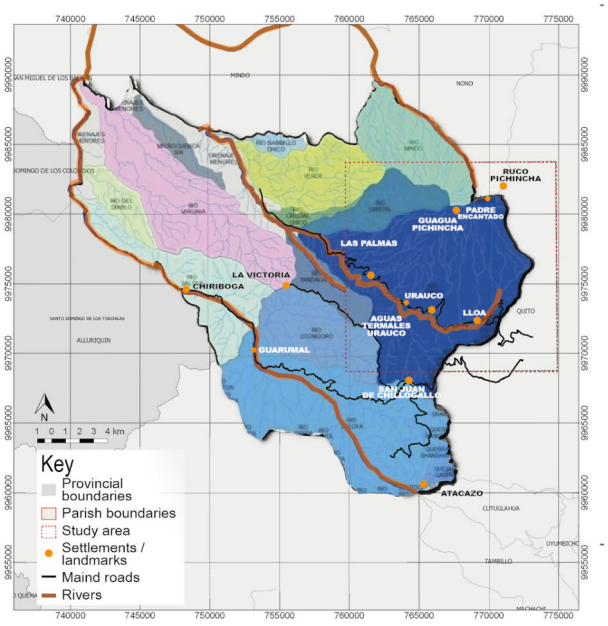
Table 1: Ecosystems of Lloa

	Lower Montane Forest	**Cloudy forest**	**High Montane Forest**	**Wasteland** (Páramo)	**Super wasteland** (Superpáramo)
Altitude (m.a.s.l.)	1240-1800	1800-3100	3100-3400	3400-4100	4100-4760
Tree characteristic	Treetops from 20 to 25 m, evergreen forest	Tree tops from 20 to 25 m, abundant moss/ low to medium dense forests	Tree tops from 15 to 20 m, sloping stems and abundant moss on the floor	Herbs in tuft and small shrubs	Low-cover rocky soil of very resistant plants
Vegetation	Mosses, ferns, orchids, bromeliads and heliconias	Mosses, ferns, orchids, bromeliads	Mosses and epiphytes	Grassland	Disappearance and gradual replacement at height
Species	Ceibo, guarumo, Zapote and Platanillo	Anthurium of Mindo,, Brunellia acostae and Piper sodiri	Reziera verrucous, Freziera canescens and Croton elegan	Chuquiragua, valerian, Grassland, Aloadilla and Saracha	Cushions, Rosetas acaulescentes, Short-stemmed shrubs and Grasses
Fauna	Dung beetles, eagles, lizards, tangaras, humming-birds, South American chameleon, dwarf iguana	Spectacled bear, whitelisted bats, High Andean mice, land frogs and carnival beetle	Nectarivorous bats, lizards, beetles and prickle	GaviláVariable, the Marsupial Frog of San Lucas and the Moorish Wolf	Condor, curiquingue, bandurria, spectacled bear, moor wolf, rabbit
Aquatic fauna	Macroinverte-brates - Astroblepus ubidiai	Macroinverte-brates - Astroblepus ubidiai	High diversity macroinverte-brates - Trout	Insects and Trout	
Notes	Maximum dry season: one month	Perfect habitat for bamboos	Transitional vegetation / Threat: excessive extraction of wood	Threat: Grassland and crop burning	Threat: Grassland burning

Notes: Elaborated by N. Rodriguez

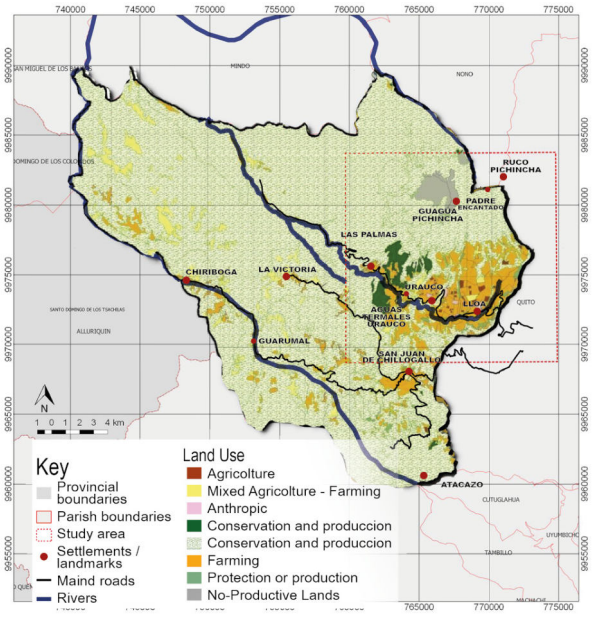
surface area (1%). However, land use shows a significant surface of ecological protection (43%), 52% is destined to renewable natural resources (RNR), and the remaining 5% is interested in non-renewable natural resources (mining), populated settlements, and dispersed agricultural residences (Figure 6). Furthermore, the majority of activities take place in the proximity of the human settlements that border Quito, while the area to the southwest is primarily protected, despite some changes to the forests brought on by agricultural activity.

The historical aspect also imparts interesting information, beginning with the parish's name, which, according to linguist Jacinto Jijón y Caamao, means "high plateau" and originates from the area's original populations, the Cara and the Colorados (PDOT). The Inca also left their mark on Lloa; it is interesting to note that the Ruta del Sol, which is a part of the network of Inca roads leading to Peru, passes through the parish. This route is enriched by other routes from more recent times, such as the Ruta de las Haciendas from the colonial era and the Ruta del Pichincha, which ascends the top of the Guagua Pichincha, circles the volcano, and leads the town of Mindo. These trails, given the topography of the place (Figure 7), provide a number of exclusive observation points that



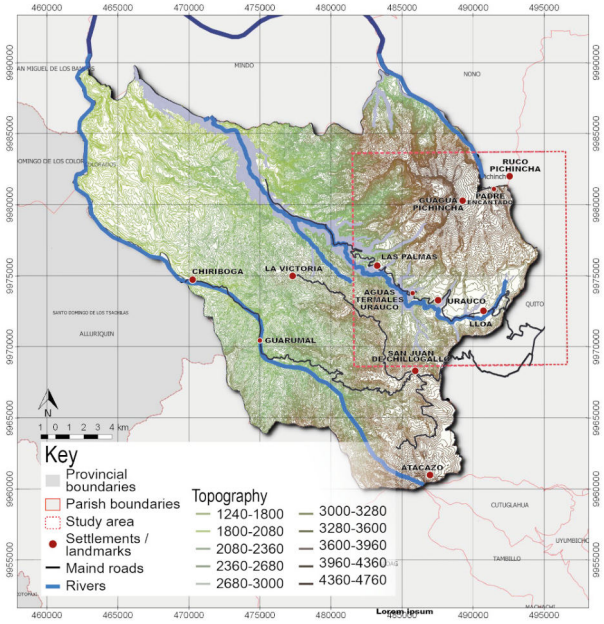
Source: PDOT of Lloa (GADP de Lloa 2019)

Figure 5: Hydrographic map



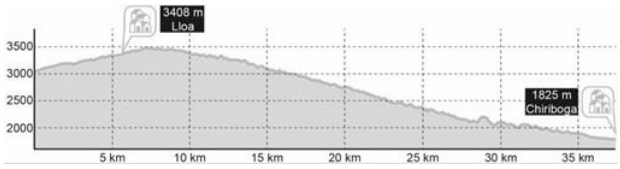
Source: PDOT of Lloa, Instituto Geográfico Militar – DMQ
Notes: Elaborated by Consultora Morales, 2015

Figure 6: Land Use



Source: DMQ open data 2016
Notes: Elaborated by Nadia Rodriguez

Figure 7: Reliefs maps



Source: GoogleEarth
Notes: Elaborated by N. Rodriguez

Figure 8: Street profile to Chiriboga W-E

are crucial to this study (Figures 8, 9, and 11). As the landscape catalogues of Catalonia indicate, "the determination of the most important observation points – by virtue of their visual scope or human frequentation – and the cartography of visual basins are essential requirements in the delimitation of landscape units, since they allow determining the extent to which each sector contributes to the perception of the landscape" (Nogué i Font et al. 2016, p. 52).

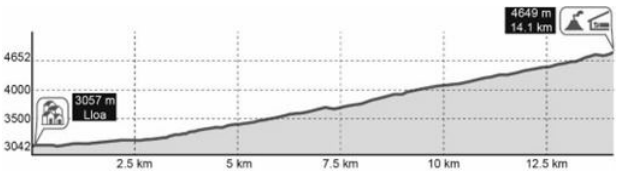
Previous elements have been processed to define landscape units; hence, the biophysical analysis data overlapped the anthropic ones. Therefore, the result stresses the importance of relief and geographical features in identifying a total of seven landscape units, described as follows:

Cordillera: it is characterized by the corresponding climate and vegetation to the moor, its vegetation is scarce and the soil rocky.

Ceja Andina: it is a strip that borders the moor and is the transition between the cloud forest and the mountain range, developing in the which corresponds to the high montane forest.

Transforming landscape: is the territory that corresponds to the areas with more inhabitants and whose land is used for crops, livestock, fishing, quarries. It presents a change from a natural landscape to an anthropic one.

Cloudy Forest: it occurs on the slopes and represents the largest portion of the parish



Source: GoogleEarth
Notes: Elaborated by N. Rodriguez

Figure 9: Street profile to Pichincha volcano S-N

Notes: Elaborated by N. Rodriguez

Figure 10: The Lloa landscape unit and the smaller area with the richest landscape

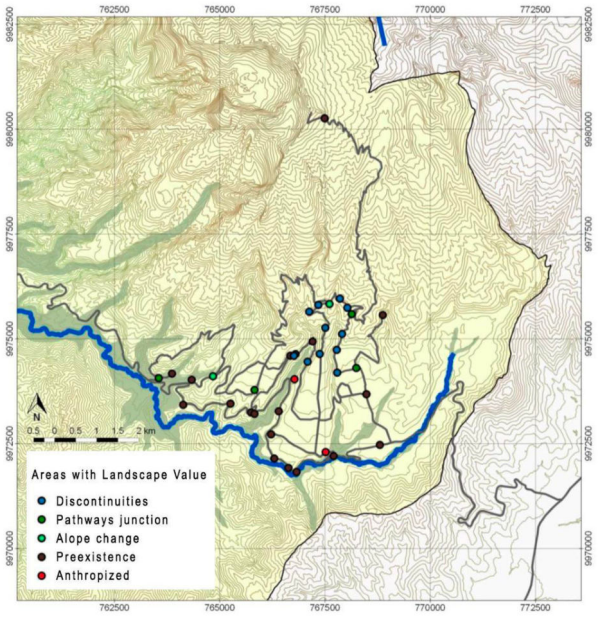
as it is the transition between the mountains and the coast, with the particularity of humidity and low clouds.

Low Montane Forest: it belongs to the sub-Andean highlands and develops under high rainfall and high humidity, causing what is known as "evergreen forests".

Rivera: it covers the extension of the two main rivers (Cinto and Saloya) and presents a strong risk of contamination of different types.

Ravines: given the topography of the parish, there are numerous ravines, but this unit describes especially the steepest one, the Río Cinto, which in fact is a limit to agricultural growth.

The analysis of the landscape units has followed several phases. The first concerns the collection of biophysical and anthropogenic information. To this end, land use analysis as well as a natural resources survey have been realized using ArcGIS software to process data and information from the open-data of Quito and Decentralized Autonomous Government databases. The macro criteria that are used in this phase are categorized as follows: urban topography, vegetation, hydrology, urban morphology, accessibility, and the dynamic of the area in relation to its historical dimensions and visual basins. The result is the landscape unit map (Figure 10), showing a smaller area really rich for the high number of different landscapes, one close to the other and nearby the urban consolidated tissue of Quito.



Notes: Elaborated by N. Rodriguez

Figure 11: Landscape Value Zone

A thorough analysis has been developed in order to learn more about the perceived value of the landscape and the visual advantages of this outlying area, building on the findings of the landscape unit definition. In order to achieve this, a focused analysis of the chosen quadrant was conducted (Figure 10). Two distinct surveys were conducted: one focused on the topography and tourist attractions (Figure 11), including ancestors', past paths, and modern paths; the other involved a topographical comparison with the surveyed locations. As landscape landmarks, it is possible to identify the Guagua Pichincha volcano peak, the Chuquiragua hill, the thermal waterfalls of Uruaco and Palmira, the waterfalls of San Juan and Chirinchos, among others, and the footpaths and cycling routes that interconnect all these natural landmarks. Along these paths, one can find interesting human endeavours that support tourism, such as the Santuario de Nuestra Señora del Cinto and a number of haciendas (farms), like Hacienda las Palmas and Hacienda Concepción Monjas, which, in addition to housing visitors, also serve to increase awareness of the area's biodiversity. In these locations, it is possible to carry out cultural activities involving learning about the local environment and traditional methods for farming, keeping animals, and fishing in trout alleyways. The Virgen del Cinto monastery, properly situated on the western edge of the Chilibulo Metropolitan Park of Quito, is another Lloa attraction. Devotees travel to the monastery as a pilgrimage destination; in particular, in September, when the Virgen del Cinto is honoured, groups of pilgrims travel by foot from Quito to the shrine.

Based on this, five types of landscape value zones are recognized:

Pre-Existence: places that have value because of tourist attractions, agricultural and built-up historical presences, and services

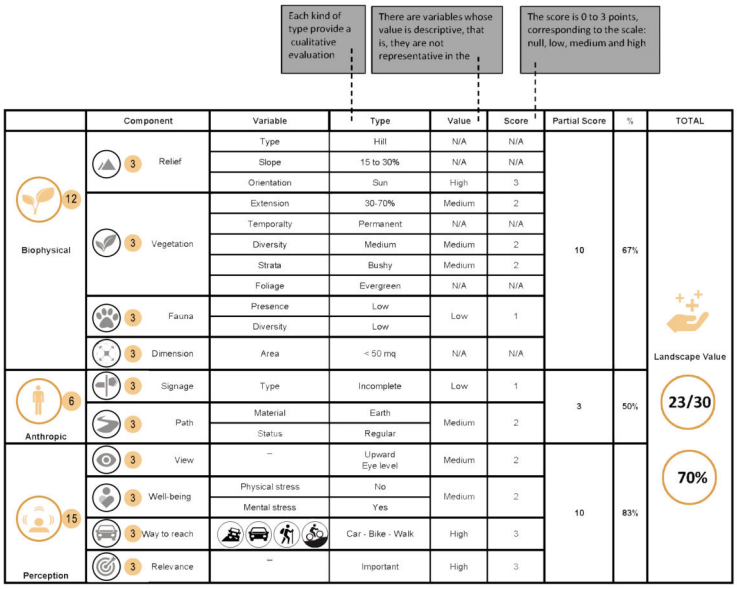
Anthropic landscape: places valuable because of the human presence

Discontinuity: open spaces along the paths with a high biophysical and perceptive component

Path cross: nodes between principal paths and route towards other attractions

Slope change: nodes between principal paths and underused trail with slope change. The trails are considered as possible potential for future activities

Table 2: Landscape Value Evaluation Matrix



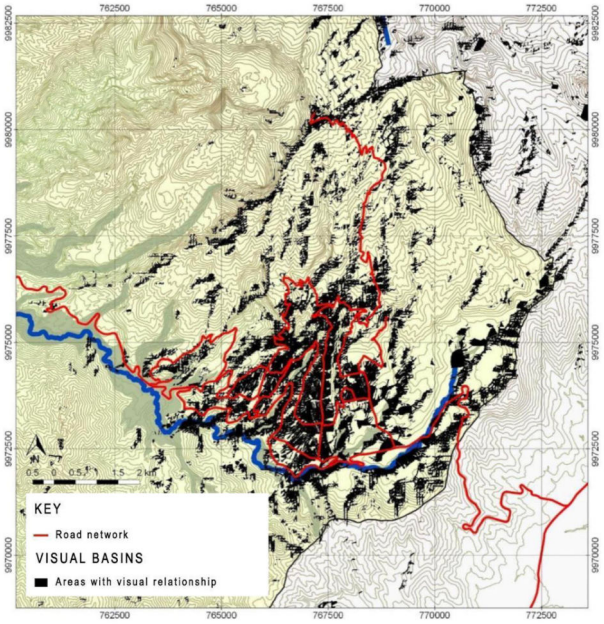
Notes: Elaborated by N. Rodriguez

An empirical analysis of the landscape value of these five categories has been conducted using a novel matrix in order to verify the data. A landscape assessment matrix is created using a survey and analysis of three attributes: biophysical, anthropological, and perceptual, which are further divided into other variables to be scored. The matrix is designed to assess the current state of the landscape, and each attribute is given a score between 0 and 3, representing a scale from "null", "low", "medium", and "high". According to this rating, the biophysical attribute is made up of four evaluable components and is worth 12 points; the anthropic attribute is made up of two components and is worth 6 points; and the perceptive attribute is made up of four components and is worth 12 points. The maximum score is 30, so this tool enables users to identify which features are weak and those that could be exploited (Table 2).

The topographical analysis shows that the relief has an important impact on the landscape value of the path system. A visual capability study of the path system was conducted in order to define the visual value of the various paths. This kind of study determines a system of visual basins that describe what is possible to see and how far it is possible to see from different selected points of interest.

For the purpose of defining the visual basins, the chosen points were processed with ArcGIS using the Visual Basins plug-in, which enables the surfaces to be in a direct visual relationship while excluding morphologically depressed areas. This step enables the identification of the most pertinent and potentially valuable points of view within the analysed area. The visual basin definition enhances perception of local differences (Figure 12).

Therefore, the concept of marginality could be complemented by the study of the landscape as a combination of spatial and empirical analysis using a multi-scalar and multidisciplinary approach. The focus area is regarded as marginal in relation to Quito based on socioeconomic studies, but thanks to the landscape approach, it reveals a high level of interest due to its divergent values and viewpoints. This is clear when examining the outcomes of the previous landscape value detail. Aspects from Quito and the Lloa protected ecosystems are gathered in this area. In terms of natural and human biodiversity, it can be compared to an ecotone using ecological parallelism.



Notes: Elaborated by N. Rodriguez

Figure 12: Visual basins

7 Concluding remarks

Marginality is a crucial topic in Latin America since this region is still embedded with multidimensional issues of vulnerability, inequality, poverty, and exclusion. According to Latin American theories, marginality is a problem caused by socioeconomic inequality, and in underprivileged areas, the chances for integral human development are severely constrained. Moreover, the impact of environmental risks, climate change, and – more recently – COVID threats calls for a novel approach that involves ecology suggestions and landscape tools in order to enhance the Latin American theory of marginality toward an integral framework of the problem. As the paper shows, there are several points of view for defining marginality, such as socioeconomic, spatial (landscape), and perceptive (citizen perception). These glances display aspects that provide a cutting-edge conceptualization of the topic: the citizen's perception confirms the socioeconomic situation, while the landscape approach gives a complementary position that opens up the possibility for potential future research.

Conceptually, marginality represents a complicated situation of socioterritorial conflict involving both outsiders and residents close to the area. Similar to the case study, such marginal areas might be small settlements a short distance from the city limits that act as a transitional area to rural lands. Furthermore, marginality is an expression of the local communities' overall underdevelopment, particularly in terms of socioeconomic issues, access to goods and services, and the precariousness of housing and the urban environment. When the landscape features are taken into account, however, marginality assumes a different meaning: in actuality, the marginal areas with high landscape values play a crucial role in articulating and governing the territory, offering the possibility for sustainable urban and tourist development.

The case study offered a number of important insights that can be divided into three main categories: (i) involving local communities in the concept's definition, (ii) setting up a testing ground, and (iii) assessing the viability of accepted theories of regeneration. Particularly, the precariousness of their urban environments and economies, as well as the scarcity of goods and services, worsen the ghettoization of Lloa's communities and the perception of marginality. For instance, the lack of adequate infrastructure severely limited communications with Quito, despite its proximity. The overall data

confirm that Lloa is a marginalized territory in both socioeconomic and infrastructural aspects; however, the interviewees showed pride and a sense of belonging, which could be a new positive aspect of marginality if related to landscape values. As a matter of fact, the awareness of landscape features is an element that opens up a new theoretical and practical horizon regarding the definition of marginality.

The landscape assessment matrix developed for the case of Lloa incorporates elements of the methodology described in the Catalan landscape catalogues while also developing an ad hoc approach for the particular situation under investigation. The features considered in the Catalonia catalogues are very broad since it is a tool developed for larger-scale studies, while in the case study a specific portion of the territory was analysed. Therefore, the evaluation framework has been specifically designed to take into account the variables helpful for addressing the issue of marginality, particularly those connected to anthropocentric actions and perception.

The catalogues are a useful tool for valuing the landscape, protecting it, and considering it an essential tool for territorial and urban planning. The landscape, when understood as a complex system, provides a novel interpretation of territories since it offers a cutting-edge definition of those areas labelled as marginal, as in the case of Lloa. It is obvious that using the catalogue's instructions as a universal guideline is not possible. Although its methodology can be used elsewhere, each distinct territory should create its own catalogues and recommendations for the local regulatory system. This research shows that there are aspects of the methodology that can be fully applied, but others require adaptation to the local situation.

Moreover, the landscape units of Lloa disclose a high value of green elements in both their biotic and abiotic components. The huge climate and landscape components demonstrate that the marginality in Quito could work as an ecosystemic balance against pollution and other urban problems. Moreover, the biodiversity and the landscape landmarks display an encouraging scenario for sustainable tourism, creating a new opportunity for developing the parish. The smart use of technology, such as the application of a visual basin plug-in, opens up new ways of interpreting and analysing the spatial features of marginal lands.

The use of landscape to study marginality could produce a potentially novel method if current theories are taken into consideration. For instance, it suggests considering the landscape when planning activities and taking marginality into account. As a result, it creates a comprehensive system of relationships between various disciplinary and analytical dimensions focused on marginality reduction as it is understood today. The research findings, however, do not alter the definition of marginality for marginal urban areas with scant or non-existent landscape values. Instead, it proposes to enhance the variables behind the topic. Further, a new study should be developed using alternative methodologies, including at least the concepts of urban landscape and values that operate on a different scale (Cullen 1976, Gehl 2014, Hillier et al. 1993, Lynch 1960).

These overarching considerations offer a possible response to the query about what specific insights on marginality are displayed by the case of Lloa. The main insight is led by the balance between socioeconomic marginality and the huge variations of landscape in the peripheral condition:

- the enhancement of the landscape view from the most interesting miradores, enables a positive condition of marginality and a perception of the environmental variations as in-transition areas between landscapes;
- a path tourist's system structure, focused on the understanding of the biodiversity of the Lloa, opened the area to new potential connections (leisure and educational) with the city of Quito;
- Sustainable development focused on responsible tourism could generate employment and local business; therefore, it could reduce the critical socioeconomic condition, increase the sense of belonging and, finally, update the perception of marginality.

The results encourage the disciplines that deal with marginality to work no longer as separate areas but as an interconnected network that must necessarily form a system to

obtain innovative results with high impact on the territories. The landscape, particularly in Latin America, is a true heritage that ought to be valued and preserved for the future because it can give marginality a positive meaning and reshape the discouraging narrative that the socioeconomic theories provide. Although descriptive, the findings from the initial phase of this research pave the way for a later stage of work that will systematize a multiscale analysis and define a set of indicators aimed at integrated action on the territory.

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Italia di mezzo: The emerging marginality of intermediate territories between metropolises and inner areas*

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Abstract. The Italian debate concerning the relationship between cities and inner areas polarized around a few dichotomous – and somehow simplifying – positions. On the one hand exists the rhetoric addressing the "villages", intended as remote places to re-inhabit, escaping from the pandemic. On the other hand is the narrative of the metropolis, envisioned as a place-fulcrum from which to start again – following the already-known patterns of growth and concentration – despite the fragilities made explicit by Covid. In order to overcome these juxtaposed approaches, our work wants to shed light on the importance of "intermediate territories" intended as priority places to rethink within a new geography of marginality. In Italy, such intermediate territories, named *Italia di mezzo*, occupy half of the national surface and host more than half of the population. Moreover, they embody extremely articulated geography: they include portions of twentieth-century urbanization (such as coastal settlements, industrial districts, various traits of "città diffusa"), medium-sized cities with different administrative and functional centrality levels, sectors of metropolitan belts and a substantial share of rural areas in plains and hills. Faced with the radical risks and uncertainties that characterize the contemporary condition, it is essential to take care of these territories not only because they urgently need investments aimed at solving forgotten critical issues (from the necessary reconversion of production chains to the impact of climate change). These territories can also play a strategic positive role in the face of crisis phenomena thanks to their characteristics of elasticity and plasticity. If we look at them from a relational point of view – and not only from a topological one – these intermediate territories can play the role of two-sided "intermediaries" and "hinges." On the one hand, they can be prepared to provide assistance and support to the inner and less densely populated areas; on the other hand, by taking advantage of their infrastructural and social capital, they can offer decongesting opportunities for most polluted metropolitan areas and more accessible living and working conditions.

*The authors shared the contents and the general layout of the essay. However, the first (Introduction), third (Defining and mapping l'*Italia di mezzo*) and last (Conclusion) chapter must be attributed to the four authors together, the second (A multi-faceted debate) to Arturo Lanzani, the fourth (An introductory profile of *Italia di mezzo*) to Federico Zanfi, the fifth (*Italia di mezzo* and the geography of socio-economic and environmental fragility) to Francesco Curci and the sixth (A recent contraction) to Agim Kërçuku.

1 Introduction

In Italy the geography of marginal territories has changed cyclically. It continuously includes some areas and populations while cutting out others. It shrinks and expands constantly. Being marginal territories means being forgotten by public policies, excluded from plans and projects, overlooked by research and studies and ignored by public opinion and cultural institutions. But being marginal also has to do with the processes of territorial and social stigmatization, both exogenous and endogenous to the territory in question. It is possible to be a marginal territory if the socioeconomic and cultural development processes are always decided elsewhere. And one can feel forgotten, marginal or belonging to second-class regions while being at the centre of the public debate. Being marginal is a complex and unobvious condition that has substantial social, economic, political and spatial implications for societies and territories.

Since the second half of the twentieth century, a constant dichotomy has characterised the process of marginalization of the Italian territory. The margin was defined through a fracture and constantly alludes to an oppositional recognition. And at several moments, the different marginal territories were described almost exclusively within three large homogeneous images: the Mezzogiorno (Southern Italy), the peripheral and the inner areas. These images define three physical and conceptual spaces, unable to welcome and foresee anything else. Our work intends to shed light on the importance of "intermediate territories" and *Italia di mezzo* intended as priority places to rethink as a new geography of marginality.

At first, the North-South duality marked the marginality of the South (i.e., about one-third of the country) and fuelled a vital policy to reduce regional gaps. Subsequently, although the gap between Northern and Southern Italy persists and has worsened in recent years, the peripheral neighbourhoods within the metropolitan areas will be considered marginal compared to the centres, becoming a field of experimentation for new integrated urban policies. In recent years, a new series of studies and policies has given rise to the experience of the Strategia Nazionale per le Aree Interne (National Strategy for Inner Areas). This strategy identifies the geography of marginality in inland mountain areas and other areas at risk of depopulation. The geography of the Aree Interne (spatially extended but of limited demographic weight) is based on the criterion of the distance of these areas from the centres that provide essential services for a citizen: a hospital equipped with high-level first aid (DEA), high schools and a silver level railway station. Silver is one of the four station classification levels introduced by the RFI. In Italy, there are 594 silver stations. These are medium/small facilities, often unattended, equipped only with urban / suburban / metropolitan services (Ministero delle Infrastrutture e Trasporti 2014). As part of this strategy, a place-based policy was consequently developed to innovatively promote access to these essential services and introduce new economic initiatives capable of retaining and attracting the population.

However, there is a fuzzy part of the geography of marginalisation in Italy. This is a large portion of the Italian territory that does not belong to the suburbs of the metropolitan areas or even to the inner areas, that lies in the middle of these two polarities that we find both in the North and South of the country. *Italia di mezzo* (in-between Italy) is a substantial part of Italy; it comprises about half of the total area in which 55% of the Italian population lives. It is a part of Italy rarely subject to integrated policies and projects. Also, it is on the fringes of scientific research and political experimentation. This Italy needs an update to its representation and a substantial redefinition of territorial policies because of the ongoing processes of marginalisation and fragilization that could reach critical levels in the coming years, affecting the fate of the entire country system. This paper intends to help respond to the first of these urgencies through the conviction that this other Italy needs a new representation that considers its evolutionary dynamics and, above all, its possible differentiated futures. Such representation will have to focus on multiple aspects. It will have to recognise recurring social, cultural, economic, demographic and environmental elements and the internal spatial articulation of these territories. It will have to show how variety of life frameworks can host different populations and how it has given (even during the recent pandemic crisis) plasticity and

resilience to the country. It will have to interpret the complex geography of the dynamics of shrinkage and growth, investigating its numerous potentials and criticalities.

After presenting the hypothesis that moves our reflection on the introduction, in the first part of the article, some trajectories of study on the Italian specificity and the international context of the intermediate territories are reconstructed. It is a reconstruction that has guided us in the perimeter and mapping of that part of the territory called *Italia di mezzo*. And in the choice of indicators, in which we have caught a robust spy capable of offering some elements of reflection on the social, economic, cultural, and environmental relevance of *Italia di mezzo* within the Italian territory. In the second part of the paper, we illustrate the criteria that helped us define a new map of *Italia di mezzo*. The third, fourth and fifth parts describe an introductory profile, illustrate the socioeconomic, socio-demographic, real estate, and environmental conditions, and introduce recent shrinking processes. The last part summarizes the dynamics and the main challenges in the territories of *Italia di mezzo*.

2 A multi-faceted debate

Except for the production of Bruno Menegatti, contained in the results of the survey initiated in 1980 by the working group Rivalorizzazione della aree marginali (Menegatti 1986) of the Association of Italian Geographers (AGEI), *Italia di mezzo* has never been treated as a single subject, neither in terms of physical and socioeconomic features nor in terms of public policies. Several studies have, however, partially explored in-between Italy from five specific perspectives. It is a multi-faceted debate made up of many coexistences and overlaps that involve different contents, places, and types of settlement. It is a partial picture. The choices are linked to the need for research and to treat a comprehensive view with constantly accumulating literature.

The first group of studies focuses on the industrial and post-industrial territories in which small and medium enterprises and then the "pocket multinationals" were born and developed (Fua, Zacchia 1983, Garofoli 1991, Becattini et al. 2009, Calafati 2009, Lanzani et al. 2016, Bianchetti 2019, Tosi Tosi).

The second group of studies focuses on the spread of urbanised spaces beyond metropolitan fringes (different from urban sprawl) and their recent transformations and shrinking (Indovina 1990, 2009, Clementi et al. 1995, Munarin, Tosi 2001, Lanzani 2003, 2011, Bonomi, Abruzzese 2004, Fabian et al. 2012, De Rossi 2018, Curci et al. 2020). More specific studies can be subdivided according to three areas of focus: land-take dynamics, which strongly affect *Italia di mezzo* (Crcs 2017, Ispra 2020); unauthorised urbanisation processes, particularly in southern Italy (Zanfi 2013, Curci et al. 2017); and hybrid and fragile landscapes and recurrent building materials (Ingersoll 2004, Navarra 2017, Gioffre 2018, Ippolito 2019), expressly within peri-urban spaces (Magnaghi, Fanfani 2010, Mininni 2012) and coastal areas (Mininni 2010, Zanchini, Manigrasso 2017).

The third group concerns the polycentric systems of medium-sized cities and their role in the Italian spatial and economic structure (Camagni 1993, Dematteis, Bonavero 1997, Trigilia 2014, Ifel 2019, Mascarucci 2020). More limited is the literature that focuses on the evolution of intensive agricultural areas, mainly located within *Italia di mezzo*, and their ecological and environmental impacts (Cannata 1989, Basile, Cecchi 2003, Marangon 2006, Bocchi 2018, Bevilacqua 2018).

A final and more recent group of studies focuses on the different forms of unease and discontent among communities in *Italia di mezzo* and the political implications thereof (Vallerani, Varotto 2006, Bonomi 2008, Viesti, Simili 2017, Di Matteo, Mariotti 2021, Carrosio 2020).

In the international context, the issue of in-between areas has been tackled from different perspectives, with significant differences concerning the way in-betweenness is defined and interpreted, also due to the objective differences existing between the national and regional contexts under study. In France, the territoires intermédiaires have long been the subject of reflections and conceptualizations that have emerged in the debate on rural territories and in that on the forms of intercommunality: Ville émergente (Dubois-taine, Chalas 1997), Métapolis (Ascher 1995), Tiers espace (Vanier 2000). The Swiss

case is also interesting in which, looking outside the urban agglomerations, it is customary to distinguish between territoires intermédiaires and régions périphériques (Ruegg, Deschenaux 2003). All attempts to define in-betweenness still discount a dependence on the city-countryside gradient.

However, in addition to the tradition of Franco-Swiss studies, we can mention the works conducted on German and Dutch territories. The Dutch term Tussenland (middle land) was used by the Dutch National Agency for the Environment to identify those territories in which different actors interact outside the logic of spatial planning that in previous decades had focused everything on containing urban expansion and the safeguarding of green spaces, without, however, paying attention to the network organization and the connective potential, and not only of the intermediate territories (Wandl 2020). With the German term Zwischenstadt (middle city), Sieverts, on the other hand, told of intermediate spaces that are the result of multiple rationalities and the action of different actors (Sieverts 2003), with interesting hybridizations, both from the physical-settlement point of view, and from an economic point of view, between local roots and globalization, but also between planned and unplanned spaces, between static and dynamism, between investments and disinvestments, between growth and contraction. Furthermore, in Germany, by articulating the concept of peripheralization, it is possible to put a crisis on the various spatial categorizations based on structural distances. These are somewhat vague categorizations that do not capture the local realities of the territories considered in-between or non-core regions (Leick, Lang 2018). These works aim to claim the need for more studies on areas that are still little explored today, but deserve to be qualified through more accurate knowledge and targeted projects (Wandl 2020).

For this reason, Sieverts' work has aroused particular interest in post-suburbanization studies, for scholars such as Keil, Young (2010) and Nüssli, Schmid (2016). It is a line of research that aims to build new interpretations of the suburban by recognizing in these spaces, in addition to some intrinsic qualities from an environmental point of view, also their own positive identity, which can be emancipated from the urban one, but also an attractive and innovator. According to these approaches, the suburban area is not only the field of rescaling traditional social and environmental questions, but is also the heart of a new political tension (Fedeli 2017). Also for this reason the theme of the in-between territories has crossed the work of scholars who are involved in investigating the correlations between the geography of (electoral) discontent and places – often too hastily defined as peripheral – in which the perception of geographical disparities is stronger (McCann 2020) and in which socioeconomic and environmental conditions are condensed such as to induce some scholars to define them as places that don't matter (Rodríguez-Pose 2018).

Another area in which it is possible to find suggestions on in-betweenness is that of critical urban studies. The theories on planetary urbanization push towards an interpretation of urbanization as a phenomenon without limits; dynamic, complex, in which forces that push towards concentration co-act (concentrated urbanization) and forces that push towards extension (extended urbanization) (Brenner, Katsikis 2020). These theories decree the definitive dissolution of the hiatus between urban and non-urban to stop understanding urbanization as city growth but rather as a process that is actively supported by non-city spaces (Soja 2000). According to these authors, urban agendas should therefore start from a re-articulation of the suburbs free from city-centric logic, starting by recognizing, for example, that today it is no longer possible to associate a suburb with a single city and vice versa.

This body of studies constitutes a fundamental basis of knowledge for the research we propose but simultaneously allows two limits to emerge. Italian research has mainly focused on specific themes and territories of Italian di mezzo, failing to build an overall portrait in which demographic, socioeconomic, and mobility aspects are integrated. Italian and international research has maintained a predominantly oppositional approach, in which the presence of a relational perspective that these territories have with metropolitan and inner areas is scarce. The proposed essay intends to advance scientific knowledge by bridging these two limits and understanding the in-between space as a relational space.

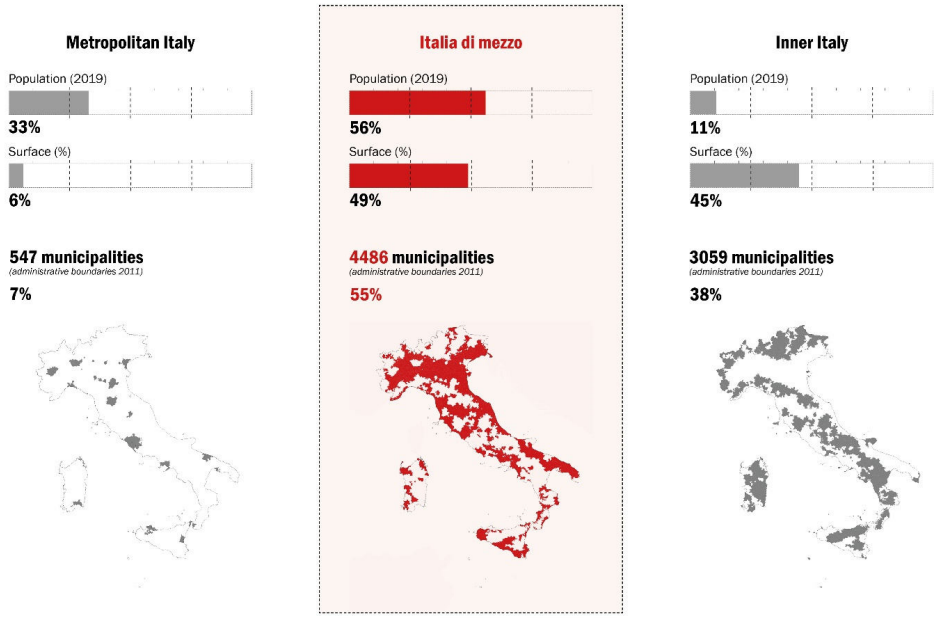

Figure 1: A significant portion of Italy

3 Defining and mapping *Italia di mezzo*

A first 'negative' delimitation of Italia Mezzo derives from the exclusion of the entirely mountainous ultra-peripheral, peripheral, and intermediate areas defined by the National Strategy for Inner Areas (SNAI). This deep or mountainous inland part of Italy represents 10% of the total population and 44% of the national area, as shown in Figure 1. Not even the de jure and de facto metropolitan cities, namely Milan, Rome, Naples, and Turin, are part of *Italia di mezzo*. Also excluded are the central municipalities of some functional metropolitan areas, as indicated by the OECD research (Brescia, Padua, Parma, Reggio Emilia, Modena, Prato, Pescara, and Taranto). Not even the de jure and non de facto metropolitan cities are part of it, as in the case of Messina and Reggio Calabria. Metropolitan Italy represents 33% of the population and 6% of the national surface, as shown in Figure 1. This is the first definition that, by subtraction, reveals a significant portion of the Italian territory, which has remained amid the dualism between inner areas and metropolitan cities.

A second 'positive' description can be made by portraying the Italian territory's settlement structure and urban-rural relationship. A spatially articulated reality emerges. Within it, at least three major types of situations can be identified.

The first is defined di mezzo of medium-sized cities with different centrality levels. These are the 'Cities' of medium and small OECD-FUAs, the traditional medium-sized cities and some minor poles. Trieste, Foggia, Sassari, Ravenna, Ferrara, Rimini, Trento, Salerno, and Monza also belong to the second type of situation, which hosts 17% of the national population and covers 10% of the total national expanse, as shown in Figure 2.

The second type of situation is represented by Italia *Italia di mezzo* of metropolitan fringes. The de facto but not de jure metropolitan areas are part of this first situation, as in the case of the extra-provincial areas of the Milanese and Neapolitan metropolises, the non-metropolitan territories of the provinces of Turin, Bologna and Bari and the entire functional areas of Reggio Calabria and Messina. About 12% of the national population lives in this territory, which represents 7% of the national surface area, as shown in Figure 2.

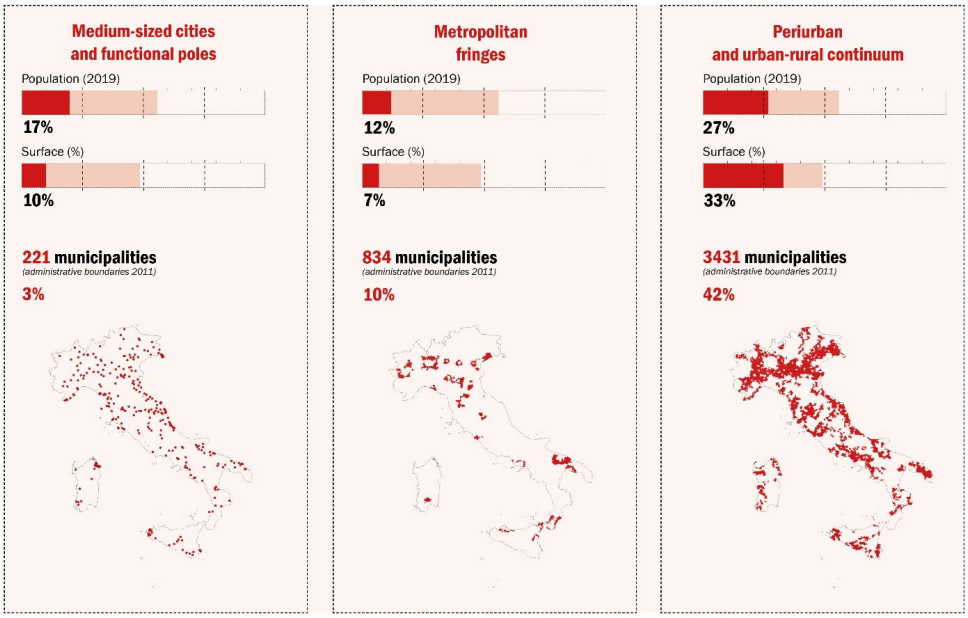

Figure 2: An articulated reality in which we can distinguish at least three settlement typologies

Finally, the third type of situation is composed of *Italia di mezzo* of the urban-rural continuum characterised by suburban belt municipalities and intermediate municipalities, with an average size of 5,000 inhabitants. *Italia di mezzo* of the suburbs and the rural-urban continuum of plains and hills are characterized by a widespread, linear, comb or reticular urbanisation. It represents 27% of the national population and covers 33% of the national surface area, as shown in Figure 2.

Adding up the three major situations, *Italia di mezzo* takes on a decisive role if we consider its weight on a national scale: 56% of the Italian population lives here and it comprises 50% of the entire national surface area.

4 An introductory profile of *Italia di mezzo*

To observe the specific characteristics and trends of *Italia di mezzo*, it is necessary to consider some specific data. With the help, above all, of the vast national and international literature observed and briefly described in the second part of this essay, we have selected 39 indicators capable of recounting the socioeconomic, socio-demographic, real estate, and environmental conditions of this part of Italy.

This investigation results from intensive research carried out to prepare a public intervention for the seminar Ricomporre i divari. Politiche e progetti territoriali contro le disuguaglianze held at Politecnico di Milano on February 2020[1]. For this reason, we used the latest available data on that date, including those of the fifteenth general census of the Italian population and dwellings (October 2011) ISPRA, Copernicus, DiPE Urbanindex, INGV, AdE-MEF, ISTAT (A misura di comune), DemoISTAT and 8milaCensus ISTAT, as shown in Table A.1. While realizing the limits of this temporal distance, we still decided to use these data for their statistical relevance and homogeneity. To facilitate

[1]Public presentation: L'*Italia di mezzo.* tra metropoli e aree interne, together with A. Lanzani, F. Curci e D. De Leo. On the occasion of the Prima sessione – Periferie in Italia: processi, geografie e risposta delle politiche of the public seminar, Ricomporre i divari. Politiche e progetti territoriali contro le disuguaglianze. Organized by A. Coppola, M. Del Fabbro, A. Lanzani, G. Pessina e F. Zanfi. DAStU, Politecnico di Milano

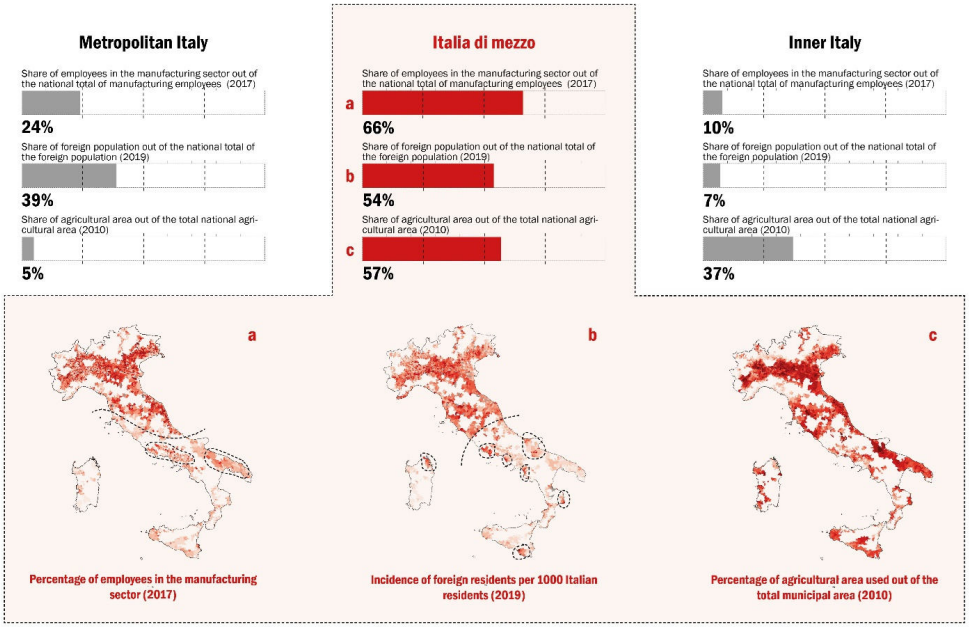

Figure 3: Common features of *Italia di mezzo*

the reading of the essay, we have inserted a summary table of the selected indicators at the end of the paper (Table A.1).

Strong manufacturing and agricultural profiles emerge if we look at the socioeconomic connotation of *Italia di mezzo*, as shown in Figure 3. In fact, this is where, in 2011, the most significant number of municipalities in the industrial district are located. About 90% of the municipalities included in the Italian industrial districts are part of *Italia di mezzo*. However, this district characterisation is more limited in the region of Piedmont, Liguria, and Friuli-Venezia Giulia, in the Tyrrhenian area of central Italy, in the south and in the islands. Furthermore, a more significant presence emerges in metropolitan fringes and urban-rural continuum if we look at the percentage of employees in the manufacturing sector in 2017. The manufacturing sector employees' rate is significantly reduced in medium-sized cities. If we examine the spatial distribution, we observe a stronger manufacturing connotation in the whole of the centre-north and along the Adriatic coast than in the rest of the country. However, looking at the number of large active companies per 1,000 employees in the municipality in 2017, we can see an inverted trend. The maximum values are reached in medium-sized cities and metropolitan Italy. A more pronounced presence of large companies emerges in the territories of *Italia di mezzo* along the Piedmont–Lombardy–Veneto foothills axis, along the Via Emilia and along the Adriatic route. On the other hand, the presence is limited along the course of the Po River, along the Tyrrhenian coast, in the south and on the islands. Alternatively, or sometimes in combination with manufacturing, there is also a solid agricultural connotation of *Italia di mezzo*, as shown in Figure 3. To confirm this, it can be noted that the percentage of the agricultural area used of the total municipal area in the urban-rural continuum is 56.6%. The geography on a municipal basis is complementary to manufacturing, with higher values in the lower Po Valley and some areas of Apulia and Sicily.

As for the socio-demographic connotation, a not-so-evident trend in the presence of immigrants must be pointed out. If we look at the incidence of foreign residents, in 2011, the highest values can be found in *Italia di mezzo* and not in metropolitan Italy, as one would imagine, as shown in Figure 3. Although the presence of immigrants increased in 2019, especially in metropolitan Italy, *Italia di mezzo* is still the area where

the greater incidence of foreigners can be observed. This data can be justified by more significant employment of the immigrant population in less skilled commercial, personal services, manufacturing, and agricultural jobs. The location pattern of foreign residents in Italy is higher in metropolitan Italy but lower in the metropolitan fringe. It returns to be higher in the urban-rural continuum and decreases in inland areas. A significant element concerns the change from 2011 to 2019 in the localisation of immigrants in large geographical areas. If the homogeneous distribution was evident in 2011, a more significant presence in the country's north could be revealed in 2019.

Let us consider the percentage of employees in the advanced services sectors, and social and health sectors in 2017. There is a more significant presence in metropolitan Italy and medium-sized cities compared to other parts of *Italia di mezzo* and inland areas. There is no notable regional variability, and this returns a homogeneous distribution within the national territory. A similar spatial distribution can also be found in the indicator of the average purchase and sale value of residential properties in 2019, affecting the cost of living for residents. This indicator has maximum values in metropolitan Italy and minimum values in inland areas. It ranks medium-low values in the three components of *Italia di mezzo*. The geographical representation shows a hold on the real estate values of *Italia di mezzo* affected by tourist phenomena, as in the case of the Liguria, Marche, Romagna, and Sardinian coasts and in the case of the territories around the great lakes in the north and in Tuscany. A similar trend is also found for the percentage of real-estate units reached by ultra-broadband 30Mb in 2016, with higher values in metropolitan Italy and medium-sized cities, followed at a great distance by the metropolitan fringes, inland areas, and urban-rural continuum. The latter has even lower values than inland areas. A further significant element is the better endowment in *Italia di mezzo* of the Tuscan territories and southern Italy compared with northern Italy. This may be influenced by the availability of structural funds for ultra-broadband investments in the south and by the presence of some critical tourist areas with high demand. Artificial land cover per capita 2018 reaches maximum values in inner areas due to urbanisation models and the value of second homes, and minimum values in metropolitan Italy. The land consumption per capita 2018 in *Italia di mezzo* assumes intermediate values. Geographically, a greater land consumption is found along the Po River, in Friuli-Venezia Giulia and Tuscany. The percentage of use of buildings 2011 is, on the other hand, minimal in inner areas and highest in metropolitan Italy. The picture of *Italia di mezzo* is not homogeneous. Minimum values similar to those of inland areas can be found in the geographical contexts of *Italia di mezzo* marked by tourism and migration, as in the case of the south, Sardinia, western Liguria, Valle d'Aosta, Abruzzo and also in the northern territories between Piedmont and Lombardy and in Friuli-Venezia Giulia. Let's also look at the data relating to the percentage of use of real estate owned by municipalities in 2016. It is possible to find a classic distinction between northern Italy and southern Italy, where the values are lower.

A final element that can help us understand the introductory profile of *Italia di mezzo* is its morphological-environmental character. In fact, *Italia di mezzo* is characterised by three settlement situations. The first situation concerns those portions of the territory with a Christallerian geography of medium-sized cities and small rural-urban centres connected through many urbanised strands. Two exemplary cases of this first situation of *Italia di mezzo* are the territories of the lower Po Valley and Apulia. However, a similar condition is also found in Tuscany, Lazio, and south-eastern Sicily. The second situation contains those complex linear urbanisations that incorporate many medium-sized centres on the coasts of peninsular Italy and Liguria. Furthermore, this second settlement situation can also be traced in some Apennine and Alpine valley bottoms. The third situation relates to widespread urbanisation outside the metropolitan areas. This is the most varied morphology of the urbanised area in terms of urbanisation density. In fact, the north of Milan metropolitan area, the widespread Lombard-Venetian Piedmont urbanisation and the sparser one of southern Piedmont, Friuli-Venezia Giulia, the Umbrian valley, and the Tiber around Perugia fall into this situation. The third situation also includes a wide variety of urbanised figures: filaments, comb, and reticular urbanised plates.

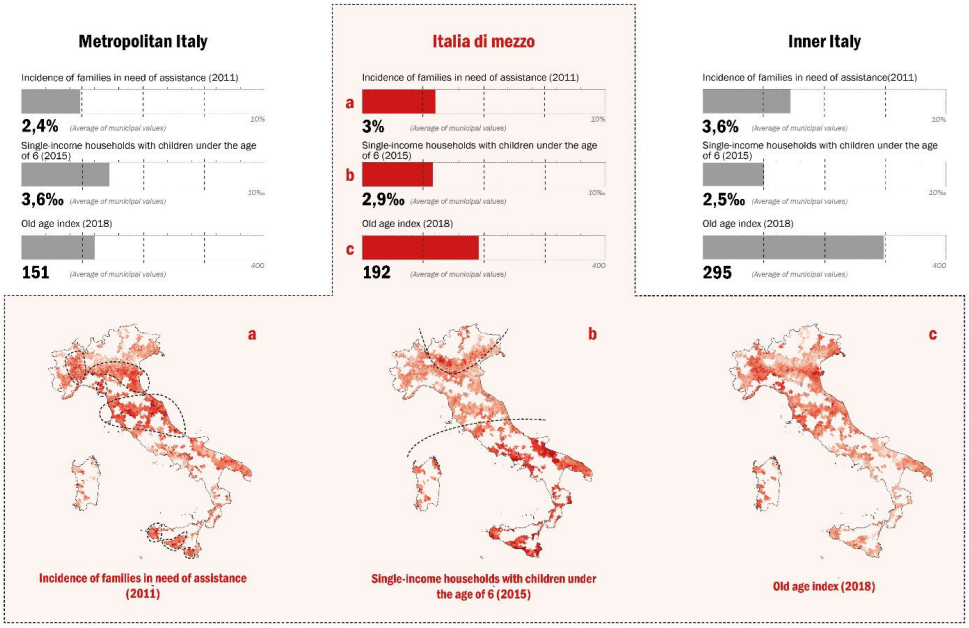

Figure 4: *Italia di mezzo* "in the middle" for some social hardships

5 *Italia di mezzo* and the geography of socioeconomic and environmental fragility

Overall, concerning the socio-demographic, socioeconomic, real estate, and environmental indicators that we have observed, *Italia di mezzo* has at least three main profiles. For some indicators, *Italia di mezzo* is in a lower fragile situation. For others it seems to be in the middle, and for some other indicators it is at greater fragility and discomfort than metropolitan Italy and inland areas.

A less problematic situation in *Italia di mezzo* than in the rest of the country seems to emerge if we look at the incidence of families with potential economic hardship in 2011. In this case, the highest values are found in metropolitan Italy, albeit with significant variance between the different municipalities, and the lowest in the urban-rural continuum, while in the average values, the medium-sized cities, inland areas, and metropolitan fringes are placed in decreasing order. Observation of the spatialized data confirms a clear distinction between the country's north and south, with a very problematic profile in the south, where only Apulia and Sardinia have lower values. Another critical spatial pattern can also be highlighted in the 'dust' of municipalities about 50km from Milan, Turin, Rome, and Naples: a sign of expulsive dynamics and long-term commuting growing solidly after 2011. A further indicator that confirms the lesser problems faced by *Italia di mezzo* concerns the incidence of young people outside the labour market and training in 2011. In this case, the maximum values can be found mainly in metropolitan Italy and the territories of inland areas. The lowest values are recorded in the three components of *Italia di mezzo*. The geographic representation presents a greater criticality in the south, where, however, Apulia – excluding the Tavoliere – Sardinia and Abruzzo report fewer problematic profiles. A particularly critical situation is recorded between Biella and Alessandria, and in lower Brescia area.

Italia di mezzo finds itself in the middle of the geography of fragility and discomfort concerning the incidence of families in need of assistance in 2011, as shown in Figure 4. In this case, the maximum value is recorded in inland areas and the minimum in metropolitan Italy. There are very high values in medium-sized cities and urban-rural

continuum. At the same time, the values of metropolitan fringes approach those of the metropolitan areas. In this case, the regional geography inside *Italia di mezzo* does not propose a condition of maximum criticality in the south, as the population remains younger, and it is rarer for the elderly to live alone. Instead, the critical conditions occur along the Po riverbank, central Italy, and medium-sized cities in general. Similarly, the old-age index in 2018 is also relatively homogeneous in *Italia di mezzo*, halfway between the higher values of inland areas and the lowest of metropolitan Italy, as shown in Figure 4. It is possible to distinguish a higher old-age index in Piedmont, along the axis of the Po River, in Friuli-Venezia Giulia and central Italy, whereas the lower levels are found in the new Lombardy-Veneto-Emilia "industrial triangle" and in the south.

Another indicator that shows an inverted trend but maintains the median value of *Italia di mezzo* is the indicator of single-income households with children under the age of six. In this case, the highest values are found in metropolitan Italy rather than in inland areas, as shown in Figure 4. In *Italia di mezzo*, major criticalities are in the metropolitan fringes with high values recorded in the south and the lower Po Valley. Another significant indicator is the per capita gross income 2015, where the lowest values are found in deep inland areas, as shown in Figure 5. The urban-rural continuum also has similar values, whereas the values in the metropolitan fringes and medium-sized cities are higher. These are the values with the most significant variation between south and north, with the maximum in Emilia-Romagna, Trentino, and Lombardy and slightly lower in Veneto and Aosta Valley. A similar trend is also recorded in the differences in income and taxes within the municipalities, in the gaps in pre-tax income, as shown in Figure 5. The gaps are more remarkable for metropolitan Italy and minimal in inland areas with medium-sized cities that tend to resemble metropolitan Italy more. Conversely, the metropolitan fringes and the urban-rural continuum resemble inland areas more. In *Italia di mezzo*, the gaps are more significant in the south than in the centre-north and occur in the outer metropolitan fringes and the urban-rural continuum of metropolises such as Milan, Naples, Genoa, Modena, Reggio Emilia, and Parma. The gaps also arise in the widespread and rural Tuscan urbanisation. Finally, the incidence of adults with a diploma or degree also has an urban profile with higher values in metropolitan Italy and medium-sized cities. Observation of the data at the municipal level indicates higher values in the Emilia, Marche, Umbrian, and Tuscan territories of *Italia di mezzo*. In the south, the lowest values are reached in Calabria, Sicily and Sardinia.

The highest disadvantage and fragile profiles in *Italia di mezzo* emerge on the environmental and settlement-territorial terrain. If we examine the percentage of municipal area occupied by sites of national interest (SIN) in 2014, we can observe randomized geography with leopard spots. We find a more significant presence mainly in urban-rural continuum and medium-sized cities. Their presence in metropolitan fringes and metropolitan Italy is lower. It is almost absent in inland areas. The Number of industrial plants with relevant risk of accident (RIR) in 2015 also shows high values in *Italia di mezzo*, as shown in Figure 6. Also in this case, there is randomized geography where the sites of Brindisi, Porto Torres, Ravenna, Alessandra, Novara, Ferrara, Cremona, Gela, some municipalities between Frosinone and Latina and the province of Terni are reported. An analogy in the spatial distribution is also found in the percentage of the resident population at risk in areas with moderate hydraulic hazards in 2017, as shown in Figure 6. Also in this regard, we can see randomized geography with a maximum criticality in medium-sized cities. As for air pollution, Pollutants Particulate Matter 10 microns (PM10) and Matter 2.5 microns (PM2.5) are highest in metropolitan areas and metropolitan fringes, as shown in Figure 6. We can highlight the particularly critical situation in the Po Valley, especially in those of Lombardy and Veneto. In this case, the contribution of the Milanese metropolitan areas, in particular the province of Monza, is decisive. We also find high values in the medium-sized cities and the urban-rural continuum of Campania, south-eastern Sicily, and central Apulia. A clearer gradient emerges from metropolitan Italy to the inland areas if we consider the pollutant's nitrogen dioxide (NO2) values instead. In this case, the intensity of urbanisation and the presence of infrastructural beams are relevant to determining the value of the pollutants. Therefore, the exceptionally high values are found in the Piedmont-Veneto area, along the axis of

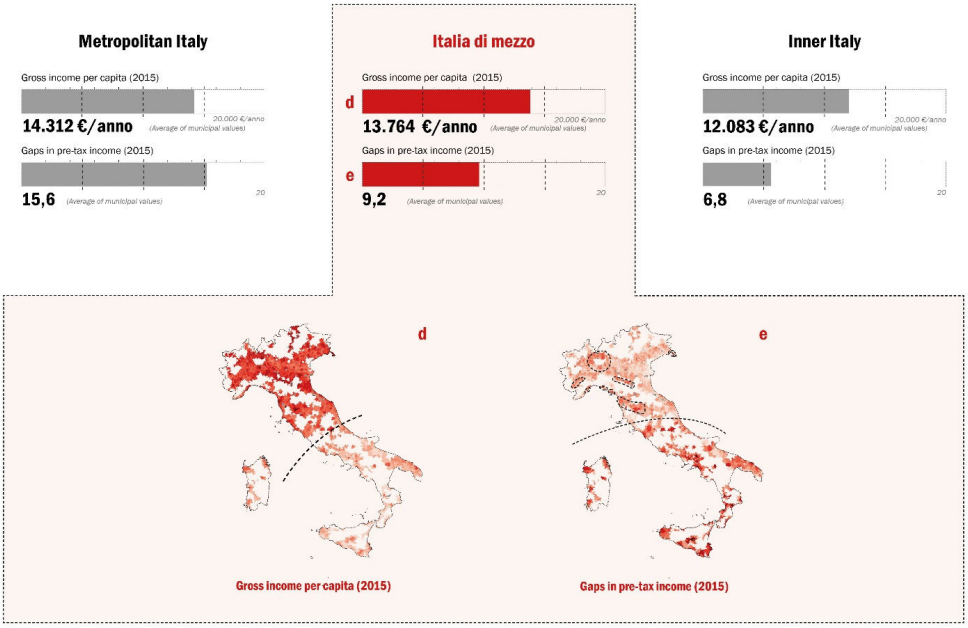

Figure 5: *Italia di mezzo* "in the middle" for some social hardships

the Via Emilia, in the highly urbanised area of Naples, in the highly urbanised oval between Pisa, Pistoia, Prato and Florence, in the urban archipelago around Rome and finally in the Emilia-Marche coastal strip of the Adriatic Sea. Ozone pollutants (O3), on the other hand, have an overturned geography, with maximum values in inland areas and minimum values in metropolitan Italy.

6 A recent shrinking

The simplest yet most significant indicator to capture the demographic contraction remains the percentage change in resident population, which in this case was between 2011 and 2019. It effectively signals how substantial portions of *Italia di mezzo* are now flanking inland areas in the dynamics of demographic contraction. The inland areas of Italy are confirmed as territories of contraction par excellence. However, the high internal variance indicates some counter-history. Cartographic observation allows us to capture anomalous positive demographic trends in many Alpine municipalities of Trentino-Alto Adige and some municipalities of Lombardy and Piedmont. After years of growth, urban-rural continuum, especially in the suburban municipalities, has entered a contraction process. Medium-sized cities and metropolitan fringes grew but presented a significant variance. In particular, medium-sized cities in the south and the belt municipalities of Messina and Reggio Calabria are decreasing, while the de facto and non de jure municipalities in the northern metropolitan area have positive dynamics. Some medium-sized non-coastal cities in southern Italy are also in decline. If we look at the map of the three components of *Italia di mezzo* in northern Italy, four areas in contraction emerge. The first one can be observed in the Piedmont Biella-Asti axes, the second one in the Po River Delta, the third one in the Friuli-Venezia Giulia region and the fourth one in the municipalities of the Liguria coastal arc. In peninsular Italy, the population still grows in most coastal municipalities – albeit in contained forms. However, some contraction processes are beginning to be seen on the Tyrrhenian coast of Calabria, Sicily, and Sardinia. The demographic contraction is more limited on the Apulian and Abruzzese shores. Instead, it is the valleys perpendicular to the sea, the municipalities in the second line of the

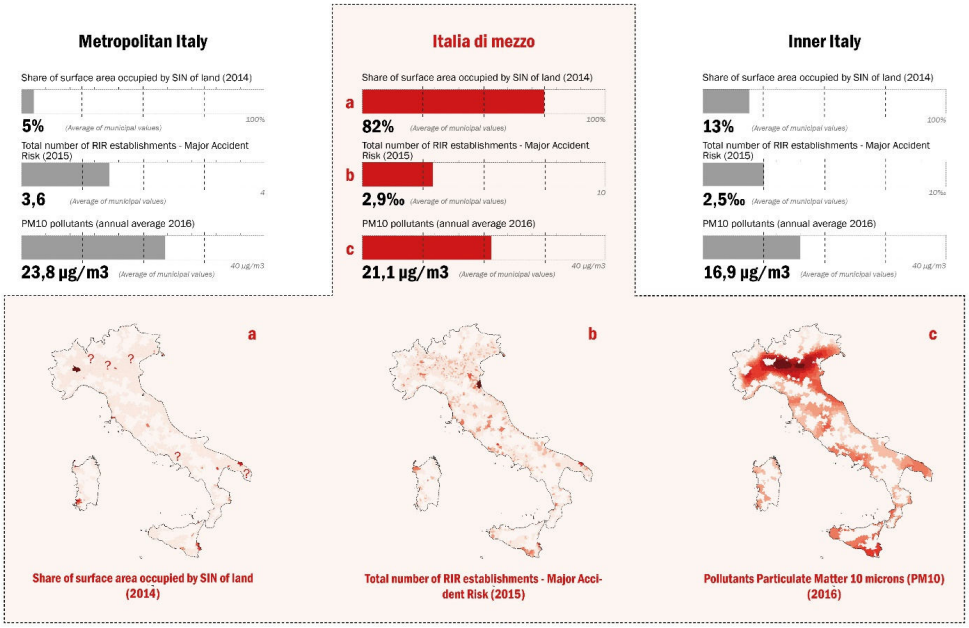

Figure 6: *Italia di mezzo* with strong environmental problems, sometimes higher than metropolitan Italy

coastal strip and the internal basins that record strong contraction dynamics, such as in the valleys and hills of Marche, across the Umbria region, in Irpinia, in the Daunia and some inland basins of southern Italy. The population of southern Italy is the only one to grow significantly but not homogeneously. The de jure and de facto metropolitan areas of Turin, Genoa and Venice are negative, and the metropolitan areas of Bari and Naples and the cities of Perugia and Taranto are stagnant.

On the other hand, if we look at the trends in the natural balance 2011–2018 per 100 initial residents, a negative value is recorded everywhere. It should be noted that the natural balance reaches maximum negative values in inland areas and minimum negative values in metropolitan Italy and metropolitan fringes. The migratory balance 2011–2018 per 100 initial residents that records long- and short-range movements of the Italian and foreign population is moderately positive everywhere, even in inland areas. Instead, the maximum values are reached in metropolitan Italy and medium-sized cities. The metropolitan fringes and urban-rural continuum achieve slightly lower values. The best trends are recorded along the entire Milan-Udine axis, in Trento, in the Parma-Bologna axis, in the Cuneo area, in Costa Smeralda, in the province of Latina, in the Neapolitan area and in the Foggia-Bari axis. The Change in the old-age index 2011–2019, on the other hand, shows us an ageing process of the population that is particularly relevant in inland areas but also significantly present in the urban-rural continuum and metropolitan fringes.

Of considerable interest is the evolutionary profile that emerges from the data on the percentage variation of employees. However, this confirms the trend towards territorial centralisation which is underway in Italy. Between 2012 and 2017, only metropolitan Italy and medium-sized cities saw an increase in employees, whereas other parts of Italy contracted. The maximum contraction is not recorded in inland areas, however, but in the urban-rural continuum. The geography of contraction always sees the Biella-Alessandra axis and the Po River axis emerge. Overall, the *Italia di mezzo* of Umbria and Calabria have a negative trend as well as the Marche-Abruzzo Adriatic axis and the Campagna region. Such dynamics are the product of a decline in manufacturing. In metropolitan

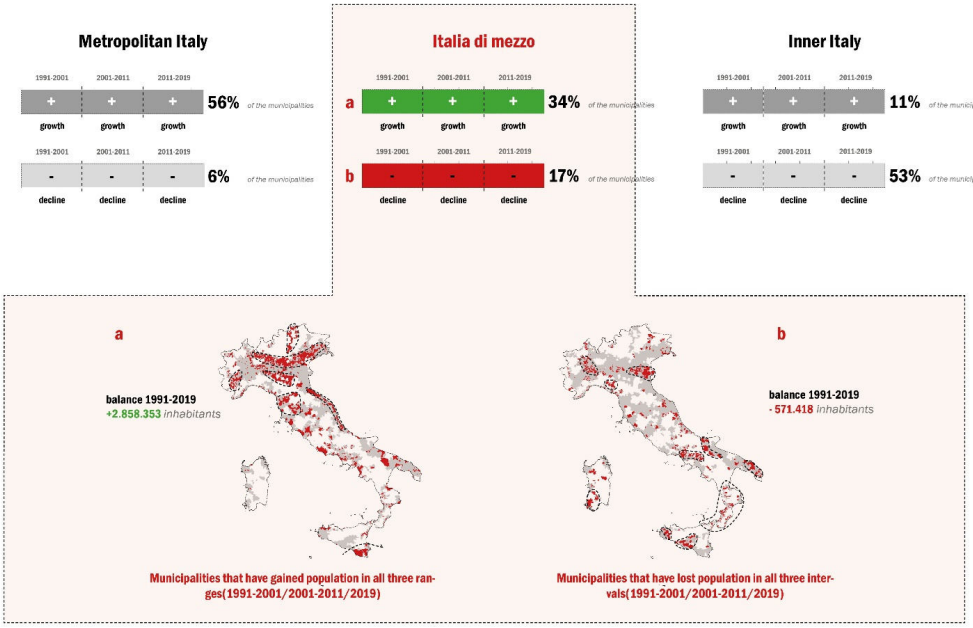

Figure 7: In many of its parts Italy is entering contraction processes after experiencing growth

Italy and some areas of *Italia di mezzo* with strong manufacturing traditions, such as in Piedmont and Friuli-Venezia Giulia, there are significant reductions of percentage change in the manufacturing sector 2012–2017. On the other hand, if we look at the percentage change in the advanced services sector for production and business 2012–2017, we can find favourable percentage variations, with maximum values in the urban-rural continuum. On the other hand, the change in percentage variation of employees in the social and health sectors 2012–2017 is positive everywhere, with high values in inland areas, following the metropolitan fringes and metropolitan Italy. But growth is more contained in medium-sized cities.

A further indicator that helps us describe a recent contracting condition is the percentage change in the average purchase and sale value of residential properties. Between 2012 and 2019, in the context of contraction in general sales prices, the slightest significant contraction is recorded in inland areas, in urban-rural continuum and in metropolitan fringes. This fact might seem to be in contrast with the demographic and employment dynamics; however, it can be explained by the still-present effects of the pre–2011 real-estate "bubble" in Italy in medium-sized cities and metropolitan Italy. There are extreme contractions in the Turin area, in Friuli-Venezia Giulia, in the Piacenza area, in the Caserta-Neapolitan area, in Tuscany, and throughout the Marche Adriatic coast south of Ancona. The latest indicator of the geography of the recent contraction concerns the per capita land take in the period 2012–2018. A high soil consumption is confirmed in inland areas and urban-rural continuum due to the robust construction production of second homes, the low-density building types, and the coexistence between abandoned and newly built properties following a land-use policy distorted by fiscal intent.

7 Conclusion

A fragment of Italy is blurred on the margins of scientific research, which is rarely the subject of integrated policies. National and EU policies have often represented an overly simplified description of Italy's territorial and urban articulation, almost solely through

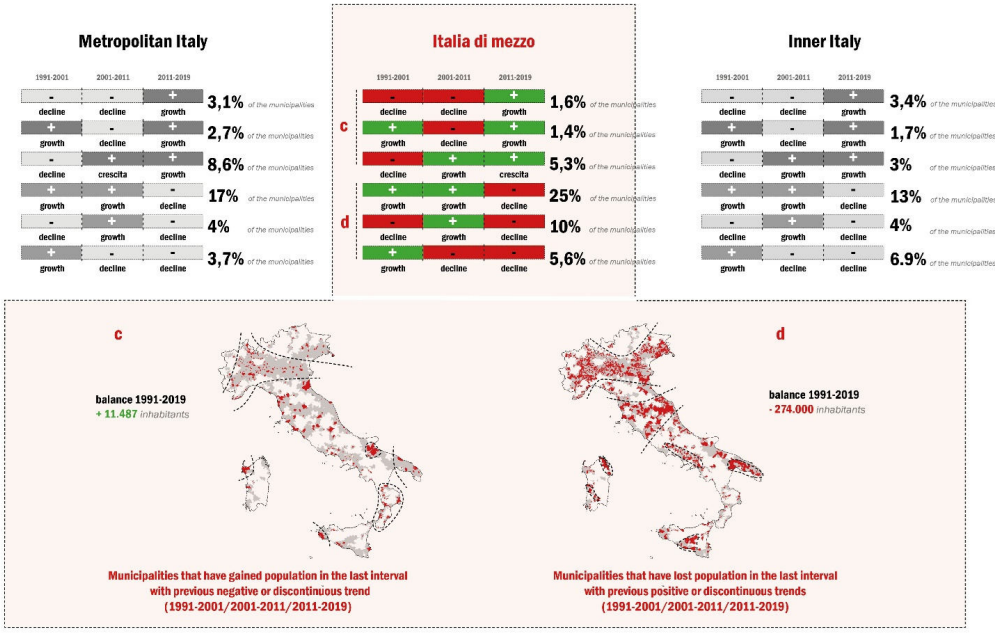

Figure 8: Contraction in non-homogeneous performances

the orientation towards inland and mountain areas on the one hand, sometimes reductively rethought as places suitable for a possible different domicile thanks to quality villages (see the recent announcement on villages by the Ministry of Culture linked to PNRR - National Recovery and Resilience Plan). On the other hand, there is a much stronger orientation towards metropolitan cities on which the country's possible progressive destinies tend to rely, thus sanctioning an apparent flaw in the territory. Within this fragmentation, in our opinion the question of *Italia di mezzo* arises, which is little observed and even less represented in its spatial, social and economic expressions and which offers alternative geography in its articulation, characterised by new imaginaries and policies for the territory.

From the socioeconomic point of view, a solid manufacturing and agricultural profile emerges as well as a significant presence of services that are suitable for people and businesses. More specifically, *Italia di mezzo* is the territory in which we can find the most important number of municipalities in the de jure industrial districts, although the significant presence of immigrants who have settled there is less obvious. Immigration is a strong presence linked to the employment of medium-low labour offered by the manufacturing / agricultural industry and personal services. A further common connotation is of a morphological-environmental type, far from the images of metropolitan polarities and those of sparsely populated inner areas. Overall, this very Italy is characterised by three settlement patterns: the first one encompasses territorial portions where a geography of urban nuclei, medium-sized or urban-rural cities and small towns is combined with many urbanised strands connected to each other. The second pattern relates to complex linear urbanisations (which incorporate various medium-sized coastal centres), whereas the third one refers to territories of widespread urbanisation (outside metropolitan areas).

In the various "Italies" investigated in this paper, two dynamics are combined: social polarization and the consolidated and recent demographic contraction. At the same time, being both in metropolitan Italy and inland areas, each of these dynamics in *Italia di mezzo* takes on its own specificity. Looking at social and economic indicators, *Italia di mezzo* has different profiles. A portion of the territory ranks in national average values such as the index of families in need of assistance, that of single-income families with

children under the age of six and the old age index. In some more limited cases, the values of social indicators reflect situations of lesser or greater discomfort; however, they maintain significant internal differences (especially with the classic distinction between north and south, where social distress is more concentrated with some exceptions). Following a long season of population and construction growth, which affected the metropolitan fringe territories to the detriment of metropolitan Italy and medium-sized cities, this process was reversed after 2011, highlighting a return to the centre. Most of the widespread urban-rural continuum seem to bring their behaviour closer to inland areas, marking the beginning of a new contraction that can be read in the trend of the population, employees, and value of the real-estate market. This contraction is undoubtedly linked to a re-centralisation of employment itself but is partly related to the residential preferences of urban inter-municipal markets. It is not a matter of homogeneous behaviours, especially since there are different critical situations in contrast to these dynamics: sometimes tourist filling, replacing residential filling, or actual depopulation.

Italia di mezzo has within it a little-recognised but fairly widespread combination of environmental discomfort and settlement malfunction. Above all, it becomes a critical issue because of its internal environmental problems. In this regard, it should be noted that this fragment of Italy records the highest percentage of the surface area occupied by polluted sites of environmental interest and the number of industrial plants with relevant risk of accident (RIR). The values of PM10, PM2.5 and NO2 reach very high indices, sometimes similar to those of some highly polluted metropolitan cities, especially those of the Po Valley. To these critical issues, the increased land consumption is added, albeit not with as relevant values as in the past. Still, substantial for already highly urbanised contexts, characterised by a strong dependence on cars for mobility.

What is perhaps the most perceived fragility condition in these territories remains to be explored. It is not a matter of the environmental-settlement condition, and it is not related to given socioeconomic patterns, but it is linked to an evolutionary trajectory. We are witnessing a transition from thirty years of solid growth (1960s–1990s) to twenty years of stagnation to more recent years which, although not everywhere, are marked by processes of relegation. A significant indicator is the unprecedented demographic contraction and perhaps a reduction in income from dependent and self-employed work, which is a hypothesis yet to be verified. Against this background, favouring multi-sectoral policies more attentive to socio-cultural and urban-environmental aspects is needed. We are witnessing a socio-demographic transition of the *Italia di mezzo* and the formation of new social fractures and differences within it. The increasingly different situations require new interdisciplinary analyses and interpretations. Producing scientific evidence becomes, then, fundamental also to support the initiatives of local authorities, increasingly faced with structures of municipal governance unable to address issues that are systemic, exogenous and conjunctural. It is also essential to connect a topological gaze, such as the one developed so far in this article, to a relational gaze in order to configure the *Italia di mezzo* territories no longer as simply middle or in-between, but as a possible intermediary and hinge between metropolitan areas and inland areas. On the one hand, they can provide assistance and support to less densely populated areas; on the other hand, by exploiting their infrastructural, social and accessibility capital, they can offer opportunities for decongesting the densest metropolitan areas.

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A Appendix:

Table A.1: List of indicators

Indicators	Year	Unit of measure	Source	Description
socio-demographic				
Old-age index	2018	index	ISTAT (A misura di comune)	Percentage ratio of the population aged 65 and over to the one aged 0-14
Incidence of adults with a diploma or degree	2011	%	8milaCensus ISTAT	Percentage ratio between the resident population aged 25-64 with a high school diploma or university degree and the resident population aged 25-64
Incidence of foreign residents	2011	‰	8milaCensus ISTAT	Incidence of foreign residents per 1,000 Italian residents as of 9 October 2011
Incidence of foreign residents	2019	‰	DemoISTAT	Incidence of foreign residents per 1,000 Italian residents as of 1 January 2019
Incidence of families with potential economic hardship	2011	%	8milaCensus ISTAT	Percentage ratio between the number of families with children with the reference person aged up to 64 in which no member is employed or retired from work and the total number of families
Incidence of young people outside the labour market and training	2011	%	8milaCensus ISTAT	Percentage ratio of residents aged 15-29 in a non-professional status other than students to residents of the same age
Incidence of families in need of assistance	2011	%	8milaCensus ISTAT	Percentage ratio between the number of families with at least two members, without cohabitants, with all members aged 65+ with at least one member aged 80+, and the total number of households.
Percentage change in resident population 2011–2019	2011–2019	%	ISTAT	Percentage change in resident population 2011 (9 October) – 2019 (31 December).
Natural balance 2011–2018 per 100 initial residents	2011–2018	%	DemoISTAT	Natural balance 2011 (9 October) – 2018 (31 December) per 100 initial residents
Migratory balance 2011–2018 per 100 initial residents	2011–2018	%	DemoISTAT	2011– 2018 migratory balance (9 October) – 2018 (31 December) per 100 initial residents

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Table A.1: List of indicators (continued)

Indicators	Year	Unit of measure	Source	Description
Change in the old-age index	2011–2019	index	ISTAT	
socio-economic				
Per capita gross income	2015	€/year	ISTAT (A misura di comune)	Total gross income of registry families / number of members of registry families.
Number of large active companies per 1,000 employees in the municipality	2017	‰	ISTAT-Asia	
Percentage of employees in the manufacturing sector 2017	2017	%	ISTAT-Asia	Percentage ratio between the number of employees in the Ateco C sector and the total number of employees in active Uls (Unità Locali– Local units)
Percentage of employees in the advanced services sectors	2017	%	ISTAT-Asia	Percentage ratio between the number of employees in the Ateco J, K, M sectors and the total number of employees in active Uls (Unità Locali– Local units)
Percentage of employees in the social and health sectors	2017	%	ISTAT-Asia	Percentage ratio between the number of employees in the Ateco P, Q sectors and the total number of employees in active Uls (Unità Locali– Local units)
Municipality in an industrial district	2011	0/1	ISTAT	Municipality that is or is not part of one of the 2011 industrial districts defined by ISTAT
Percentage of real-estate units reached by ultra-broadband 30Mb	2016	%	ISTAT (A misura di comune)	Real-estate units reached by the broadband / Total real-estate units per 100
Single-income households with children under the age of 6	2015	‰	ISTAT (A misura di comune)	Households in which there is at least one minor under the age of 6 and a single income earner / Single-income households per 100

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Table A.1: List of indicators (continued)

Indicators	Year	Unit of measure	Source	Description
Gaps in pre-tax income	2015	index	ISTAT (A misura di comune)	Ratio of the income of the richest households to the income of the poorest households. Total equivalent pre-tax income owned by 20% of those registered in the registry with the highest income / Total equivalent pre-tax income owned by 20% of those registered in the registry with the lowest income
Percentage variation of employees	2012–2017	%	ISTAT-Asia	
Percentage change in the manufacturing sector	2012–2017	%	ISTAT-Asia	
Percentage change in the advanced services sector for production and business	2012–2017	%	ISTAT-Asia	
Percentage variation of employees in the social and health sectors	2012–2017	%	ISTAT-Asia	
Percentage of agricultural area used (SAU) of the total municipal area	2010	%	Istat Censimento Agrocultura	
real estate				
Percentage of use of buildings	2011	%	Censimento ISTAT	Percentage ratio between unused buildings and total buildings
Percentage of use of real estate owned by municipalities	2016	%	AdE-MEF	Percentage ratio between the sum of unusable properties and unused properties owned by the municipality and the total buildings owned by the municipality
Average purchase and sale value of residential properties	2019, I sem.	€/m^2	AdE-MEF	Average purchase and sale values (max + min / 2) of properties in normal condition of all residential types

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Table A.1: List of indicators (continued)

Indicators	Year	Unit of measure	Source	Description
Percentage change in the average purchase and sale value of residential properties	2012–2019, I sem.	%	AdE-MEF	Percentage change between the first half of 2012 and the first half of 2019 in the municipal average purchase and sale value of residential properties
environmental				
Artificial land cover per capita	2018	m^2/ resident	ISPRA	
Percentage of municipal area occupied by "sites of national interest" (SIN)	2014	%	Ministero dell'Ambiente e della Tutela e del Mare (from Atlante web dei territori post-metropolitani)	
Maximum value of the maximum ground acceleration of the values of the grid points falling within the municipal area	2004	cm/s2	INGV (from ISTAT-Casa Italia: Mappa dei rischi dei Comuni Italiani)	Maximum ground acceleration (50th percentile) calculated on a grid with 0.02° step: maximum (MAX) of the values of the grid points falling within the municipal area
Percentage of resident population at risk in areas with average hydraulic hazard - P2	2017	%	ISPRA (from ISTAT-Casa Italia: Mappa dei rischi dei Comuni Italiani)	
Total number of industrial plants with relevant risk of accident (RIR)	2015	num	Ministero dell'Ambiente e della Tutela e del Mare (from DiPE: Urbanindex.it)	
Ozone pollutants (O3)	2016	µg/m^3	Copernicus	Average value for the ozone (O3): AOT40, AOT60, SOMO35, T40, T50, T80, T120, T240
Pollutants Nitrogen dioxide (NO2)	2016	µg/^{3}	Copernicus	Average value for nitrogen dioxide (NO2): T40, T200, T400
Pollutants Particulate Matter 10 microns (PM10)	2016	µg/^{3}	Copernicus	Average value for Particulate Matter 10 microns (PM10): T40, T50, T80.

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Table A.1: List of indicators (continued)

Indicators	Year	Unit of measure	Source	Description
Pollutants Particulate Matter 2.5 microns (PM2.5)	2016	µg/^{3}	Copernicus	Average value for Particulate Matter 2.5 microns (PM2.5): T25
Per capita land take in the period 2012–2018	2012–2018	m^2/ resident	ISPRA	Artificial land cover 2018 - Artificial land cover 2012 / Resident population 2018

Table A.2: Descriptions of the Italian municipalities

Municipalities	Description
ultra-peripheral municipalities	The municipalities that are part of the classification: SNAI Ultra-Peripheral Municipalities with more than 5,000 inhabitants; SNAI Ultra-Peripheral Municipalities with 5,000 or fewer inhabitants. Considered peripheral are the municipalities that are part of the classification: SNAI Peripheral Municipalities with more than 5,000 inhabitants; SNAI Peripheral Municipalities with 5,000 or fewer inhabitants. Considered intermediate are the municipalities that are part of the classification: totally mountainous SNAI intermediate municipalities with more than 10,000 inhabitants; Totally mountainous SNAI intermediate municipalities with 10,000 or fewer inhabitants.
large de facto and de jure metropolitan areas	The municipalities that are part of the classification: Municipalities in Cities of FUA Large Metropolitan OECD capitals of Metropolitan Cities (Naples, Rome, Turin, Milan); Municipalities in Cities of FUA Large Metropolitan OECD, not capital cities; Municipalities in Commuting zones of FUA Large Metropolitan OECD included in Metropolitan Cities.
de facto and de jure metropolitan areas	The municipalities that are part of the classification: Municipalities in Cities of FUA Metropolitan OECD included in Metropolitan Cities (Cagliari, Palermo-Bagheria, Catania, Bari-Bitonto-Molfetta, Florence, Genoa, Bologna, Venice); Municipalities in Commuting zones of FUA Metropolitan OECD included in Metropolitan Cities.
de facto or de jure Metropolitan Area Centres	Considered de facto or de jure Metropolitan Area Centres are the municipalities that are part of the classification: Municipalities in Cities of FUA Metropolitan OECD not included in Metropolitan Cities (Bergamo, Brescia, Verona, Padua, Parma, Reggio Emilia, Modena, Perugia, Prato, Taranto); Municipalities in Cities of FUA Medium OECD capitals of Metropolitan Cities (Messina, Reggio Calabria)

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Table A.2: Descriptions of the Italian municipalities (continued)

Municipalities	Description
de facto but not de jure metropolitan areas	The municipalities that are part of the classification: Municipalities in Cities of FUA Large Metropolitan but outside Metropolitan Cities (valid only for Milan); Municipalities in Commuting zones of FUA Large Metropolitan but outside Metropolitan Cities; Municipalities in Commuting zones of Metropolitan FUA but outside Metropolitan Cities; Municipalities in Commuting zones of FUA Medium included in Metropolitan Cities; Other Municipalities with more than 50,000 inhabitants in Metropolitan Cities; Other Municipalities with populations between 20,001 and 50,000 inhabitants in Metropolitan Cities; Other Municipalities with populations between 5,001 and 20,000 inhabitants in Metropolitan Cities; Other Municipalities with 5000 inhabitants or less in Metropolitan Cities.
cities with functional centrality	The municipalities that are part of the classification: Municipalities in Cities of FUA Medium and Small OECD provincial capitals (Alessandria, Asti, Novara; Como, Cremona, Lecco, Pavia, Varese; Treviso, Vicenza; Bolzano, Trento; Savona, La Spezia; Ferrara, Forlì, Piacenza, Ravenna, Rimini; Pordenone, Udine, Trieste; Arezzo, Grosseto, Livorno, Massa, Pisa; Terni; Ancona, Pesaro; Latina; L'Aquila, Pescara; Campobasso; Avellino , Caserta, Salerno; Andria, Barletta, Brindisi, Foggia, Lecce with Surbo, Trani; Matera, Potenza; Catanzaro, Cosenza; Gela, Ragusa, Syracuse, Trapani; Sassari); Municipalities Cities of FUA Medium and Small OECD that are not provincial capitals (Gallarate, Carpi, Sassuolo, Battipaglia, Cerignola, Bisceglie, Gela).
traditional medium-sized cities	The municipalities that are part of the classification: Capital cities with more than 50,000 inhabitants (Cuneo, Rovigo, Cesena, Lucca, Pistoia, Siena, Viterbo, Benevento, Teramo, Chieti, Agrigento, Caltanissetta, Crotone, Olbia); Non-regional centres with more than 50,000 inhabitants (Sanremo, Faenza, Fano, Carrara, Viareggio, Foligno, Cava de 'Tirreni, Manfredonia, San Severo, Lamezia Terme, Marsala, Modica, Vittoria); Provincial capitals with between 20,001 and 50,000 inhabitants (Aosta, Biella, Verbania; Vercelli, Sondrio, Mantua; Belluno; Gorizia; Imperia; Ascoli, Macerata, Fermo; Rieti, Frosinone; Vibo Valentia; Enna; Nuoro, Carbonia, Iglesias, Oristano).
minor poles	The municipalities that are part of the classification: Other municipalities Polo SNAI with 50,000 or fewer inhabitants; Other municipalities SNAI inter-municipal hub with 50,000 or fewer inhabitants.
suburban belt municipalities	The municipalities that are part of the classification: Other municipalities SNAI belt with more than 10,000 inhabitants; Other municipalities SNAI belt with 10,000 or fewer inhabitants.
intermediate municipalities	The municipalities that are part of the classification: Other SNAI intermediate municipalities with more than 10,000 inhabitants; Other municipalities Intermediate SNAI with 10,000 or fewer inhabitants.

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Prediction Models and Testing of Resilience in Regions: Covid19 Economic Impact in USA Counties Case Study

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Abstract. A significant amount of research has been conducted regarding the resilience of the regions and the factors that contribute to allow them to face challenges, crises, or disasters. The rise of promising sectors like Machine learning (ML) and Artificial Intelligence (AI) can enhance this research using computing power in regional economic, social, and environmental data analysis to find patterns and create prediction models. Through Machine Learning, the following research introduces the use of models that can predict the performance of a region in disasters. A case study of the performance of USA Counties during the Covid19 first wave period of the pandemic and the related restrictions that were applied by the authorities was used in order to reveal the obvious or hidden parameters and factors that affected their resilience, in particular their economic response, and other interesting patterns between all the involved attributes. This paper aims to contribute to a methodology and to offer useful guidelines in how regional factors can be translated and processed by data and ML/AI tools and techniques. The proposed models were evaluated on their ability to predict the economic performance of each county and in particular the difference of its unemployment rate between March and June of 2020. The former is based on several economic, social, and environmental data -up to that point in time- using classifiers like neural networks and decision trees. A comparison of the different models' execution was performed, and the best models were further analyzed and presented. Further execution results that identified patterns and connections between regional data and attributes are also presented. The main results of this research are i) a methodological framework of how regional status can be translated into digital models and ii) related examples of predictive models in a real case. An effort was also made to decode the results in terms of regional science to produce useful and meaningful conclusions, thus a decision tree is also presented to demonstrate how these models can be interpreted. Finally, the connection between this work and the strong current trend of regional and urban digitalization towards sustainability is established.

Key words: Regions, Resilience, Covid19, Machine Learning, Prediction Models, USA, Counties, Restrictions, Economic Impact, Unemployment rate

1 Introduction

Extensive research has been conducted regarding the resilience of the regions and the factors that contribute to allow them to face challenges, respond and recover from disturbances, crises, or disasters. There is a vast amount of related literature available.

This study aims to:

- create models through Machine Learning that predict the performance of a region in disasters to find the parameters/factors (confirm obvious from classic regional approaches or show hidden from data) that affect the resilience of the regions.
- mainly contribute to a methodology and offer useful guidelines on how regional factors can be translated and be processed by data and ML/AI tools and techniques.

1.1 The notion of resilience

The notion of resilience has recently gained more popularity due to the extended economic crises that most of the entire world faced in the last decades and the recent health crisis due to Covid19. Originally, resilience was used in engineering and ecology (Holling 1973), but since then, the concept has been used in many fields including regional economics. Half of the world's population resides in cities, with urban population expected to reach 70% of the global population by 2050 (United Nations 2016). Urban areas serve as locations that drive sustainable development, equality, inclusivity, cultural diversity, and are centers for innovation (Dhar, Khirfan 2017, Pickett et al. 2004). The recent economic and health crisis along with ecosystem pressure, climate change, migration, and other issues have increased the impact of urban crises. Therefore, the community resilience concept and corresponding mechanisms to build resilience on the community's complex systems have become popular (Abdul-Rahman et al. 2021). In addition, developing Community Resilience Assessment (CRA) tools is attributed to building a sustainable world (Seeliger, Turok 2013).

Regional resilience has been defined in many forms. A definition of regional resilience is the one proposed by Foster (2007). According to Foster (2007), it is the "ability of a region to anticipate, prepare for, respond to, and recover from disturbance". Bristow (2010)Bristow (2010) defines resilience as "the capacity of a system to absorb disturbance and reorganize while undergoing change, so as to still retain essentially the same function, structure and feedbacks". Kallioras (2011) argues that "resilience of a region is measured based on the evaluation of its ability to maintain a successful path of development after a disturbance, whether success is perceived in terms of traditional indicators such as growth or change of employment, or in terms of a synthetic index". According to Proag (2014), the concept of the regional resilience takes two broad forms: (1) hard resilience: the direct strength of structures when placed under pressure such as increasing the resilience of a structure through specific strengthening measures to reduce their probability of collapse, and (2) soft resilience: the ability of systems to absorb and recover from the impact of disruptive events without fundamental changes in function or structure, which depend on the flexibility and adaptive capacity of the system as a whole, rather than simply strengthening structures or institutions in relation to specific stresses, as in the hard resilience approach The most basic ways regions respond after each disorder are resistance, recovery, re-orientation, and renewal or resumption (Martin 2012). However, Pendall et al. (2010) argue that "regions face two main categories of disturbance: shocks and slow burns". In addition, according to the degree of resilience in a disturbance, regions are classified by three main categories (Briguglio et al. 2006, Hill et al. 2008):

- Economically resilient regions that improve or at least return to their original condition
- Shock-resistant regions that withstand and don't "escape" from their course
- Non-resilient regions which cannot return to their original state

The measurement of resilience is not an easy exercise, as this depends on the specific system under study and the ways that resilience is considered or requested to be calculated, either qualitatively or quantitatively. A qualitative assessment is useful to understand the current situation while quantitative measures give quantified estimates of performance that may be more meaningful to stakeholders e.g., policy makers seeking for parameters and values or researchers studying specific fields in the region (Proag 2014).

There are several different methodologies or complex indicators proposed in the literature or by authorities that measure resilience. They mainly involve economic, environmental, societal indicators, statistical analysis, and comparison with parameters strongly related to resilience, such as GDP and employment. The aim is to identify the drivers of crisis recovery and investigate the structural characteristics of the regions. Efforts are also made for a common framework. For example, a relevant technical report by the Joint Research Centre (JRC), which is the European Commission's science and knowledge service, proposes a simple 'handy' composite Regional Resilience Indicator to measure and monitor economic system resilience at the regional level in order to facilitate a common and easy understanding of this complex and dynamic process. This approach extends the existing theoretical framework and contributes to resilience a well-defined life cycle. The composite indicator weights have been attributed through weight elicitation techniques built upon principal component analysis (Serpieri, Pontarollo 2018).

In this study, the authors are exploring a hybrid (both qualitative and quantitative) assessment of the resilience. We are attempting to assess regional response to shock, classifying regions (counties) mainly in the range of the last two categories (shock resistant and non-resilient) without absolute correspondence, while also exploring the parameters that may affect this assessment and classification, which can then be used for policy making or research.

1.2 Machine Learning and Resilience

The rise of promising sectors in computer science such as Machine learning (ML) and Artificial Intelligence (AI) can boost many fields of research from e.g., medical applications and diagnosis (Shehab et al. 2022, Ahsan, Siddique 2022, Qezelbash-Chamak et al. 2022), to drug discovery (Patel, Shah 2022), and cybersecurity (Berghout et al. 2022). This also includes topics in the general framework of regional science, such as construction and infrastructure applications or seismic performance (Mirzaei et al. 2022, Mangalathu et al. 2022), regional crop yield forecasting (Paudel et al. 2022), spatio-temporal modeling of urban growth (Kim et al. 2022), and visual analyses of regional economy (Bai et al. 2022). The use of ML and the increasing computing power can support regional research to expand beyond the classic math, quantitative methods, and statistical analysis. It can contribute to the automation of searching, creating, calculating, and validating models, though hidden paths and by performing correlations and combinations which their execution would consume unrealistic time with the classic manual tools. Thus, ML can be applied in regional -economic, social, and environmental- data, to find patterns, forecast, and develop prediction models, contributing to policy making and strategic planning.

According to relevant literature the relation between statistics and machine learning consists of an increase in data complexity and the number of input variables and their possible associations make classical statistical inference less tractable and precise. While in such cases we could use ML approaches instead to fill in the unobserved aspects of the system while being effective even when the data are gathered without a carefully controlled experimental design and in the presence of complicated nonlinear interactions (Bzdok et al. 2018). In similar cases, we could also use ML to extract information from data more effectively (Zhang et al. 2022). ML tools and techniques provide means for empirical validation e.g., machine learning proved to be essential in understanding and linking indicators and indices to policy, resilience, and empirical data, contributing to a better understanding of climate resilience (Feldmeyer et al. 2020). ML tools can expand the capabilities of traditional models e.g., capture nonlinear effects which are not detected by traditional econometric models. This has been demonstrated by detecting important factors and nonlinear relationships between regional GDP per capita and Higher Education Systems indicators that have provided useful insights and suggestions for policymakers (Bertoletti et al. 2022) or to incorporate spatial, contemporaneous, and historical dependencies e.g., lead-lag non-linear relationships among past urban changes in each region and its neighbors (Kim et al. 2022). As indicated above, the discussion in literature of comparing traditional models (mainly statistical) with ML models is active. In many applications, ML models performed better than statistical models, e.g., predict particulate matter (Kulkarni et al. 2022) or suicides (Grendas et al. 2022). ML

models have improved the existing models when combined with statistical ones, e.g., Alzheimer's disease (Tan et al. 2021). They have also optimized model calibration (Amroun et al. 2022). Although the core of these techniques uses mathematical models; the field of the search is significantly expanded by the acceleration and automation provided by computers.

As mentioned, data techniques used in various cases can be found in the literature, mainly concerning specific and more focused fields or topics than general ones. Until recently, related research of using ML tools in regional science focused on overall sustainability and performance, and resilience of regions had been limited, especially compared to other fields such as medical applications. In recent years, the standard has transitioned to a comprehensive and overall study of regions and areas using such tools e.g., using decision trees for regional Development Classification Models (Munandar, Winarko 2015). A recent study of resilience focused on earthquakes using historical data from previous seismic events and long-term historical behavior of regions (Fantechi, Modica 2022) is another example of combining traditional econometric with ML techniques (Bertoletti et al. 2022), which can apply ML to land-use change modeling (Kim et al. 2022). ML is also expected to play a major role in building better and modern Community Resilience Assessment tools by incorporating the use of big data, machine learning, and artificial intelligence to take care of spatio-temporal dynamism (Abdul-Rahman et al. 2021).

The paper adds to the debate on regional resilience by introducing the use of models through the utilization of Machine Learning. For this purpose, we use ML techniques to predict the performance of regions under shock, identify the more important attributes, and propose a methodological framework of how regional status can be translated into models. The paper is structured whereas the next section (Section 2) presents the methodology in detail, including the defined time period, the case study, the data sets, the variables, and the models used. Section 3 presents the analysis and the results of models' development and execution, whilst Section 4 illustrates the conclusions and future directions.

2 Methodology

2.1 The Case Study

This paper will focus on economic impact of Covid19 in USA Counties and in particular their change of unemployment rate during the first wave of pandemic and the related restrictions to examine the implementation of machine learning techniques and related ways/methodology to achieve this. The overview of the case is presented in Table 1 and it will be further analyzed in the next chapters.

The period between March and June of 2020 is termed the "Disaster Period" and defines the event studied for the selected regions in terms of their resilience and especially for this case, their ability to handle the increase of unemployment during the restrictions period. The information and related data that exist until the start of this period are considered as the current situation of the regions. These are considered as the input of the models. On the other hand, changes in values of various regional statistics during the disaster period -or values just after the end of the period- indicate how much they were affected -absolutely and comparatively- and thus are considered as performance and resilience indicators and as the output for the models.

2.2 Data Semantics and Dimensions

The current research mainly studies the response of the unemployment rate -not as unique but as a commonly accepted indicator of economic performance- in the specific disturbance defined as first wave and related restrictions of Covid19. Resistance and recovery belong to the current field of research due to both being types of regional responses. The results of the prediction models can contribute to the determination of resistance and recovery, and therefore to the degree of resilience of the areas.

In addition to the challenge itself (the efficient operation of machine learning models in regional science), great challenges are also identified in finding and properly adapting

Table 1: Case Study Details

Disaster Period: First wave of Covid19 - First Period of Restrictions and Impacts; March 2020 – June 2020 (4 months)

Disaster amplitude: Stay at home order restrictions start from March 2020 and duration up to 4 months

Input/Output

Input: Statistics regarding demographics, economy, business & industries, commuting & mobility, health, social, geographical, and other factors per county. Mainly referred in the 2019-2018 records/status and in percentages of the county's totals.

Output: Change of Unemployment Rate (March 2020 – July 2020) per County

Includes/Excludes

Includes: All the counties of USA (mainland, 3107 counties with mean population 104k)

Excludes: States of Alaska, Hawaii, and Puerto Rico (not in mainland) County Rios Aribas in New Mexico (due to data issues)

Testing Tool: Weka Platform – University of Waikato; Weka is an open-source machine learning software, widely used for teaching, research, and industrial applications (Frank et al. 2016).

available data to make the tested and applied techniques work. Appropriate input and output of the models should be clearly defined and selected with right semantics and dimensions. In this direction, the following should be defined:

- The time frame of "disaster period" for which resilience and correspondence of areas are studied: in this case, the disaster period is defined as the first Covid wave and the related stay-at-home orders of the states and in some cases of the counties (autonomously), which are generalized in the USA at the time between March and June of 2020.
- The amplitude of the disaster: as an assumption is related mainly to the duration of the restriction's orders (the longer the restriction period, the greater disaster) and secondary to their starting date (not so much concerning the disaster size, but as an extra comparison indicator for similarity between disasters of different counties). As we study the resilience and mainly the economic impact on the areas, pandemic data such as cases and deaths were considered irrelevant (or indirect factors), while the focus was on the restrictions that were raised by authorities (probably implied and forced by cases and deaths. If the resilience of the health system(s) was studied, then these parameters could be considered as direct) and have affected directly the businesses and the mobility of the counties. Other related data e.g., number of business closed or other market related parameters were strongly considered to be part of the research, but their collection was not possible due to unavailability. Therefore this is considered to be part of future research focused in regions where the related data are available.
- The areas/regions: in this case US Counties will be defined as different instances of the structure defined below.
- The data set as the set or subset of the instances (areas/regions) used to train and test the model: in this case the subsets as defined in Subsets of examination test.
- The data:
  - Appropriate input/output as attributes (values per instance) which together constitute the basic data structure:
    - input as current state: most recent stats before the start date of disaster period or constants/slow changing characteristics of the counties
    - output as performance indicators: to be the change of examined value during disaster period (or similar metrics taking into consideration seasonal adjustment).

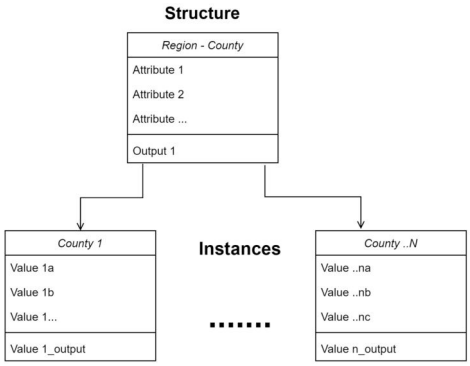
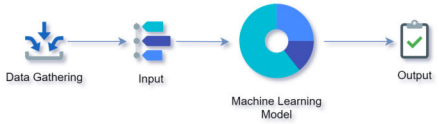


Figure 1: Structure of data



Note: graphs created in app.diagrams.net

Figure 2: Flow of the Models

  - Output attributes should be clustered properly as the models are better in predicting clusters of performance and not specific values (good or bad performance). Cluster could be applied with specific techniques e.g., K-Means or by just filtering values e.g., greater or smaller than a value.
  - Both input/output attributes should be proportional and representative meaning that date should be percentages and some other absolute numbers depending on their nature and meaning.

- Data regarding and during the "disaster period", disaster amplitude, and/or regional characteristics to find similar -in this case same restrictions due to Covid19 and/or similar population- cases/areas to define the data set required as referred above, to be studied.

Figure 1 presents the structure of data -attributes and instances- while an overall scheme of the model's flow is displayed in Figure 2.

2.3 Subsets of examination test

In the framework of the preliminary and main research of this study, several subsets were tested (with several criteria such as similarity or variance of population, Covid restrictions, counties in Neighboring or similar e.g., coastal states) in order to explore the application of ML models. There are unlimited sets and subsets that can be tested or demonstrated; most of which are very difficult to result in efficient prediction models. The research and comparison of different data sets and the effect of their similarities or differences in the models is included in our future research. Within the scope of this paper and based on the results of the execution, the two subsets below were selected as indicative to present our main methodology and the factors taken into consideration while translating real- life information to data sets for the purpose of machine learning techniques. To differentiate between data sets, the desire was to display that models can be created in both types of models (general or more focused with similar population category and disaster amplitude). That is why these two subsets were selected.

Subset A is a generic subset, from all the available US counties, of counties that performed "good" or "bad" during the restrictions. Subset B is more homogeneous as it includes counties that performed "good" or "bad" but also maintain a large population

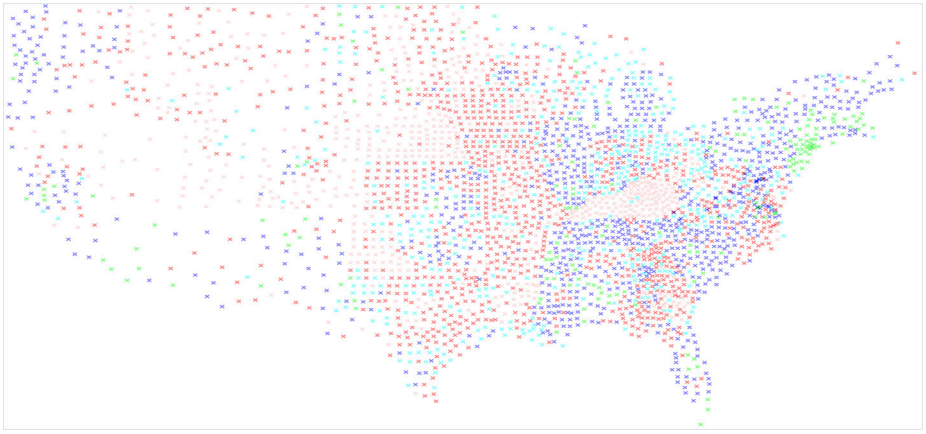


Figure 3: From WEKA: Indicative Map of US Counties

(100k and above). Counties in subset B had more similarities in the amplitude of the disaster faced (stay-at-home-order duration and when order declared).

The subsets were tested to create models predicting good or bad performance in their output, meaning the increase of unemployment rate during disaster period for the counties included.

Subset A: counties that:

- performed good (0-0,7%) or bad (7% and over increase of Unemployment Rate)
- from all available counties
- therefore 377 counties/instances

Subset B: counties that:

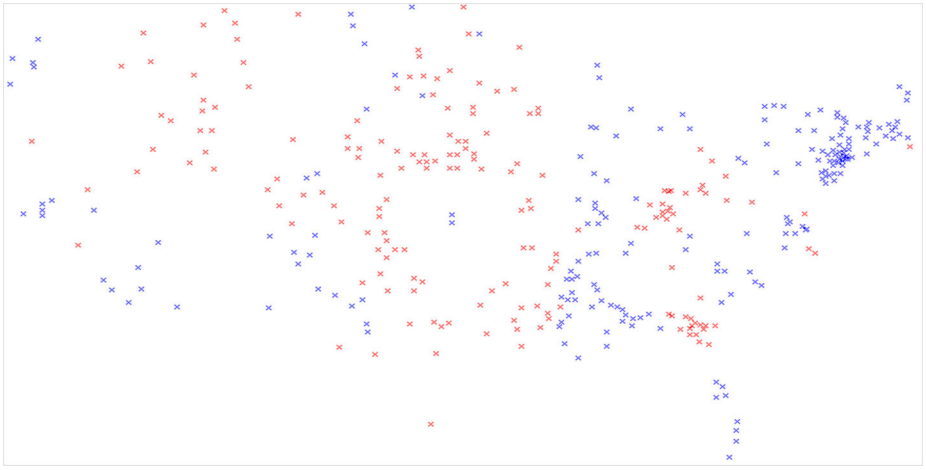
- performed good (under 2,5%) or bad (6% and over increase of Unemployment Rate)
- from counties with population > 100k and same restrictions (17-40% of the disaster period covered with stay-at-home-order and order declared soon in the first 4,5% of the period)
- therefore 89 counties/instances

Figure 3 is an indicative USA map with all the counties, Figures 4 and 5 present the specific subsets A and B of counties defined in that map.

2.4 Attributes selection and values

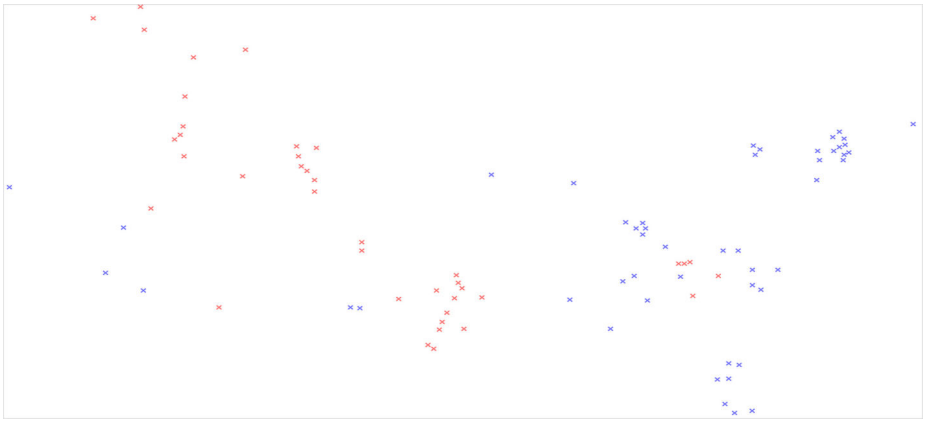
The selection of the appropriate attributes referred to in Section 2.2 is crucial to apply ML models and provide useful results. Below the selection of the three main types of data is discussed, while Appendix A displays the list of the selected attributes used in the models' execution, along with description and sources.

- Input attributes were selected based on demographic, industrial, employment, commute, and mobility, social, environmental, and health sector factors. As already mentioned, data mostly consists of percentages but sometimes absolute numbers dependent on their nature. Also, for the use of a-priori technique to find rules, data were converted from numerical into classes. The selection of the attributes and/or their type/category is generally based on regional science and literature in both fields of theory and on specific examples of indicators used in models (e.g., Feldmeyer et al. 2020, Jackson et al. 2019, Munandar, Winarko 2015). The search for useful attributes was performed in many factors affecting regional resilience. As



Note: bad in blue, good in red

Figure 4: From WEKA: Subset A – 377 Counties Performance



Note: bad in blue, good in red

Figure 5: From WEKA: Subset B – 89 Counties Performance

proposed by Christopherson et al. (2010), it is important each factor to be different in each region and some examples are a diversified economic base, the existence of competitiveness, a regional system that supports innovation and learning, partnerships, supportive financial system, modern production base which has modern infrastructure, an innovative workforce, and of course the existence of a supportive system of governance. Proposed variables estimated to relate pandemic with regional conditions are also taken into consideration (Killeen et al. 2020). Finally, any extra interesting indicator identified was selected and tested. The general approach is the constant addition of several attributes (many times even correlated with each other) to be tested and validated though the ML prediction models. ML models can be effective even when the data are gathered without a carefully controlled experimental design and in the presence of complicated nonlinear interactions (Bzdok et al. 2018).

- Output was clustered to fit prediction models which required output. The discontinuously distinct clusters (like these demonstrated here) seem to have better performance, while the prediction of the continuous ones is a much more complex and difficult problem.

- Other attributes used to cluster counties into interesting subsets to be tested (restrictions and pandemic stats) or other such as geographic coordinates to study the geographical distribution and nature of the findings.

Table 2: Performance of Models

Model	Subset A	Subset B
Multilayer Perceptron	85.15 %	91.01 %
J48	85.41 %	82.02 %
Naive Bayes	79.58 %	86.52 %

Table 3: Multilayer Perceptron Results (tested in subset B)

Model	Classified as Bad	Classified as Good
Real Class Bad	45	4
Real Class Good	4	36

2.5 Models used

In order to execute ML models, counties are defined as Instances having several attributes as Input and an Output Class. Models produced from classifiers try to classify this out class as "good" or "bad" using the input attributes. The model's performance is the percentage of the correctly classified instances to the whole set. The specific techniques seen below were tested. The most interesting cases and these with best performance are presented in detail later in this study:

- Classifiers:
  - Multilayer Perceptron (Neural Network)
  - J48, Random Tree, REPtree (trees)
  - Naive Bayes
  - Decision Tables, JRip, OneR (rules)
  - AdaBoostM1, Attribute Selection (e.g., wrapper selecting best subsets of attributes), Stacking, Bagging (Meta Classifiers)
- A priori (association method, not a classifier, produces rules associating any input/output attribute)

3 Testing and results

3.1 Classifiers models

As discussed, many tests in different models and with different sets of input attributes were tested in the framework of the study. A performance table (Table 2) shows the three most interesting models created in both A and B subsets using selected input attributes, which show the percentage of Correctly Classified Instances using mainly the 10-fold cross-validation. This validation is considered the most valid and complete and it is used to separate the set as: 90% for training and 10% for testing being repeated 10 times so the whole set is tested as 10 independent tests. As displayed, the Multilayer Perceptron and Naive Bayes have a better performance in Subset B (which is the more focused -similar counties- approach), while J48 performs better in the more general Subset A.

Table 3, Table 4 and Table 5 present the full details regarding the best performance tests for every model.

All the models have a very good prediction ability with the Multilayer Perceptron able to correctly predict the performance of 81 out of 89 counties with only eight counties being incorrectly classified (4 as bad, 4 as Good). Although it is not clear without further analysis what factors affected the models' decisions. Therefore, proportionally, the resilience of the counties can be a very useful prediction tool.

Table 4: J48 Results (tested in subset A)

Model	Classified as Bad	Classified as Good
Real Class Bad	174	25
Real Class Good	30	148

Table 5: Naive Bayes Results (tested in subset B)

Model	Classified as Bad	Classified as Good
Real Class Bad	43	6
Real Class Good	6	34

3.2 Decision Tree alternative use example

Although the decision tree models (J48, Random Tree, REPtree) are mainly used as classifiers (with separated training and testing sets), they can also be used in an alternative way; in tests using the whole set as the training set. This use of trees aims to find patterns and critical attributes and their specific critical values that may affect (or ways that one can understand based on variables) whether a county will have good or bad performance in the disaster period. An example presented below will be displayed and explained. It was trained with the100% of subset, while scoring 96,62% as a tree model. Performance, in the case where the whole set is also the training set, has a different meaning than the classify/prediction rate. It means that tree can find a "way of thinking" to describe, in this example, the performance of 86 counties correctly and only three incorrectly.

The main purpose of the tree is to visualize rules that result in a decision, in this case about whether a county is estimated/predicted to perform good (under 2,5%) or bad (6% and over increase of unemployment rate) during the specific disaster. A simplified visualization of the tree is displayed in Figure 7. It was produced in the Weka machine of the corresponding "code" is presented in Figure 6. We can detect, based on the output of the model, specific factors that can affect the performance of a county. It is also important that we can see specific values involved.

In this specific case, we can see that the commute time and way, vehicles available, and work from home affected the performance and the change of unemployment rate of the counties during the first wave restrictions of Covid-19. Some conclusions that can be produced from the figure are:

- If the presence of people that have a commute time above 30 minutes in their work and they drive alone (attribute: Long Commute Drives Alone) is under or equal to 17% in some county, this means that this county will perform "good".
- If the above is above 17%, but the percentage of people owning 1 vehicle is below or equal to 14,8%, then the (attribute: 1 Vehicle PCT) then by chance 90% (18.0/2.0 referred to the output of Figure 6) this county will perform "good".
- And similar for all the levels of the tree

It may be obvious that some parameters could positively affect the performance of the county (e.g., better commuting conditions will affect a lot of regional aspects including resilience), but models like this provide specific numbers e.g., the referred 17% of long commute driving alone or 0,26% commuting with bicycle. These specific numbers are an additional level of information.

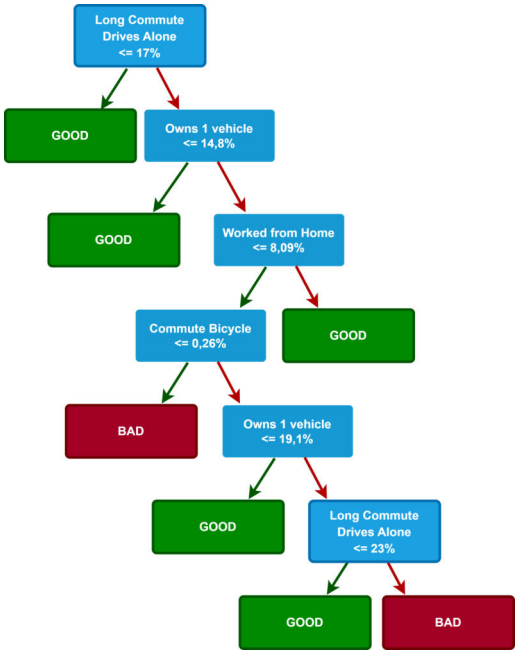
4 Discussion & Conclusion

Based on the work, practices, and approaches described in Section 2, an overall methodological framework (displayed in Figure 8) has been developed. The first step is to find

Weka output: J48 pruned tree

```
Long Commute - Drives Alone_PCT <= 17: good (12.0)
Long Commute - Drives Alone_PCT > 17
|   1_Vehicle_PCT <= 14.8: good (18.0/2.0)
|   1_Vehicle_PCT > 14.8
|   |   Worked from home PCT <= 8.09
|   |   |   Bicycle PCT <= 0.26: bad (33.0)
|   |   |   Bicycle PCT > 0.26
|   |   |   |   1_Vehicle_PCT <= 19.1: good (6.0)
|   |   |   |   1_Vehicle_PCT > 19.1
|   |   |   |   |   Long Commute - Drives Alone_PCT <= 23: good (3.0/1.0)
|   |   |   |   |   Long Commute - Drives Alone_PCT > 23: bad (13.0)
|   |   Worked from home PCT > 8.09: good (4.0)
```

Figure 6: From WEKA: Output - Tree

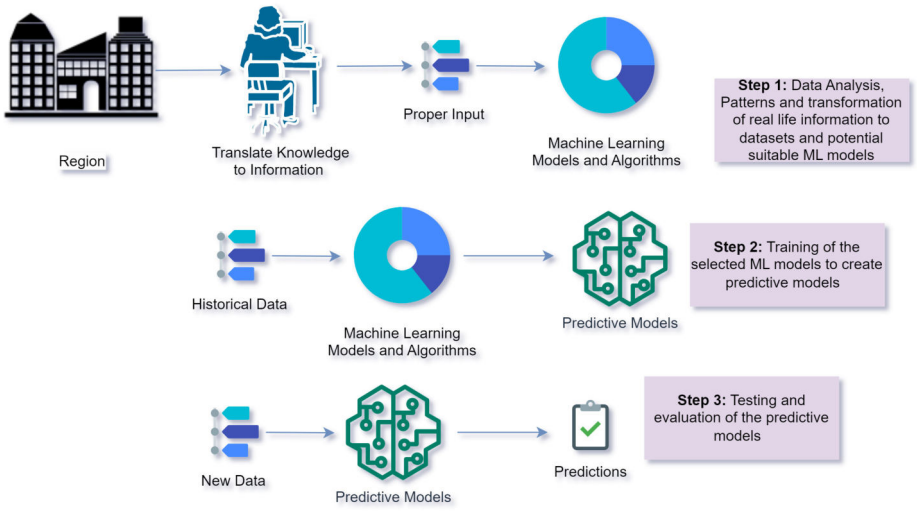


Note: graph created in app.diagrams.net

Figure 7: Decision tree

appropriate study cases (Section 2.1) and translate the regional information to appropriate input for the predictive models. Appropriate input includes forming data sets (Section 2.2) for training and testing the models, as well as the crucial step of defining the appropriate semantics and dimensions of the data (e.g., meaningful input and clustering for the output). Based on these data sets, several machine models can be selected for testing and evaluation. Historical data are used for training the ML models, resulting in some predictive models (step 2), which are then tested and evaluated according to their ability to predict the defined output on new (not used before for the training) input data set(s) (step 3).

This study has created several ML models predicting the performance of a region during disasters and has found parameters that may affect the resilience of the regions. It also has presented the above methodology and useful guidelines in how regional factors can be translated and processed by data and ML/AI tools and techniques, thus creating related models like the ones that have been demonstrated. As for the models, some like the Multilayer Perceptron and Naive Bayes seem to have a better performance in focused and homogeneous data sets, while others such as J48 have better results in general data



Note: graph created in app.diagrams.net

Figure 8: Methodology Overview

sets. Furthermore, although all models have done well in predicting the performance of the counties; decision trees offer more semantics and human readable information from the other models offering specific parameters and values that affect the results and thus may affect the resilience of an area. Multilayer Perceptron and Neural Networks function like "black boxes" and it is difficult to extract information and readable conclusions from their equations.

As for the development of these models using regional, social, economic, and environmental factors and indicators and examining regional properties related to sustainability and resilience; there are challenges on how to properly adjust and translate these real-life data and properties into appropriate data to make ML models work. A key contribution of this study is that it presents a methodology, examples, and practices on how to represent regional factors in terms of data for the input of models (as attributes), the time frame and the amplitude of disaster, and the areas/regions (as instances) forming the required data set. It indicates how to choose the appropriate input and output of the models from this data set, clearly defined and selected with right semantics and dimensions, and how to find and properly adapt the available data to make the tested and applied techniques work.

As for the models' execution and demonstration, it was displayed that creating models for predictions related to regional properties and especially for resilience that having satisfying performances is possible and deserves the attention of the regional scientists and potentially could support decisions in policy making and regional development strategies.

4.1 Future research suggestions and challenges

Data sectors, along with their increasing computing power could support regional research to expand beyond the classic math, quantitative methods, and statistical analysis, contributing to the automation in the development and validation of models though hidden paths and performing correlations and calculating combinations whose calculation using traditional methods would consume an unrealistic amount of time. The added value of ML in other fields and especially in technical issues is already examined in the literature (Section 2.2). The verification of the corresponding added value of ML and its application in the less technical field of regional development is an important field of future further research. Additionally, the appropriate selection of different model types having different performance in different cases and types of test sets (in terms of focused or general, similar, or different regions and amplitude of disasters, small or big data etc.) should be strongly considered. As far as the selection of input attributes is concerned, it

was based on regional science theories. However, any extra interesting indicator that was identified was tested as ML models can handle many parameters independently of their correlation. Specifically, ML models include algorithms for the appropriate selection of sets and subsets of input attributes. They can also calculate any correlation between all input parameters (each other) and any contribution in the output. Therefore, the proposed general approach is the constant addition of several attributes (even correlated) and factors to be tested and validated though ML prediction models. This effort can be further studied to enhance the function of the models measuring the effect of the input parameters, their category, and/or their number in the model's performance. A further analysis should be dedicated to regional dimensions and direct related parameters (e.g., coordinates) by reason that coordinates were not used as input attributes in this study. Another issue that should be studied is the understandability of the ML models created. As discussed, classifiers such as Neural Networks (e.g., Multilayer Perceptron used) function as "black boxes". Thus, we must find ways to decode the models and export valuable and readable information and conclusions about the factors affecting their decisions and the regional resilience. Research in this direction may be combined with statistical analysis or other classic methods. On the other hand, decision trees display specific values and variables indicating factors and values affecting the resilience. A further study should evaluate the true impact of these identified factors. It is of great importance and a great challenge to properly apply regional analysis in all information exported by the ML models and integrate this knowledge smoothly to regional science research. The use of integrated models, combining classical with ML techniques, should and will be strongly considered in our further research. The way that information resulting from predictions can be used is very crucial and the improper use of it can lead to losses instead of benefits (either technically or socially). Technical knowledge and work cannot replace the social, humanitarian, political, and environmental dimensions. This work should be used as a tool with computational and ancillary activity. Despite the challenges, these models that are utilizing the innovations on infrastructures and computer power could enhance and modernize the toolbox of regional analysis (currently mainly based on mathematical offline methods), which could reveal new patterns and regional factors that could enable calculations that were not possible before. Additionally. "real-time" results, information, and predictions could be introduced. These tools and models could be used (or even be the baseline) in the framework of the current trend of digitalization of regions towards sustainability. They could be used to exploit data collected from IoT or crowd sensing platforms, provide related features to digital tools enabling smart and sustainable regions or cities, and therefore support decisions in policy making and regional development strategies.

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A Appendices

A.1 Input Attributes and other variables per County used in the research

NAME OF ATTRIBUTE	DESCRIPTION	SOURCE
POPESTIMATE2019	Estimation of population 2019 – Used mainly to clustering subsets and not as input	https://www2.census.gov
FEMALE_PCT	% of women in population	https://data.census.gov/
Race and ethnicity Percentages	% of people in specific ethnicities	https://www.countyhealthrankings.org
NOT PROFICIENT IN ENGLISH_PCT	% of people	https://www.countyhealthrankings.org
RDOMESTICMIG2019	Net domestic migration rate in period 7/1/2018 to 6/30/2019	https://data.census.gov/
HOUSEHOLD_AVRG_SIZE	average size of households	https://data.census.gov/
Age Groups Percentages	% of people in specific age group	https://data.census.gov/
PRIVATE_WORKERS_PRC	% of workers in the specific type of employment	https://data.census.gov/
SELF_INCORPORATE_WORKERS_PRC	% of workers in the specific type of employment	https://data.census.gov/
PRIVATE_NON_PROFIT_WORKERS_PRC	% of workers in the specific type of employment	https://data.census.gov/
GOV_MUN_FEDERAL_WORKERS_PRC	% of workers in the specific type of employment	https://data.census.gov/
SELF_NON_INCORPO_FAMILY_WORKERS_PRC	% of workers in the specific type of employment	https://data.census.gov/
COMMUTE_TIME_X_Y_PRC	% of people with commuting time to work x to y minutes e.g. 0-14 or 15-30 etc.	https://data.census.gov/
DRIVE ALONE TO WORK PCT	% of people driving alone to work	https://www.countyhealthrankings.org
CAR, TRUCK, OR VAN PCT	% of people with the specific commuting way	https://data.census.gov/
PUBLIC TRANSPORTATION (EXCLUDING TAXICAB) PCT	% of people with the specific commuting way	https://data.census.gov/
WORKED FROM HOME PCT	% of people with the specific commuting way	https://data.census.gov/
NOVENICLE_PCT	% of people with no vehicle	https://data.census.gov/
N_VENICLE_PCT	% of people with N vehicle(s)	https://data.census.gov/
HOMEOWNERS_PCT	% of homeowners	https://www.countyhealthrankings.org
BEST_INDUSTRY_CLASS	Class of the biggest industry (in terms of employment, of the 20 main industry sectors Appendix B – Industries Classes)	https://data.census.gov/
Industry classes percentages	Industry information in the 20 main industry sectors (e.g. proportional size of each class/sector Appendix B – Industries Classes in terms of employment to the whole employment force)	https://data.census.gov/
UNINSURED_ADULTS_PCT	% of population under age 18-65 without health insurance	https://www.countyhealthrankings.org

NAME OF ATTRIBUTE	DESCRIPTION	SOURCE
INCOME_INEQUALITY_-RATIO	Ratio of household income at the 80th percentile to income at the 20th percentile	https://www.countyhealth-rankings.org
SOCIAL_ASSOCIATIONS_-RATE	# of membership associations per 10,000 population	https://www.countyhealth-rankings.org
SOME_COLLEGE_PCT	% of adults ages 25-44 with some post-secondary education	https://www.countyhealth-rankings.org
HEALTH_RATE_FACTOR	A factor combining Adult smoking, Adult obesity, Food environment index, Physical inactivity, Access to exercise opportunities, Excessive drinking, Alcohol-impaired driving deaths	https://www.countyhealth-rankings.org
AIR POLLUTION - PAR-TICULATE MATTER	Average daily density of fine particulate matter in micrograms per cubic meter (PM2.5)	https://www.countyhealth-rankings.org
MEDIAN HOUSEHOLD INCOME 2019	Median Household Income 2019	https://www.countyhealth-rankings.org
ALAND	Land Area – – Used mainly to clustering subsets and not as input	https://www2.census.gov/geo https://www.census.gov/geo-graphies/
INTPTLAT	coordinate – NOT used as input, only for demonstration of results	https://www2.census.gov/geo https://www.census.gov/geo-graphies/
INTPTLONG	coordinate – NOT used as input, only for demonstration of results	https://www2.census.gov/geo https://www.census.gov/geo-graphies/
DEATHS_TILL_JUNE_PCT	% of deaths per population till JUNE 2020 – NOT used as input, only to clustering subsets of datasets – NOT used as input, only to clustering subsets of datasets in the overall research	https://usafacts.org/visuali-zations/coronavirus-covid-19-spread-map/
CASES_TILL_JUNE_PCT	% of cases per population till JUNE 2020 – NOT used as input, only to clustering subsets of datasets in the overall research	https://usafacts.org/visuali-zations/coronavirus-covid-19-spread-map/
DEATHPERCACE_PCT	% of deaths per cases till JUNE 2020 – NOT used as input, only to clustering subsets of datasets in the overall research	https://usafacts.org/visuali-zations/coronavirus-covid-19-spread-map/
STAY_AT_HOME_PCT	% of period with stay-at-home order in power (base: period 1/3/20-30/6/2020) (how much they stay in lockdown) – NOT used as input, only to clustering subsets of datasets A,B	https://en.wikipedia.org/wi-ki/U.S._state_and_local_go-vernment_responses_to_-the_COVID-19_pandemic https://www.nashp.org/gover-nors-prioritize-health-for-all/ https://www.cdc.gov/mmwr/-volumes/69/wr/mm6935a2.htm https://www.finra.org/rules-guidance/key-topics/covid-19/-shelter-in-place
STAY_AT_HOME_START	% of period with stay-at-home order in power (base: period 1/3/20-30/6/2020) (how much they stay in lockdown) – NOT used as input, only to clustering subsets of datasets A, B	https://www.countyhealth-rankings.org/explore-health-rankings/measures-data-sour-ces/2020-measures

NAME OF ATTRIBUTE	DESCRIPTION	SOURCE
DIFF_MAR_JUL_2020	To cluster the main output - % Change of unemployment rate Mar2020 to Jul2020 , NOT used as input	https://data.bls.gov/lausmap/-showMap.jsp
POS_GOOD_BAD	THE OUTPUT	Clustering in DIFF_MAR_JUL_2020 (different for any subset)

A.2 Industries Classes

Industry	Code
Agriculture, forestry, fishing and hunting	C1
Mining, quarrying, and oil and gas extraction	C2
Construction	C3
Manufacturing	C4
Wholesale trade	C5
Retail trade	C6
Transportation and warehousing	C7
Utilities	C8
Information	C9
Finance and insurance	C10
Real estate and rental and leasing	C11
Professional, scientific, and technical services	C12
Management of companies and enterprises	C13
Administrative and support and waste management services	C14
Educational services	C15
Health care and social assistance	C16
Arts, entertainment, and recreation	C17
Accommodation and food services	C18
Other services, except public administration	C19
Public administration	C20

A.3 Counties of Subsets

A.3.1 Subset A

Butler County Alabama, Dallas County Alabama, Greene County Alabama, Hale County Alabama, Lowndes County Alabama, Macon County Alabama, Mobile County Alabama, Montgomery County Alabama, Perry County Alabama, Washington County Alabama, Wilcox County Alabama, Yuma County Arizona, Jackson County Arkansas, Lincoln County Arkansas, Newton County Arkansas, Prairie County Arkansas, Searcy County Arkansas, Sevier County Arkansas, Woodruff County Arkansas, Alameda County California, Contra Costa County California, Kings County California, Los Angeles County California, Mono County California, Orange County California, Riverside County California, Sacramento County California, San Bernardino County California, San Diego County California, San Francisco County California, Siskiyou County California, Solano County California, Archuleta County Colorado, Chaffee County Colorado, Garfield County Colorado, Gilpin County Colorado, Las Animas County Colorado, Logan County Colorado, Mesa County Colorado, Ouray County Colorado, Pueblo County Colorado, Summit County Colorado, Teller County Colorado, Hartford County Connecticut, New London County Connecticut, Broward County Florida, Lake County Florida, Miami-Dade County Florida, Monroe County Florida, Orange County Florida, Osceola County Florida, Palm Beach County Florida, Polk County Florida, Appling County Georgia, Atkinson County Georgia, Bacon County Georgia, Ben Hill County Georgia, Berrien County Georgia, Charlton County Georgia, Clay County Georgia, Clinch County Georgia, Dodge County Georgia, Fannin County Georgia, Glascock County Georgia, Irwin County Georgia, Jeff Davis County Georgia, Long County Georgia, Marion County Georgia, Pulaski County Georgia, Schley County Georgia, Telfair County Georgia, Worth County Georgia, Bingham County Idaho, Bonneville County Idaho, Franklin County Idaho, Gooding County Idaho, Idaho County Idaho, Jefferson County Idaho, Jerome County Idaho, Oneida County Idaho, Shoshone County Idaho, Alexander County Illinois, Boone County Illinois, Coles County Illinois, Cook County Illinois, Franklin

County Illinois, Hardin County Illinois, Jefferson County Illinois, Macon County Illinois, Massac County Illinois, Peoria County Illinois, St Clair County Illinois, Saline County Illinois, Winnebago County Illinois, Orange County Indiana, Chickasaw County Iowa, Crawford County Iowa, Floyd County Iowa, Howard County Iowa, Lyon County Iowa, Sioux County Iowa, Cheyenne County Kansas, Hamilton County Kansas, Sedgwick County Kansas, Stanton County Kansas, Sumner County Kansas, Wichita County Kansas, Barren County Kentucky, Boone County Kentucky, Boyle County Kentucky, Campbell County Kentucky, Fayette County Kentucky, Franklin County Kentucky, Jefferson County Kentucky, Jessamine County Kentucky, Kenton County Kentucky, Knox County Kentucky, Lincoln County Kentucky, Madison County Kentucky, Marion County Kentucky, Mercer County Kentucky, Warren County Kentucky, Beauregard Parish Louisiana, De Soto Parish Louisiana, Franklin Parish Louisiana, LaSalle Parish Louisiana, Orleans Parish Louisiana, Richland Parish Louisiana, Sabine Parish Louisiana, St Helena Parish Louisiana, Union Parish Louisiana, Webster Parish Louisiana, Androscoggin County Maine, Cumberland County Maine, Oxford County Maine, Barnstable County Massachusetts, Berkshire County Massachusetts, Bristol County Massachusetts, Essex County Massachusetts, Franklin County Massachusetts, Hampden County Massachusetts, Hampshire County Massachusetts, Middlesex County Massachusetts, Nantucket County Massachusetts, Norfolk County Massachusetts, Plymouth County Massachusetts, Suffolk County Massachusetts, Worcester County Massachusetts, Calhoun County Michigan, Genesee County Michigan, Muskegon County Michigan, Wayne County Michigan, Aitkin County Minnesota, Brown County Minnesota, Kittson County Minnesota, Le Sueur County Minnesota, Mahnomen County Minnesota, Norman County Minnesota, Yellow Medicine County Minnesota, Chickasaw County Mississippi, Claiborne County Mississippi, Clay County Mississippi, Coahoma County Mississippi, Hinds County Mississippi, Holmes County Mississippi, Humphreys County Mississippi, Issaquena County Mississippi, Jefferson County Mississippi, Leflore County Mississippi, Neshoba County Mississippi, Noxubee County Mississippi, Panola County Mississippi, Quitman County Mississippi, Tunica County Mississippi, Washington County Mississippi, Camden County Missouri, Daviess County Missouri, Hickory County Missouri, Mercer County Missouri, Morgan County Missouri, Shelby County Missouri, Stoddard County Missouri, Beaverhead County Montana, Chouteau County Montana, Judith Basin County Montana, Liberty County Montana, Sweet Grass County Montana, Teton County Montana, Valley County Montana, Adams County Nebraska, Arthur County Nebraska, Buffalo County Nebraska, Cass County Nebraska, Cheyenne County Nebraska, Colfax County Nebraska, Dawes County Nebraska, Dawson County Nebraska, Dodge County Nebraska, Franklin County Nebraska, Jefferson County Nebraska, Kearney County Nebraska, Kimball County Nebraska, Lincoln County Nebraska, Madison County Nebraska, Otoe County Nebraska, Phelps County Nebraska, Red Willow County Nebraska, Richardson County Nebraska, Saunders County Nebraska, Scotts Bluff County Nebraska, Seward County Nebraska, Thayer County Nebraska, York County Nebraska, Clark County Nevada, Elko County Nevada, Eureka County Nevada, Lyon County Nevada, Atlantic County New Jersey, Bergen County New Jersey, Burlington County New Jersey, Camden County New Jersey, Cumberland County New Jersey, Essex County New Jersey, Gloucester County New Jersey, Hudson County New Jersey, Hunterdon County New Jersey, Mercer County New Jersey, Middlesex County New Jersey, Monmouth County New Jersey, Morris County New Jersey, Ocean County New Jersey, Passaic County New Jersey, Salem County New Jersey, Somerset County New Jersey, Sussex County New Jersey, Union County New Jersey, Warren County New Jersey, Bernalillo County New Mexico, Chaves County New Mexico, Grant County New Mexico, Lea County New Mexico, Lincoln County New Mexico, Sandoval County New Mexico, San Juan County New Mexico, Santa Fe County New Mexico, Taos County New Mexico, Albany County New York, Bronx County New York, Broome County New York, Chemung County New York, Dutchess County New York, Erie County New York, Fulton County New York, Greene County New York, Kings County New York, Monroe County New York, Montgomery County New York, Nassau County New York, New York County New York, Niagara County New York, Oneida County New York, Onondaga County New York, Orange County New York, Orleans County New York, Putnam County New York, Queens County New York, Richmond County New York, Rockland County New York, Schenectady County New York, Suffolk County New York, Sullivan County New York, Ulster County New York, Westchester County New York, Dare County North Carolina, Edgecombe County North Carolina, Tyrrell County North Carolina, Logan County North Dakota, McIntosh County North Dakota, McKenzie County North Dakota, Rolette County North Dakota, Stark County North Dakota, Williams County North Dakota, Adams County Ohio, Gallia County Ohio, Holmes County Ohio, Huron County Ohio, Jackson County Ohio, Monroe County Ohio, Vinton County Ohio, Cimarron County Oklahoma, Texas County Oklahoma, Clatsop County Oregon, Lincoln County Oregon, Multnomah County Oregon, Wallowa County Oregon, Allegheny County Pennsylvania, Beaver County Pennsylvania, Dauphin County Pennsylvania, Delaware County Pennsylvania, Elk County Pennsylvania, Fulton County Pennsylvania, Lehigh County Pennsylvania, Luzerne County Pennsylvania, Monroe County Pennsylvania, Philadelphia County Pennsylvania, Providence County Rhode Island, Allendale County South Carolina, Cherokee County South Carolina, Chester County South Carolina, Horry County South Carolina, Marion County South Carolina, Marlboro County South Carolina, Orangeburg County South Carolina, Union County South Carolina, Buffalo County South Dakota, Day County South Dakota, Dewey County South Dakota, Faulk County South Dakota, Hutchinson County South Dakota, Jerauld County South Dakota, Oglala Lakota County South Dakota, Potter County South Dakota, Spink County South Dakota, Stanley County South Dakota,

Davidson County Tennessee, Hancock County Tennessee, Haywood County Tennessee, Madison County Tennessee, Maury County Tennessee, Sevier County Tennessee, Shelby County Tennessee, Bailey County Texas, Blanco County Texas, Bosque County Texas, Carson County Texas, Comanche County Texas, Crane County Texas, Crosby County Texas, Ector County Texas, Hamilton County Texas, Hansford County Texas, Hardeman County Texas, Hemphill County Texas, Houston County Texas, Jeff Davis County Texas, Knox County Texas, Moore County Texas, Rains County Texas, Red River County Texas, Roberts County Texas, Runnels County Texas, Starr County Texas, Swisher County Texas, Terrell County Texas, Wilbarger County Texas, Yoakum County Texas, Davis County Utah, Tooele County Utah, Utah County Utah, Highland County Virginia, Lancaster County Virginia, Emporia city Virginia, Franklin city Virginia, Hopewell city Virginia, Martinsville city Virginia, Newport News city Virginia, Norfolk city Virginia, Petersburg city Virginia, Portsmouth city Virginia, Richmond city Virginia, Clark County Washington, Pierce County Washington, Clay County West Virginia, Forest County Wisconsin, Menominee County Wisconsin, Carbon County Wyoming, Park County Wyoming

A.3.2 Subset B

Jefferson County Alabama, Mobile County Alabama, Montgomery County Alabama, Tuscaloosa County Alabama, Cochise County Arizona, Yuma County Arizona, Riverside County California, Sacramento County California, Boulder County Colorado, Douglas County Colorado, El Paso County Colorado, Jefferson County Colorado, Larimer County Colorado, Mesa County Colorado, Pueblo County Colorado, Weld County Colorado, Broward County Florida, Collier County Florida, Hillsborough County Florida, Lake County Florida, Lee County Florida, Polk County Florida, Seminole County Florida, Cherokee County Georgia, Clayton County Georgia, Columbia County Georgia, Forsyth County Georgia, Hall County Georgia, Houston County Georgia, Bonneville County Idaho, Kootenai County Idaho, Wyandotte County Kansas, Prince Georges County Maryland, Hinds County Mississippi, St Louis city Missouri, Flathead County Montana, Gallatin County Montana, Missoula County Montana, Yellowstone County Montana, Clark County Nevada, Allegheny County Pennsylvania, Beaver County Pennsylvania, Berks County Pennsylvania, Bucks County Pennsylvania, Dauphin County Pennsylvania, Delaware County Pennsylvania, Lackawanna County Pennsylvania, Lehigh County Pennsylvania, Luzerne County Pennsylvania, Monroe County Pennsylvania, Montgomery County Pennsylvania, Northampton County Pennsylvania, Washington County Pennsylvania, York County Pennsylvania, Providence County Rhode Island, Charleston County South Carolina, Dorchester County South Carolina, Horry County South Carolina, Spartanburg County South Carolina, Sumter County South Carolina, York County South Carolina, Davidson County Tennessee, Hamilton County Tennessee, Montgomery County Tennessee, Rutherford County Tennessee, Sumner County Tennessee, Wilson County Tennessee, Bell County Texas, Brazos County Texas, Collin County Texas, Comal County Texas, Ector County Texas, Ellis County Texas, Grayson County Texas, Guadalupe County Texas, McLennan County Texas, Midland County Texas, Parker County Texas, Potter County Texas, Randall County Texas, Rockwall County Texas, Smith County Texas, Taylor County Texas, Williamson County Texas, Cache County Utah, Davis County Utah, Utah County Utah, Washington County Utah, Weber County Utah

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Economic impact of hotels and similar establishments in Veszprém District

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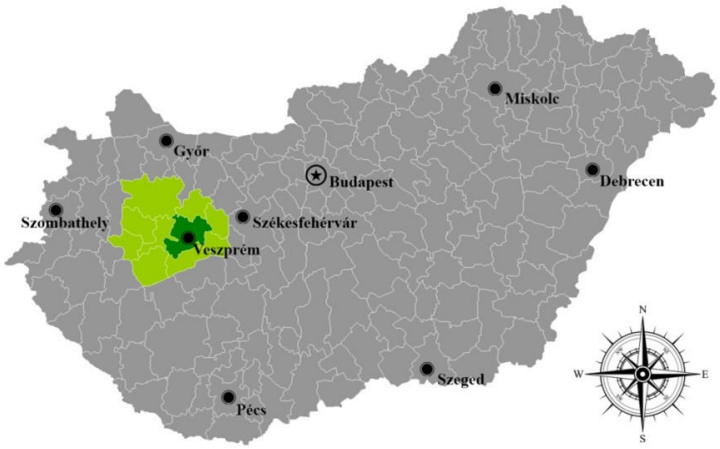
Abstract. This study measures the economic impact of hotels and similar establishments on the overall economy of the Hungarian Veszprém District. It is considered to be an individual part of the total hospitality sector. In the study, the 'Local Multiplier' is utilized from three perspectives: direct, indirect and induced effects. Both secondary public data as well as primary data sources, merely questionnaires, were used to collect data. The resulting score for the induced impact (*LM3*) is 1.96, meaning that for every Forint brought into the economy of the district of Veszprém by the hotels and similar establishments, another extra Forint is generated. The study also finds that revenues of the Veszprém district as share of the national figures have shrunk significantly and development has stagnated in absolute terms over the past four years.

Key words: hotel, local multiplier, Veszprém, hospitality industry

1 Introduction

Tourism has been presented as a critical driving force in economic development of a region (Lea 1988). However, as Mayer, Vogt (2016, p. 170) write, "more often than not these high hopes fall short and either the number of visitors or the resulting economic contribution or even both do not meet earlier expectations" pointing at research by Vogt (2008), Blake et al. (2008) and Lehmeier (2015) supporting this view. Still, it is held as one of the major service sectors (Bansal, Eiselt 2004). To illustrate, the tourism and travel sector played an important role in the world economy by generating 334 million jobs, contributing 10.4% of the global GDP in 2019 (WTTC 2021).

Overall, tourism is considered to have a positive impact by several different ways: (1) by increasing the income of households, (2) it bolsters the state budget by providing tax collection from the tourism establishments and (3) as a suitable way to prevent joblessness (Andriotis 2002). It also is found to have significant spillover effects on nearly every other sector in a given region or country (Mansfeld, Winckler 2008). Furthermore, being a service industry, it possesses a potential in terms of significantly multiplying national and regional incomes of related economic activities as well (Balaguer, Cantavella-Jordá 2002). Hence, a fair rise in tourism expenditure should boost further activities in connected businesses in the region. Because of this, tourism is now increasingly seen as a policy tool to influence the future of different regions as well as their economy (Van Leeuwen et al. 2009). The Hungarian government also considers tourism to be a strategic priority in terms of future economic development of the country (OECD 2018).



Source: Wikipedia page of Veszprém district

Figure 1: Veszprém district (dark green) within Veszprém County (light green) and Hungary

In line with the statement by Mayer, Vogt (2016, p. 170) that "one of the most important drivers is the spending behavior of visitors", the multiplication effect is the main focus of this study: by direct, indirect, and induced impacts that are the mere consequences of the tourism expenditure in the region (Vogel 2001).

While the importance of the tourism industry as a whole has been underlined, this study will focus on the hotel industry within the whole tourism industry. According to the study of Zion Market Research (ZMR 2019), the assessed value of the worldwide hotels market was about 147.57 billion USD in 2018 and this number is expected to reach approximately 211.54 billion USD till the year 2026.

1.1 Research Question

Hence, the main objective of this study is to evaluate the economic impact of hotels and similar establishments, resulting in the following Research Question:

> What is the economic impact of the hotels and similar establishments on the local economy in the Veszprém district of Hungary in 2019?

By stating hotels and similar establishments, all commercial accommodation establishments are included (hotels and guest houses). Short-term rental apartments such as Airbnb are excluded, as they have quite a different business model and classification in the database as well. The acquired results will be helpful for policy makers regarding support of the local economy and well-being of the local community by making appropriate decisions for the hotel sector.

Section 2 gives a literature review discussing similar studies. Section 3 will discuss the role and features of tourism multipliers as an explanatory coefficient in the economy as well as factors that may affect them. Section 4 is on the methodology used and the data collection, while Section 5 presents results including a discussion. Section 6 provides the conclusions.

2 Literature Review

In general, the trend that tourism is perceived as a powerful economic driver has sparked a lot of policy and research interest in recent years with regards to taking advantage of its benefits of boosting the economy (Van Leeuwen et al. 2009, Teigeiro, Díaz 2013). However, while numerous studies exists dealing with the economic impact of tourism on the economy, there are fewer studies dealing with merely the impact of the hotel

industry, especially from a regional perspective. One of the examples that dealt with the regional impact of the hotel industry is conducted by Kim, Kim (2015). They studied the economic impact of two hotel industries of Texas (USA) by utilizing input-output (IO) analysis which made it quite convenient to look for the connections between the hotel industry and other industries. The authors have achieved multipliers based on IO tables and concluded that both hotel industries (hotels and motels; other accommodations) have a significant induced effect on the economy of Texas. Another research done by Mitchell et al. (2014) applied value chain analysis for a single hotel located in Southern Turkey in order to find ways to increase the impact on the local economy and hence provide more benefits to local people and retailers.

When it comes to analyze the regional impact of the tourism sector as a whole, Kronenberg et al. (2017) investigated the economic impact of tourism in the Jamtland region of Sweden from a multi-period perspective. Similarly, Tohmo (2017) looked for the regional economic contribution of tourism in Central Finland and compared the impact with national domestic and international tourism. In addition, Gelan (2003) and Daniels, Norman (2003) quantified the local economic impact of major sporting events in Angus (Scotland) and South Carolina (USA).

All these studies have in common that they aimed to produce results based on calculated multipliers that can be helpful for policy makers.

3 Economy and Multipliers in Tourism Sector

There are several concepts in the literature that investigate the impact of the tourism industry on economic development of a specific area. Nonetheless, multipliers are especially useful in these terms because they are looking at direct leakages of income from the economy of the local community since they are usually taken and paid outside the local area (Wanhill 1994). In addition, when it comes to regional economic development initiatives by government authorities, the size of local multipliers is critical in this regard (Moretti 2010). As the leakages from the local economy increase, the calculated coefficients of the local and regional multipliers decrease accordingly, especially in the case of import leakages (Glasson 2018) which make the economy less capable to be self-sufficient and able to retain the generated revenues. However, also other types of leakages exist, such as savings and taxation (Vellas, Bécherel 1995). That is why it is fruitful to utilize multipliers in terms of measuring local impacts. In this regard, the question might be which features of the economy or area effect the multiplier coefficients (see Mayer, Vogt 2016). For instance, according to the meta-analysis on the tourism sector in six Dutch towns made by Van Leeuwen et al. (2009), the larger the size of the economy being examined, the larger the multiplier accordingly is. Of course, it should be noted that identifying "regional activities" – hence the economic base – depends on where the local market ends and the export market begins (Thulin 2015). Hence, in most cases, regional multipliers are lower than that of the national multipliers (Van Leeuwen et al. 2009) and larger regions are more capable to be self-sufficient (Thulin 2015). Because of this, we should not expect high coefficients in our study as the economy of only one District is the point of focus.

4 Methodology

4.1 Local multiplier

Many types of multipliers are available and discussed in literature (Archer 1984, Fletcher, Archer 1991, Briassoulis 1991, Fletcher 1994, Frechtling 1994, Horváth, Frechtling 1999). Fletcher, Snee (1989) for instance distinguish between six tourism multipliers: a change in output, sales or transaction, income, employment, government revenue or imports. Hughes (1994) describes the income multiplier as "perhaps the most frequently encountered" which for a good reason is mentioned as the 'normal' multiplier by Archer (1982).

While the study originally envisaged to use a micro based input-output analysis (see Kamann, Krolis 1991, Oosterhaven 2019), this had to be abandoned because of uncertainty about the expected reliability of the data made available. Moreover, no official

input-output data at a regional level existed, let alone at a district level. And, as Horváth, Frechtling (1999, p. 325) remark "they are expensive to develop at the regional level given their extensive data requirements". This left the present methodology as sole opportunity to shed light on the economic impact of the hotels and similar establishments, maintaining the same 'bottom-up micro based philosophy'.

Hence, in order to measure the economic impact of the hotels and similar establishment in Veszprém, the Local Multiplier (LM) which was developed by the New Economics Foundation (NEF) (Sacks 2002) was selected for this study. From a micro viewpoint, this local multiplier is an appropriate instrument for quantifying economic efficiency at the local level (Feagan 2008).

In this study, 3 types of impacts are distinguished. They coincide with the phases of the methodology of calculating the local multiplier according to Sacks (2002): Direct impact ($LM1$), Indirect impact ($LM2$) and Induced impact ($LM3$)

The first phase of the calculation consists of determination of the direct effects which are the straightforward to determine since they are the result of visitors spending money in enterprises (Goeldner, Ritchie 2009). In this case, this is the revenue of the hotels and similar establishments of the Veszprém District (Round 1). Therefore, $LM1$ is going to be equal to the total revenue of the hotels and similar establishments (Initial revenue or Round 1) in Veszprém.

The second phase includes indirect effects which are the related local expenditures from the initial revenues (Goeldner, Ritchie 2009) of the commercial accommodations (Round 2). The calculation of the indirect impacts ($LM2$) is according to the following formula (Sacks 2002):

$$LM2 = \frac{\text{Round 1} + \text{Round 2}}{\text{Round 1 (initial revenue)}} \tag{1}$$

Finally, in the third and last phase of the calculation of the local multiplier – $LM3$, induced effects are also being included which indicates the assessment of how much money has been spent in Veszprém by local employees (Round 3) (Březina et al. 2013). The final calculation of the $LM3$ will be as follows (Sacks 2002):

$$LM3 = \frac{\text{Round 1} + \text{Round 2} + \text{Round 3}}{\text{Round 1 (initial revenue)}} \tag{2}$$

The final coefficient of $LM3$, should be interpreted that a score of for example 2.5 means that every Forint earned by the hotels and similar establishments created an extra 1.5 Forint in the local economy.

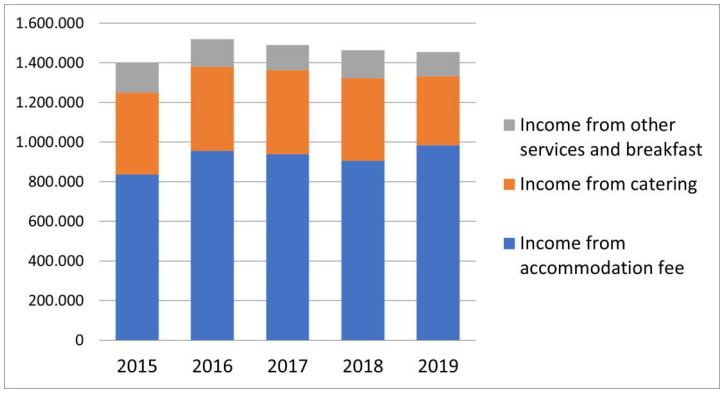
4.2 Data

In this study, both preliminary data based on questionnaires and secondary public data from the Hungarian Central Statistical Office (HCSO, https://www.ksh.hu/?lang=en) have been used. In addition, several estimations have been made which will be elaborated in the next paragraphs.

First of all, in terms of the total revenues of the hotels and similar establishments in the region, the data have been derived from the website of the Hungarian Central Statistical Office. In fact, in the database, the data of income of commercial accommodation establishments is classified into 3 types: as income of accommodation fee, income of catering and income of other services and breakfast.

As the aim of this study is to trail all of the income that has been earned by the hotels and similar establishments, we need the total respective revenues. That is why all three types of incomes have been summed up for the first step (Figure 2).

In the second phase we need data regarding the local expenditures that have been made within the borders of the District of Veszprém of the commercial accommodation establishments. Precise measurement of local expenditures for all of the commercial establishments would be quite arduous and time-consuming, not to mention the data is sensitive for commercial establishments. For these reasons, estimations have been made according to the online questionnaires that were filled in by the representatives of the establishments.



Source: HCSO

Figure 2: Income of accommodation establishments of Veszprém district (thousand HUF)

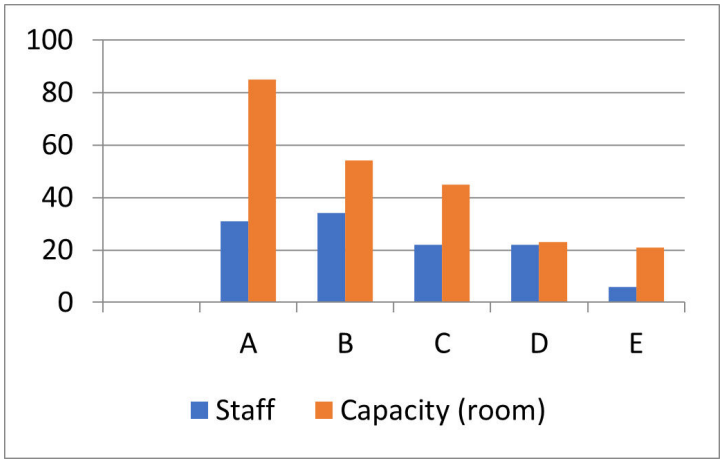


Figure 3: Four hotels (A, B, C, D) and one guest house (E) in Veszprém District

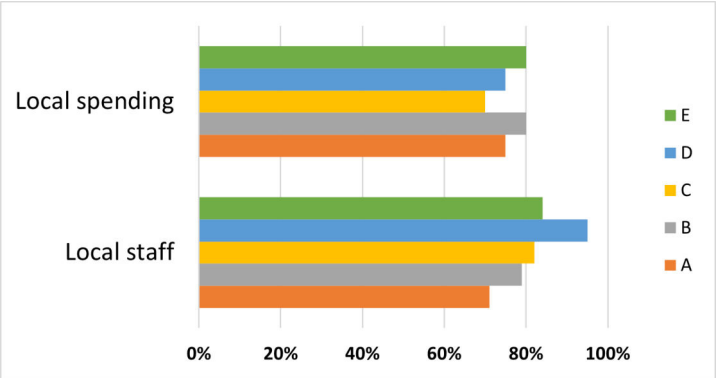
Questionnaires have been sent to mail addresses of 20 of the 29 registered establishments in Veszprém. With 7 replies the initial response rate is 35%. Only 5 respondents filled in the questionnaires completely which produces an effective response rate of 25%. These five respondents cover 29 percent of all registered rooms in the district. This is a reasonable rate in case of the tourism industry, given that most tourism surveys have poor response rates, especially from the small and medium tourism firms, as indicated by Buhalis (2003) who received a response rate of 25,2%. Louvieris et al. (2001) also received quite a low response rate of 21,7%.

The main aim of the questionnaire was to estimate the local spending patterns of the hotels and similar establishments in Veszprém District. The need for a diverse sample was met (Figure 3) where two hotels – A and B – were premium hotels, two – C and D – offered at an average price range and one respondent – E – was a guest house.

From the questionnaire expired that the participating commercial accommodation establishments spent on average 75% of their income within the borders of the Veszprém District (Figure 4). This estimate was used for the second phase of our calculation.

The required data of the last phase consist of the amount of money that has been spent merely in the Veszprém District by the employees of the aforementioned commercial accommodation establishments.

In order to proceed, we need data on the sum of net earnings of all employees that work in the commercial accommodation establishments in Veszprém District. However, in the database of the HCSO, such data is only available at the county level, hence we have to estimate the needed amount for the Veszprém District based on the data of the



Source: Author's editing based on questionnaires

Figure 4: Percentage local embeddedness in spend and staffing¸5 establishments (2019)

Table 1: Share of accommodations among the 9 districts of Veszprém County (2019)

District	Number of commercial accommo-dations	Share (%)	Rooms	Share (%)	Estimated number of employees (capita)	Sum of estimated net earnings of employees (thou-sand HUF)
Veszprém	29	9.70%	784	9.40%	396	582,630 (9%)
Ajka	13	4.40%	215	2.60%	177	258,947 (4%)
Balatonalmadi	44	14.80%	952	11.40%	600	938,681 (14.5%)
Balatonfűred	108	36.20%	4.612	55.40%	1.473	2,913,149 (45%)
Devecser	3	1.00%	15	0.20%	41	323 (0.5%)
Papa	20	6.70%	269	3.20%	273	420,788 (6.5%)
Sumeg	6	2.00%	213	2.60%	82	129,473 (2%)
Tapolca	55	18.50%	994	11.90%	750	906,313 (14%)
Zirc	20	6.70%	269	3.20%	273	258,947 (4%)
Veszprém County (total)	298	100%	8.323	100%	4.065	6,473,664 (100%)

Source: HCSO.

Veszprém County (Table 1).

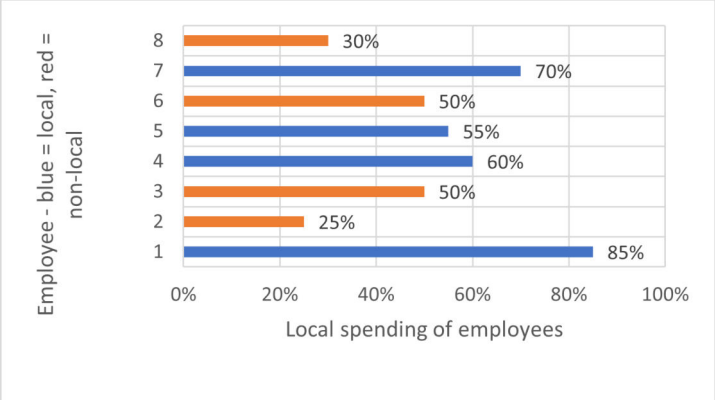
In order to estimate the right amount, Table 1 was constructed, using available data from the HCSO. Table 1 shows that both the share of number of rooms and the share of establishments of Veszprém District constitute over 9% of the total of rooms and establishments within the whole Veszprém County. As the data for Varpalota District is missing from the database and hence the calculation, a final estimation for the Veszprém District of 9% of the sum of net earnings of the commercial accommodation employees in Veszprém County seems acceptable.

Following the above calculation, the re-spending propensity has to be determined of the eight employees of the hotels and similar establishments in Veszprém according to questionnaires filled in by them. The aim of this questionnaire was simply to determine which percentage of the salary of the hotel employees of the Veszprém is spent within the borders of the district. Four employees indicated they are living outside the Veszprém district, while the other four are local residents.

According to the answers of the 8 employees shown in Figure 5, the average spending in Veszprém for the local employees is 68% and 39% for non-local employees. The relatively high score of half of the non-locals, stating they still spend 50% of their income in Veszprém can be explained by the Central Place hierarchy of Veszprém, being county and district capital and having higher order shop offers (see Openshaw, Veneris 2003).

It is estimated – using the results so far and data available – that, employees of the hotels and similar establishments spent 308,794 thousand HUF (on average 53% of their income) merely in the District of Veszprém in the year of 2019.

Based on the elaborations above, at this stage we have all of the required data in order to calculate the *LM1*, *LM2* and *LM3* for the Veszprém District.



Source: Author's editing based on questionnaires

Figure 5: Employee spending in Veszprém

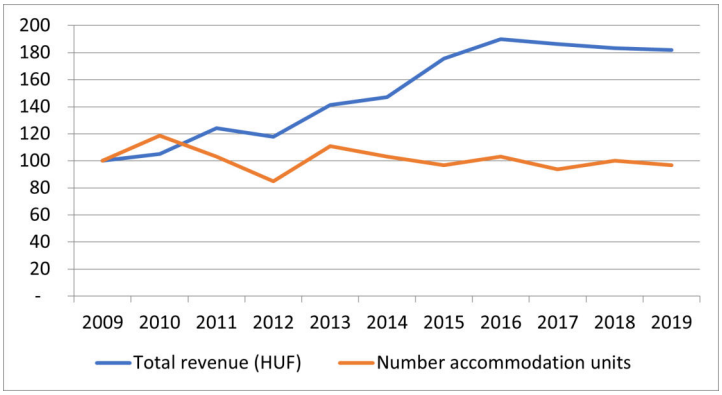


Figure 6: Total revenues in HUF of commercial accommodation establishments in Veszprém District (2009 = 100)

5 Results and Discussion

5.1 Direct impact (LM1)

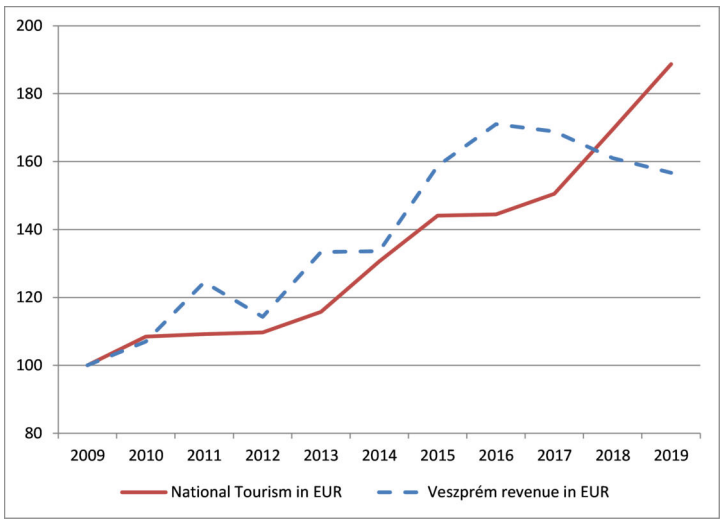
As stated, the, direct impact includes the total revenues of the hotels and similar establishments in the area. Figure 6 shows that the total revenue of the commercial accommodation establishments in Veszprém has almost doubled in 7 years and remained more or less stable since 2015. It was 1,453,982 thousand HUF in the final year of observation 2019. Therefore, the "Initial revenue" (Round 1) that we need for the calculation is 1,453,982 thousand HUF. Figure 5 also shows the lack of growth in accommodation units.

5.2 Indirect impact (LM2)

According to the determined initial revenue (Round 1) for our calculation, we can move on to the second phase in order to calculate the indirect impact (*LM2*). The calculation of *LM2* is as follows:

$$LM2 = \frac{145,398,200,0\ HUF + 145,398,200,0\ HUF * 75\%}{145,398,200,0\ HUF\ \text{(initial revenue)}} \tag{3}$$

Based on the calculation above, *LM2* equals to 1.75.



Source: Author's editing based on HCSO data

Figure 7: Growth patterns of the total revenues in Euro of commercial accommodation establishments in Hungary and the Veszprém district between 2009-2019. (2009=100)

5.3 Induced impact (LM3)

Since both *LM1* and *LM2* have been calculated, the complete data which is necessary to calculate the *LM3* is available. Hence, the final calculation of *LM3* is as follows:

$$LM3 = \frac{145,398,200,0\ HUF + 145,398,200,0\ HUF * 75\% + 308,794,000\ HUF}{145,398,200,0\ HUF\ \text{(initial revenue)}} \quad (4)$$

In accordance with equation (4), a coefficient of 1.96 results for *LM3*. This means that every Forint that is spent in the economy of the district of Veszprém by hotels and similar establishments in the year of 2019 almost generated another extra Forint in the local economy.

5.4 Regional development of the hospitality industry

An important aspect studied is the regional development pattern of the hospitality industry in Veszprém district. In particular: what is the position of the district within the whole country? In general, since joining the European Union in 2004, the number of individual tourist arrivals to Hungary grew considerably since then (Formadi et al. 2017). As the tourist flow increased into the country, naturally regional tourism also is expected to flourish as well. Figure 7 illustrates data of both the district and the country. It shows the development patterns – or growth rate – of the hospitality industry. To compensate for the deteriorating exchange rate of the Hungarian Forint, all figures are expressed in Euro this time, using the appropriate exchange rate of the specific periods.

Figure 7 shows that tourism at a national level shows a steady growth pattern over the years. Since 2009, there has been a continuous increase in the total revenues of commercial accommodations in Hungary till the end year of 2019. On the other hand, when we look at the data of the Veszprém district, we first of all see that up to 2016, the Veszprém district was outperforming the national figure in terms of growth, even while this growth pattern was much more volatile. However, after the peak year of 2016, the growth in revenue of the Veszprém district has significantly decreased till the end of the observed period. Revenue in HUF stabilized (Figure 6) which effectively means and constituted only 0.27% of all such revenues in Hungary by the year 2019. This share being at a consistent high level around 0.39% between 2011 and 2016 (Figure 8).

Figure 8 clearly shows how the share of Veszprém district has been significantly shrinking regarding the total revenue of hotels and similar establishments in Hungary in

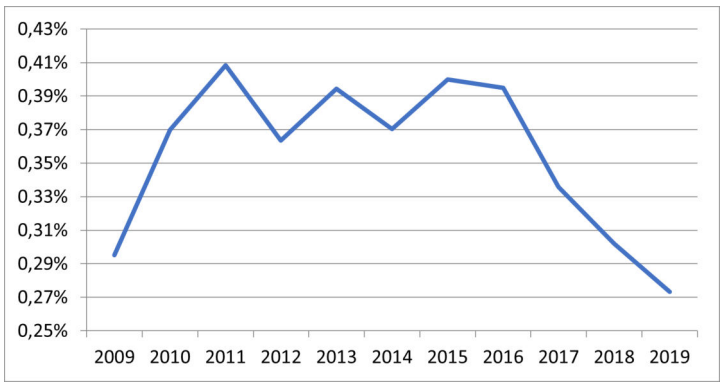


Figure 8: Share of the Veszprém District in the National Revenue of the hospitality industry

recent years. This might be a signal for the decreasing competitiveness of tourism and hospitality industry of Veszprém district. It also might be that Veszprém has historically been more oriented towards domestic tourism, combined with a steady stable flow of business visitors to any of the numerous foreign subsidiaries in the district. Domestic tourism has a trend of going abroad instead of domestic trips. In that case, it is more the maturing domestic tourism market and the increasing domestic income that may cause this relative lack of growth in Veszprém.

In this context, it will be interesting to study the effects of the preparations to be the European Capital of Culture (ECOC) by the year 2023. Already, some hotels received policy oriented funds to expand and modernize; this adds 47 newly constructed modern hotel rooms. Some culture focused pubs and meeting places have been funded, potentially attracting tourists by making the city more attractive. It is expected that the tourist flow will increase towards Veszprém during and after the year when the ECOC project will take place. However, we remind the warning by Mayer, Vogt (2016, p. 170) that in many such cases, "high hopes fell short". The future will tell.

5.5 Limitations and future studies

Compared to other multiplier studies, the multiplier value calculated in this study may seem high, given the small size of the district (see Khan et al. 1995). For, in general, "A direct relationship between size and domestic effects is expected" (Robles Teigeiro, Díaz 2004, Van Leeuwen et al. 2009, Wiersma et al. 2004). However, as these authors also complain about the leakage of spending from the area studied, we could point at the strong social local network embeddedness and cohesion observed among the (hotel) managers in the Veszprém district, the relatively high local reinvestment score and local Veszprém spending by local hotels, employees and even half of the non-local employees, spending 50% of their income in Veszprém (Figure 4). In so far this amount spent also goes to multinational retail companies in food, fashion, domestic appliances and DIY-material, there would be unrecorded leakage and this could to some extent explain the higher score than expected. However, on the other hand, all hotels are local hotels; none is part of a national or international chain. Compared to other areas, this seems an exception rather than a rule and because of this may reduce leakage from Veszprém, causing a higher multiplier.

Considering all above and the results of this study, *LM3* has produced evidence of genuine economic benefit from local hotels and similar establishment in the Veszprém district.

One issue however, appears to be problematic in practice. When it comes to the employees' spending and company purchasing behaviour, this behavior appears to be challenging: an enterprise cannot order its employees to support local businesses and a local authority cannot order companies to source locally, especially when they are part of a multi-site chain.

This study has methodological shortcomings regarding the used *LM3* technique, particularly in terms of the assumptions regarding the data collection for its calculation because the most cost-effective method in this regard has been chosen and applied. Despite of this, Silovská, Kolaříková (2016) consider there is a possibility of calculating further local multipliers such as *LM4*, L*M5* and so on. However, by going through calculations of further local multipliers each time, the loss regarding the degree of accuracy in the data occurs. This argument is understandable because while at the first step it is quite easy to collect precise data regarding the revenues of the hotels and similar establishments even without getting in direct contact with them – merely by the use of official statistical database. On the other hand, as we go further, we have to rely on the personal answers of the individuals such as the data about the share of salary of hotel workers that has been spent only inside the district.

Considering the aforesaid factors, the results of *LM3* may not be considered accurate enough to be used as a progress monitor or to compare local initiatives (Thatcher, Sharp 2008). That is why, as recommended in the literature (Hewings 1985), more precise and mixed-method approaches are suggested for future attempts to measure and analyze the local impact of hospitality entrepreneurs.

6 Conclusion

In this study, the effect of the hospitality industry on the regional economy of Veszprém has been investigated for the year 2019. In this regard, the Local Multiplier has successfully been utilized and three levels of the local multiplier have been calculated based on primary and public data.

The observed findings made it clear that the hotels and similar establishments have a significant impact on the local economy of Veszprém district as every Forint that has been spent in the economy created another Forint for the economy of the region in the year 2019.

Additionally, this study also revealed that, throughout the last decade, the development pattern of the hospitality industry of Veszprém district has been stagnating. While initially outperforming the national figure, from 2016 onward a stagnating growth and shrinking share in the national revenue occurs. It will be interesting to study the impact of the new activities and services, funded by the 2023 European Capital project, which is expected to attract more tourists and help the region to overcome this stagnating situation.

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Between leading and lagging: Interregional migration, unemployment and over-education among college graduates in the aftermath of the 2008 recession

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Abstract. In this paper, we analyse the interregional migration of Spanish-born young adults by educational attainment and explore unemployment and over-education in the labour market among internal migrants and sedentary individuals with a university degree. We used register data of population movements from 2000 to 2018 to analyse internal migration patterns and the Labour Force Survey to study the educational attainment of migrants, as well as unemployment rates and over-education among college graduates. Our results indicate a regional polarisation after the economic crisis. Peripheral regions in the interior of Spain have been affected by an increasing exodus of university graduates, in addition to high levels of unemployment and over-education among individuals with a university degree who remain at origin. However, peripheral regions in the north-west and south of Spain have been less affected by out-migration. The central region of Madrid has emerged as the main destination for university graduates, with a large capacity to employ populations with university education from other regions. Semi-central regions of the Mediterranean and north-east of Spain retain local college graduates and exhibit good labour market conditions among residents with a university degree, but they are not destinations of individuals with university education from other regions.

Key words: Human-capital mobility, internal migration, unemployment, over-education, Spain

1 Introduction

Skilled human capital is essential for economic development, as the globalisation production system is characterised by an increasing importance of the knowledge economy (Dotti et al. 2013, Corcoran, Faggian 2017). The level of human capital is therefore linked to the potential for economic growth and innovation (Florida et al. 2008). Areas with low levels of human capital show low levels of economic growth, while those with a concentration of skilled workers thrive in today's globalised economy (Sassen 1991, Haapanen, Tervo 2012). The characteristics of jobs in an area depend on the local economy. Typically, global cities concentrate technological, financial activities and advanced service and therefore most skilled jobs (Sassen 1991, Sánchez-Moral et al. 2018). However, the economy of peripheral regions, usually with rural areas and small and medium-sized

cities, has traditional industries and a low-tech service sector (Kabisch, Haase 2011, Nelle 2016).

Human capital mobility responds to inequalities in the spatial distribution of economic activities (Myrdal 1957, Sassen 1991, Sleutjes, Roterman 2014). Internal migration, mainly among the highly educated population, is driven by a mismatch between economic activities and the characteristics of the local labour force (Beine et al. 2008, Martin-Brelot et al. 2010). Central regions with global cities concentrate technological activities and high salaries, attracting high-skilled migrants (Sjaastad 1962, Fielding 1992, Harvey 2006). These regions also offer better opportunities of socio-economic progression (Kooiman et al. 2018). The economy of peripheral regions, however, is based on traditional industries which demand medium- and low-skilled workers (Nelle 2016). Levels of unemployment and over-education among university graduates in peripheral regions are therefore higher than the national average (Serracant 2005, Sánchez-Sellero et al. 2013), and this encourages the out-migration of highly qualified populations (Martin-Brelot et al. 2010, González-Leonardo et al. 2022). Since the 2008 economic crisis, some studies have documented an increasing polarisation both between countries (Pernagallo, Torrisi 2022) and among regions and a low resilience in some peripheral regions with traditional industries and high levels of mono-specialisation (Rodríguez-Pose, Ketterer 2012, Nelle 2016). In addition, public-sector job cutbacks have had a notable impact on the employability of university graduates in these regions – regions where graduates would normally have a large share of public-sector employment (Cox, Schmuecker 2010, Tomaney et al. 2010).

Peripheral regions are typically affected by brain drain and thus by the loss of high-skilled human capital (Sassen 1991, Docquier, Rapoport 2012, González-Leonardo et al. 2019). These human capital flows usually move from peripheries to central regions of the territorial hierarchy, especially towards areas with global cities (Sassen 1991, Fielding 1992, González-Leonardo et al. 2022). Brain drain has negative consequences at the origin, with increasing accumulation dynamics at the destination (Myrdal 1957, Beine et al. 2008, Sleutjes, Roterman 2014). Mobility is explained as a rational decision by individuals to obtain higher returns on their skills, which are better rewarded in chief regions (Fielding 1992, Rowe et al. 2017, Sánchez-Moral et al. 2018). The greater the mismatch between skills and the returns on them at the origin, the greater the out-migration of highly skilled human capital (Martin-Brelot et al. 2010). Non-economic factors, such as cultural activities or a cosmopolitan environment, also influence the choice of place of residence, especially among the "creative class" (Florida 2002). However, economic factors usually have a more significant influence on the decision to migrate (Martin-Brelot et al. 2010, Thomas 2019).

Most studies analysing the mobility of qualified human capital have focused on international migration (Docquier, Marfouk 2006, Docquier, Rapoport 2012, Cavallini et al. 2018) and talent attraction in global cities (Florida 2002, Faggian, Royuela 2010, López-Gay et al. 2020). Less is known about the patterns of internal migration by educational attainment (Faggian et al. 2007). In this research, we contribute to this topic through a case study on Spain. Like other Southern European countries, Spain shows great interregional inequalities that determine human capital mobility (Cavallini et al. 2018, Basile et al. 2019). Madrid region, the Mediterranean area, and the north-east of Spain have developed and diversified economies with more technological industries, a higher GDP per capita and lower unemployment rates, while regions of the interior, northwest and south of Spain have a traditional and less diversified economy, a lower GDP per capita, higher rates of unemployment and a great dependence on public jobs, specifically to employ university graduates (Peña-Sánchez, Jiménez-García 2013, Cavallini et al. 2018). Despite low levels of internal migration in Spain (Bell et al. 2015, Rowe et al. 2019), there is a great territorial heterogeneity when migration patterns by educational attainment are assessed, with Madrid as a main destination of internal migrants with a university degree and the regions surrounding the capital of Spain as sending areas (González-Leonardo 2020, González-Leonardo et al. 2022). The interregional polarisation observed after the 2008 economic crisis in other counties (Nelle 2016) suggests that the economy of Spain's peripheral regions may have been significantly affected and, as a result, migration

patterns by educational attainments between regions.

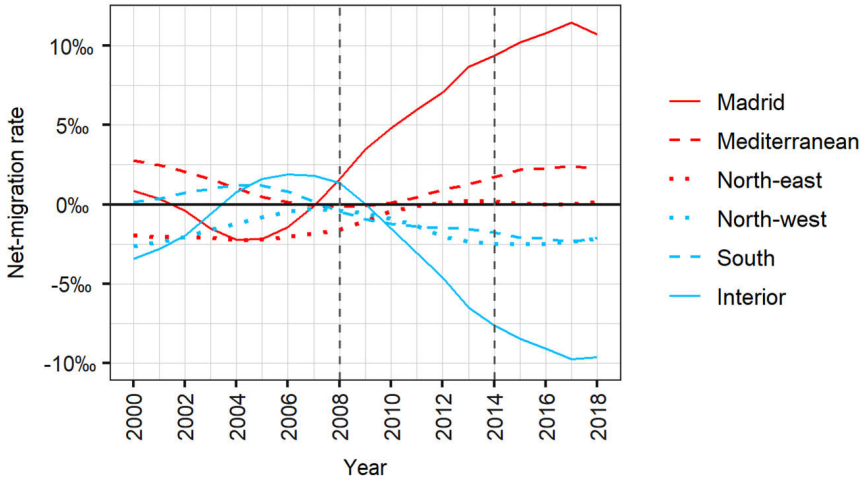
In this paper, we aim to analyse the interregional migration of Spanish young adults by educational attainment from 2000 to 2018. Drawing on register data from the Residential Variation Statistics and socio-demographic information from the Spanish Labour Force Survey, we study how the mobility patterns and educational attainment of migrants changed during the period 2000–2018 at NUTS 1 level. First, we analyse trends of internal migration and the educational profile of internal migrants of each region. We then explore unemployment rates and over-education levels in the labour market among in-migrants, out-migrants and sedentary individuals with a university degree, as they are potential driving forces of changes in internal migration. We specifically aim to respond to the following research questions: How did internal migration patterns change during the economic crisis 2008-2013 and the recovery period from 2014? How did the educational profile of internal migrants vary? How did unemployment rates and over-education levels change among sedentary and non-sedentary university graduates? We expect a polarisation between regions in terms of internal migration patterns and the educational selectivity of internal migrants since the economic crisis of 2008, as well as increasing unemployment and over-education levels among college graduates in peripheral regions. The remainder of the paper is structured as follows: a section on methods and data (Section 2); a division of the results (Section 3) into three sub-sections (internal migration patterns, educational profile of internal migrants and an analysis of unemployment and over-education); and finally, a discussion of this research and our conclusions (Section 4).

2 Data and method

We used micro-data from two sources of the National Institute of Statistics (*Instituto Nacional de Estadística* [INE]) for the period 2000-2018: Residential Variation Statistics (*Estadística de Variaciones Residenciales* [EVR]) and the Labour Force Survey (*Encuesta de Población Activa* [EPA]). The EVR comprises granular register data, including all changes of residence across regions. We used this source to analyse interregional migration patterns. As the EVR includes only basic demographic variables, such as place of birth, sex and age, we used the EPA to analyse the educational attainment and labour market characteristics of migrants. The EPA is a quarterly survey of 160,000 individuals designed to study the labour market, which allows an analysis of internal migration through comparison of the variables "region of birth" and "residence".

We focused our study on the Spanish population aged 25–39, the most mobile population group in Spain. We used Eurostat's NUTS 1 units as regions (see Eurostat's NUTS 1 map- https://ec.europa.eu/eurostat/web/nuts/nuts-maps) but included the Canary Islands with Andalusia and Murcia because they have a similar location (southern Spain) and characteristics. Initially, we tried to use NUTS 2 regions, but internal migration is a rare event, and the EPA sample did not allow us to analyse unemployment and over-education among migrants at this territorial level. The final classification includes the following categories: ES1-north-west (Galicia, Asturias and Cantabria), ES2-northeast (Basque Country, Navarre, La Rioja and Aragon), ES3-Madrid, ES4-interior (Castile and León, Castile-La Mancha and Extremadura), ES5-Mediterranean (Catalonia, Community of Valencia and Balearic Islands) and ES6+ES7-south (Andalusia, Murcia and Canary Islands).

First, we used the EVR to calculate net migration rates in each region (NMR^i) to measure the loss or gain of young adults by internal migration. Second, we used the EPA to study the educational profile (people with and without a university degree) of the sedentary population (individuals living in their region of birth), out-migrants (those who left the region of birth i and live in the region X) and in-migrants (populations residing in the region i who were born in the region X). Finally, we analysed unemployment rates and the labour profile of university graduates for sedentary individuals, out-migrants and in-migrants in each region. In this stage, we categorized the years into three sub-periods according to GDP growth and unemployment levels to simplify the visualisation of the results: the economic growth during the first seven years of the 21st



Source: Compiled by authors using data from *Residential Variation Statistics* and *population counts (INE)*

Figure 1: Net migration rate by geographical area for the Spanish-born population aged 25–39: 2000–2018.

century, the recession from 2008 to 2013 and the economic recovery between 2014 and 2018. We created the labour profile variable by recoding the original *Código Nacional de Ocupaciones* (CNO) classification into three categories: high-skilled jobs (directors and managers, technicians and scientists), medium-skilled jobs (support technicians, administrative workers, medium-skilled workers of industry, construction or farming and machinery assemblers) and low-skilled jobs (personal services and elementary occupations). We defined a person with a university degree as over-educated in the labour market if this individual is working in the last two categories rather than in the first one.

$$NMR_{25\_39}^{i,t+1} = \frac{(I_{25\_39}^{i,t+1} - O_{25\_39}^{i,t+1})}{(P_{25\_39}^{i,t} + P_{25\_39}^{i,t+1})/2} * 1000$$

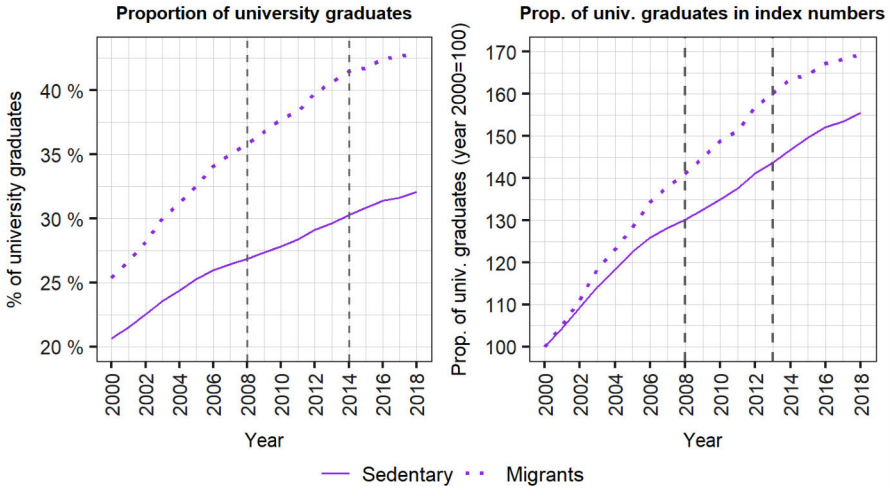
where I is the number of in-migrants to the region i during the period $t+1$, O is the number of out-migrants from the region i, $P^{i,t}$ is the initial population at 1 January, and $P^{i,t+1}$ is the final at January 1st of the following year.

3 Results

3.1 *Population lost due to internal migration in peripheral regions of the interior vs. concentration of individuals in Madrid*

During the period 2000–2018, the interregional migration rate of the Spanish-born population aged 25–39 increased from 11.8‰ to 17.9‰. Before the 2008 economic crisis, this increase was unaccompanied by significant variations in net migration rates in the Spanish regions, as in-flows and out-flows were closely balanced (Figure 1). However, we do identify a regional polarisation from 2008. Madrid's net migration rate increased from 2.5‰ to 11‰ between 2008 and 2018 and declined in the peripheral interior regions during the crisis and the post-crisis period, from 2.5‰ in 2008 to -10‰ in 2018[1]. Variations on net migration rates in the peripheral southern and north-western regions were of less importance than those in the regions of the interior. Generally, the semi-central regions of the Mediterranean and north-east showed balanced rates over time.

[1]We observe positive net migration rates in the Interior between 2004 and 2008, but rates are lower than 2 per thousand. It was caused by a specific trend of suburbanisation from the Metropolitan Area of Madrid to the north of Guadalajara and Toledo provinces which are located within the interior region and bordering Madrid.



Source: Compiled by authors using data from the *Labour Force Survey (INE)*.

Figure 2: Proportion of university graduates in % (left) and index numbers (right) among sedentary population and internal migrants: 2000–2018. Spanish-born population aged 25–39.

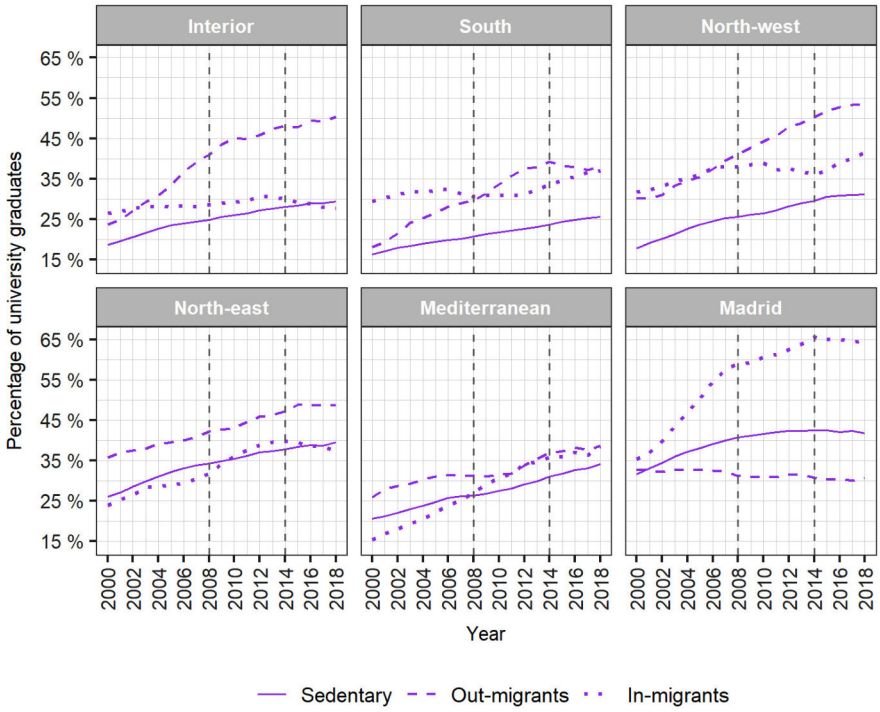
3.2 Internal brain drain vs. brain gain

In this section, we analysed the educational attainment of internal migrants and educational selectivity by comparing the proportion of university graduates between migrants and the sedentary population (Figure 2). The proportion of university graduates increased among both sedentary and internal migrants over the period 2000–2018 due to educational expansion. Nonetheless, the increase in the number of university graduates was higher for migrants, thus increasing the educational selectivity of internal migration. The percentage of the sedentary population with a university degree increased from 21% in 2000 to 32% in 2018, a growth of 55%, whereas among internal migrants, it increased by 70%, from 25% to 43%. As the rise in selectivity displays an almost linear growth trend from 2000 to 2018, it did not show an effect of the economic crisis.

We next compared the proportion of university graduates between the sedentary population, internal out-migrants and in-migrants in each region (Figure 3). We reveal that out-migrants from the peripheral regions of the interior were more educated than the sedentary population, and that this mismatch increased over time. The educational profile of out-migrants was also higher than that of in-migrants, and this gap also increased between 2000 and 2018. In 2018, 47.5% of out-migrants, 27.5% of the sedentary population and 27.5% of in-migrants had a university degree, while in 2000 these values were 24.5%, 17%, and 25.5%, respectively.

In the peripheral regions of the north-west and south of Spain, the proportion of out-migrants with a university degree was also higher than that of sedentary individuals and internal in-migrants. The mismatch between groups was, however, lower. In these regions, we observe the effect of the economic crisis only on the decline in the educational achievement of in-migrants, compared to that of out-migrants. In semi-central regions of the north-east and the Mediterranean, we also observe educational selectivity among out-migrants who, since the economic crisis, were also more educated than in-migrants in the former region.

We observe negative selectivity only among out-migrants in Madrid, where the educational level of people leaving this region was lower than that of the sedentary population. In addition, out-migrants were more educated than in-migrants. We also identify a significant increase in the proportion of university graduates among internal in-migrants. The percentage of university graduates for the sedentary population, out-migrants and in-migrants was around 25–27% in 2000, whereas this proportion increased to 42.5% for sedentary individuals, 27.5% for out-migrants, and 65% for in-migrants in 2018.



Source: Compiled by authors using data from the *Labour Force Survey (INE)*.

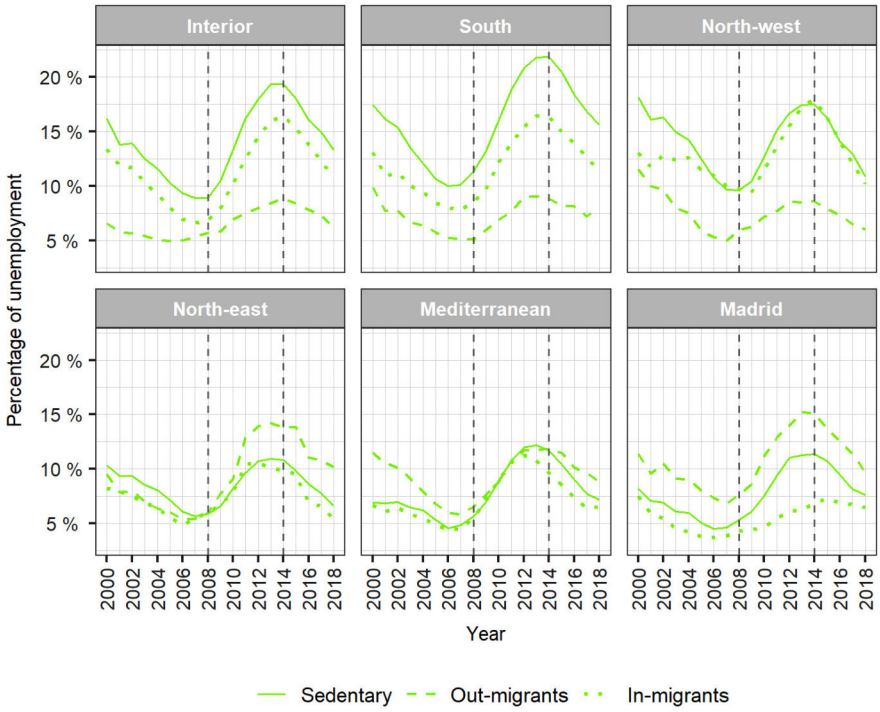
Figure 3: Percentage of university graduates among the sedentary population, internal out-migrants and in-migrants by geographical area: 2000–2018. Spanish-born population aged 25–39.

3.3 Unemployment and over-education among migrants and sedentary individuals with a university degree

We identify the effect of economic cycles on the unemployment rates of young Spaniards with university degrees in all regions: these decreased over the economic growth period 2000–2007, increased during the crisis from 2008 to 2013 and declined during the economic recovery between 2014 and 2018 (Figure 4). We observe that in both periods of growth and economic downturn, the highest levels of unemployment were among the sedentary population in the peripheral regions of southern and interior Spain and, to a lesser extent, in the north-west: these were, respectively, 15.5%, 14%, and 11% in 2018. Levels of unemployment were much lower among out-migrants—around 7.5% for the same year. Generally, in-migrants were also less affected by unemployment than the sedentary population. Our results may underpin the fact that out-migration in these regions plays an important role in the avoidance of high regional unemployment levels at origin. Irrespective of educational attainment, however, we should consider that unemployment rates are much higher per se in southern Spain. Moreover, the interior and the south, as we have seen, show similar levels of unemployment among the sedentary university graduates.

In central and semi-central regions of the north-east and the Mediterranean, lower unemployment rates among sedentary young adults with a university degree were observed – around 7% in 2018 – with levels not being much different from those of out- and in-migrants. Among the sedentary population of Madrid, the unemployment rates were similar to those of the Mediterranean and the north-east; internal out-migrants from Madrid were more affected by unemployment, a trend that contrasts with what was observed in other regions. In-migrants in Madrid, however, have the lowest levels of unemployment in the whole country.

Finally, we explore the labour profile among the sedentary population, out- and in-migrants with a university degree. To summarise the information according to what



Source: Compiled by authors using data from the *Labour Force Survey (INE)*.

Figure 4: Unemployment rate among the sedentary population, internal out-migrants and in-migrants with a university degree by geographical area: 2000–2018. Spanish-born population aged 25–39.

we observed in previous results, we grouped our period of study into three sub-periods corresponding to the economic cycles (GDP growth and unemployment): growth from 2000 to 2007, recession between 2008 and 2013 and economic recovery since 2014. During the economic growth period of 2000–2007, 57% of sedentary young adults with a university degree worked in high-skilled jobs (national average). The north-west and north-east regions had, however, a lower proportion of university graduates working in high-skilled jobs than the national average, while Madrid, the Mediterranean and the south had a higher share (Figure 5). In all the regions, the proportion of out-migrants with a university degree and, to a lesser extent, of in-migrants working in high-skilled jobs was higher than that of sedentary individuals, with the out-migrants from the interior and in-migrants in Madrid showing the highest shares. Despite the economic downturn between 2008 and 2013, the proportion of the sedentary population with a university degree working in high-skilled jobs increased slightly in most regions, but with territorial variations, as well as among out-migrants from the interior, the north-east and the Mediterranean and among in-migrants in Madrid and the Mediterranean.

In the post-crisis period of 2014–2018, the share of the sedentary population with a university degree working in high-skilled jobs increased in all regions, but again with significant territorial variations. We observed the greatest rise in Madrid and the Mediterranean, where, respectively, 67.5% and 65.3% of sedentary individuals with a university degree worked in high-skilled jobs, while the lowest proportions were in the interior (58.6%), and the north-west (57.6%). We also observed increases among out-migrants and in-migrants, but certain significant features can be highlighted. For instance, 68.4% of out-migrants with a university degree from the interior worked in high-skilled jobs, compared to 58.6% of the sedentary population. As for unemployment, our findings suggest that out-migration may help to avoid over-education in the labour market at origin among graduates from these regions. We also found that 73.3% of internal in-migrants in Madrid had high-skilled jobs, the highest proportion in the whole country.

Source: Compiled by authors using data from the *Labour Force Survey (INE)*.

Figure 5: Percentage of university graduates by level of job qualification and geographical area among the sedentary population, internal out-migrants and in-migrants: 2000–2018. Spanish-born population aged 25–39.

4 Discussion and conclusion

Interregional migration of Spanish young adults has increased over the 21st century. The rise in internal migration did not lead to significant variations in net-migration rates in the Spanish regions before the 2008 economic crisis. From 2008, however, we observed a regional polarisation in terms of internal migration, probably driven by growing processes of regional socio-economic inequality. The peripheral regions of the interior showed significant negative net migration rates both during the economic crisis and the post-crisis period. We identified a growing exodus of young adults, as well as an increase in the educational selectivity of out-migrants who were much less educated than in-migrants.

Net migration trends in peripheral regions in the south and the north-west were less affected than those of the interior. These regions also lost a higher proportion of young people since 2008 due to internal migration compared to the pre-crisis period, and the educational attainment of the out-migrants was higher than that of the sedentary population and internal in-migrants. Nonetheless, these figures are far from the values recorded in the interior.

Our results in terms of internal migration are in line with the international literature, which argues that there has been an increasing polarisation between regions since the economic crisis of 2008 (Nelle 2016). Our findings also indicate rising inequalities among regions in the employability of university graduates after 2008, suggesting that out-migration among university graduates could be a strategy for avoiding high levels of unemployment and over-education at origin.

However, we find region-specific dynamics, probably driven by contextual factors. For instance, the interior had lower rates of unemployment than the south for the total population, but both regions registered similar levels of unemployment among university graduates. In this context, it should be considered that not having a job in a region with large unemployment rates, while perhaps socially accepted, could be a social burden in a region with similar levels of unemployment that the national average, thus encouraging out-migration. Rising rates of unemployment in the interior might therefore underpin

the increase in out-migration to Madrid among university graduates. The distance to the main urban agglomerations might also explain different migratory behaviour among peripheral regions. The main urban centres tend to attract population from surrounding areas, and therefore individuals from peripheral regions bordering urban agglomeration are more likely to migrate than those from other peripheral regions farther away. (von Berlepsch, Rodríguez-Pose 2021). It could explain why the interior regions, the closest to Madrid, show the highest loss of human capital due to internal migration. Furthermore, it should be noted that peripheral regions are highly dependent on public-sector employment (Tomaney et al. 2010). The interior of Spain shows higher proportions of university graduates than the national average (González-Leonardo et al. 2019), and a high share of university graduates works in the public sector which has great importance on the employability of college graduates in these regions (Cucarella Tormo et al. 2011). Therefore, cutbacks since the economic crisis may have played a major role in the rising numbers of university graduates leaving the interior of Spain to Madrid.

The attractiveness of Madrid to young adults with a university degree has increased considerably since the economic crisis of 2008. Previous studies pointed to large economic growth in Madrid caused by the following factors: the capital-city effect; the development of radial infrastructures around Madrid; and agglomeration economies, preliminarily driven by the growth in foreign investment, which included an important share of technological activities involving electronics, telecommunications and various advanced services. (Gutiérrez-Portilla et al. 2019, Rodríguez-Pose, Hardy 2021).

In semi-central regions of the Mediterranean and the north-east, out-flows and in-flows were closely balanced, both before and after 2008, and the educational profile of out-migrants and in-migrants was similar, although out-migrants were selected by education. These regions showed a high share of the population with a university degree working in high-skilled jobs, but they do not attract university graduates from other regions.

Our findings provide evidence on the impact of the economic crisis on human capital mobility in Spain, as well as its effect on unemployment and over-education levels among internal migrants and sedentary individuals with a university degree. Our results suggest that variations on human capital mobility among regions are driven not only by regional differences with respect to unemployment and over-education among university graduates, but also by other contextual factors. This study shows that human capital mobility has changed since the economic crisis and suggests a regional polarisation in terms of the labour market. However, this work is descriptive, and we can only hypothesize a potential relationship between changes in the labour market and internal migration. Therefore, future lines of research should explore causal mechanisms between labour market and human-capital mobility in Spain, as well as other factors underpinning variations on internal migration, such as cutbacks related to the economic crisis or the distance to main urban agglomerations. Policymakers should be aware of our results and give preferential attention to the economic development of the peripheral regions to reduce the territorial polarisation driven by today's globalised economy.

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Economy and Creativity Multiparametric Clustering: Regional Comparisons and New Perspectives for Ukraine

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Abstract. This paper suggests a way to cluster Ukrainian regions by using economy and creativity-related multiparametric sets so as to reveal the main roles of players in cross-regional comparisons. Special attention was paid to an analysis of invaded regions since 2014 and 2022. The methodology is based on a consistent utilisation of structured analysis, correlation, regression and clustering modelling. Sets of parameters were selected from secondary data via correlation and regression analyses aimed at defining the most impactful factors. The study sample includes 25 regions in Ukraine. The research results contribute mainly to the theorisation of comparative regional analysis and to the relationship between the economy and creativity and their specific behaviour in regions directly linked to war crisis.

JEL classification: C10, O18, O34, O52, R12, R15

Key words: regional comparisons, economy, creativity, culture, clustering, Ukraine

1 Introduction

Regional economic development depends heavily on a capability to connect local factors in a way that results in an effective and efficient use of economic resources and high economic outputs.

These connections are dynamic and transform with changes in direct and indirect business environments with a further evolving of new structures, components and relationships.

In recent decades, creativity, as a developing economic resource and an element of business ecosystems, has received special attention (Howkins 2001, Kaufman, Beghetto 2009). Its importance then grew dramatically upon its consideration as a booster of both economic activities and as a foundation for a newly formed notion of creative sectors. Even though this paper does not aim to explore the issue of creative industries directly, it is worth mentioning that many international organizations and countries, following the first governmental attentions to this area (Government of Australia 1994, UK Government's Department for Culture, Media and Sport 1998), and after decades worth of studies on the concept, began adopting similar high-level policies and programs (Mt. Auburn Associates 2000, DeNatale, Wassall 2007, UNESCO-UIS 2012, UNESCO 2013, Boix-Domènech, Rausell-Köster 2019).

As a result, many countries, including Ukraine, began investigating a structured collection and utilisation of domestic statistics from creative and cultural economic activities, along with their types and industries (Vakhovych, Chul' 2014, Davymuka, Fedulova 2017, Farinha 2017, Skavronska 2017). Key goals were to align with international approaches and achieve a more open format to facilitate a broader public dissemination (Sotnikova 2017, Skavronska 2017). In this context, a recent report by the Ukrainian government indicates a steady annual growth of creative sectors for the period 2013-2018, reaching a 3,86% share of total value added across all industries, and an increase of 30% over this period (Ministry of Culture and Information Policy of Ukraine 2020). This is comparable to shares in developed countries, the same indicators in the USA (2019) and UK (2018), for example, are respectively 3,0% and 2,7% (OECD 2021). Of course, the absolute values and the structure of industries will differ significantly. Many Ukrainian regions, including those invaded or already de-occupied, due to their previous experience or remaining creative activities can develop unique paths for economic and cultural revival in such complicated circumstances.

Creativity is receiving increasing attention in many emerging and developing countries which expect to change their traditional ways of development through undertaking a creativity model and introducing it widely across economic activities (Barrowclough, Kozul-Wright 2008, Jakusenko, Kalasnikova 2012, Satrio et al. 2021). The recent report by UNCTAD (2022) specifically emphasises how new technologies can be helpful in reaching these goals.

However, the question regarding an exact definition of creativity and its relation to economic outputs remains open, and it seems there will be no visible progress in achieving consensus on this in the near future (Plucker, Beghetto 2004, Hennesey, Amabile 2010, Lazzeretti, Capone 2015), although in some papers there is a strong appeal to develop a common definition (Markusen et al. 2008).

Thus *the main purpose* of this paper is to define economy and creativity-related regional multiparametric clusters and to interpret the discovered concentrations, emerging hierarchies and disparities in analysed regional groupings, and with a special focus on regions under invasion since 2014 and those invaded since 2022.

Towards this goal, the paper is structured as follows. In the literature review, several domains of research are analysed: creativity as a term and its different perspectives, mutual connections between the economy and creativity, and the role of creativity in regional development. Next, the methodology used is described as a combination of three approaches: regional structural analysis, correlation and regression analysis and regional clustering. Finally, the research results with policy recommendations are developed and the discussions and conclusions are described.

2 Literature review

The literature review which follows is designed to focus on several research tasks: understanding creativity, its domains and relations to economy; and links between the economy, creativity and a regional context. Explaining the previous research results aims to understand why it is important to consider regional roles based on economy and creativity multiparametric concentrations.

2.1 Understanding creativity criteria and classifications

Initially, when creativity as a term started appearing in research in the 1920-1950s, the main focus was on creative personality and creative thinking techniques (Hennesey, Amabile 2010). Later, originality (novelty) and effectiveness were identified as distinctive features in the standard definition of creativity, generalised among others by Runco, Jaeger (2012). In the historical overview of the term's evolution in publications in 1950-1960s there was a consistent emphasis on a bipartite nature of creativity, and the contrary terms of pseudocreativity and quasicreativity were used to explain the absence of a product's effectiveness. In contemporary research, the same double-edged approach to creativity is used as in the standard definition (Ritchie 2007), but many others have suggested using a

larger number of criteria (Boden 2004, Simonton 2012, Amabile, Pratt 2016, Sternberg 2018, Kaufman, Glaveanu 2019).

An interesting question in discussing creativity arises in connection with knowledge: whether it is important for creativity or not. Although some authors tend to argue that there is no need for specialised knowledge in this case, it is growing more widely accepted that knowledge is necessary for achieving a creative novel result (Cropley 2011). Previously, creativity has been understood as a separate stream because of the existence of a related creative class who are the possessors of such knowledge (Florida 2002). Subsequently, the latter concept was somewhat appositionally re-analysed (Pratt 2008).

In turn, the need for novelty and effectiveness as distinctive creativity characteristics appeared to be the same as those used by some countries for patenting inventions (Simonton 2012); among them are requirements to be new, useful and nonobvious (surprising). This explains why a perception of intellectual property objects as creativity products is so commonly and widely held.

The broader sense of the term creativity has been adopted in recent papers by Cerisola (2018), where the author distinguishes three types: artistic, scientific and economic, using the UNCTAD (2010) classification for this purpose. The more recent UNCTAD report (2022) suggests greater success would be achieved by including artistic, cultural and industrial aspects of creative economy. This conceptual approach was also applied for analysis in subsequent parts of the present paper.

2.2 Creativity, culture and economy

As mentioned above, in recent decades creativity has started to be considered as a very important resource for the economy (Bakhshi et al. 2008, Trüby et al. 2008, Kaufman, Beghetto 2009, UNESCO 2013). This growing emphasis on the importance of creativity started in the 1990s along with an extension of research into it and potential fields of applicatons (for example, the learning economy by Lundvall, Johnson 1994). Consequently, a huge variety in definitions appeared (Hennesey, Amabile 2010) or attempts at defining the term were simply abandoned.

In the latter part of that decade the UK Department for Culture, Media and Sport (DCMS) prepared the Creative Industries Mapping Documents, paying special attention to certain types of industries based on creative activities. Although the list of industries was specified, the definition they gave was quite broad (as widely quoted in later research, including for example Potts, Cunningham 2008): "Creative industries is a new analytic definition of the industrial components of the economy in which creativity is an input and content or intellectual property is the output". Because creativity itself is a difficult term to measure, creativity products in the form of intellectual property can serve well for this purpose.

However, in some of research there was often an attempt to use the term "creativity" in a sense heavily weighted to cultural activities; and because "everything is cultural", this generated some opportunistic discussions. In fact, many authors have conceptually connected the term "creativity" with art, artistic types of activities, and literature, rather than with other types of creativity, and that indeed was traditionally well accepted. Culture was considered in those works and documents as a core part of creativity or they are both articulated in such closeness that were perceived to be a truly integrated (Mt. Auburn Associates 2000, DeNatale, Wassall 2007, Markusen et al. 2008).

In other research, by contrast, it was said to be necessary to consider a broader definition of creativity, based on its occurrence in a wide range of different economic sectors. On these grounds, two domain groups of creativity were distinguished in research – aesthetic (artistic/cultural) and functional (economic) (Cropley 2011). They were also used in other investigations in conjunction with scientific creativity (for example, UNCTAD 2010, Cerisola 2018). Some authors view creativity as a mediator between culture and economy (Capello et al. 2020).

The recent two decades of the information era brought to our attention new relations between "knowledge, information, creativity, innovation, and economic structure and growth that are enabled by digitally networked information and communication technologies" (Flew 2015), which clearly vary from country to country. This approach was

previously strengthened by embedding innovations in many cultural activities (UNCTAD 2010, Sacco 2011) and further supported by new investigations of UNCTAD (2022).

As can be seen from a review of the literature, the discussion regarding an appropriate definition of creativity has resulted in a wide diversity of approaches and types of investigation in this area. Researchers have tried to reveal not only the direct outputs of creative industries, but also the relational impact of creativity on economic development in general (Cerisola 2018, Capello et al. 2020), and that is also among the tasks in the present article. These authors and indeed many others suggested that creativity and culture have a much wider effect, in that they influence the economy both directly and indirectly, and have a stabilizing impact on society, economy and territories (Bakhshi et al. 2008, EU 2010, Davymuka, Fedulova 2017, Lazzeretti et al. 2017, Cerisola 2018, Capello et al. 2020). The OECD (2021) concluded recently: "The economic footprint of cultural and creative sectors is even larger. The value-added generated directly by the sector itself does not reveal its full importance, particularly as it has large backward linkages in the economy that drive upstream production..."

Thus, on the basis of the literature analysis above, and for the purpose of the present research, the use of the term "creativity" is suggested to be spread over various domains: (1) scientific creativity, consisting of two sub-domains – industrial and copyright intellectual property; (2) aesthetic creativity (embedded in art and culture symbols, artefacts and activities); and (3) economic or functional creativity (with reported innovations). This scheme allows for a better analysis of the impact of creativity on the economy as a whole and is the one used in the methodology part of the present study, below.

2.3 Creativity, culture and regional economic context

Since the 1990s the importance of relations between creativity, culture and economic development has also been emphasized in regional and territorial research.

Regional researchers study both tangible (Lash, Urry 1994, Zukin 1997, Martins 2020) and intangible (Swedberg 1998, Tabellini 2010) culture that impacts economic development and, as a part of it, an innovative process, and also try to analyse the way they are embedded into local space (Simonsen 2001, Gregson et al. 2001, Landry 2008, Capello et al. 2020).

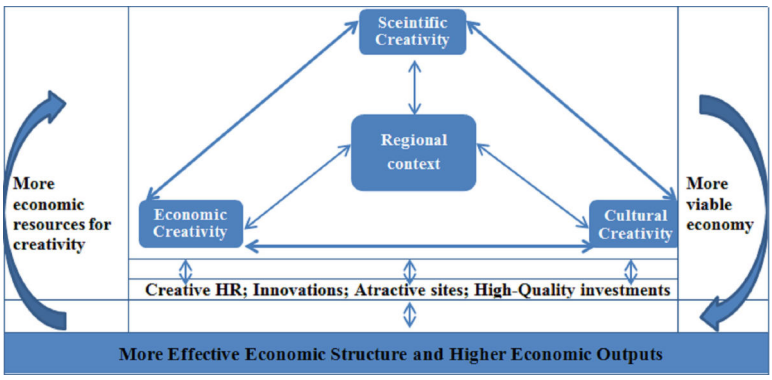
In recent research, cultural resources have also been investigated as a part of the cultural ecology (Gross, Wilson 2019). Authors have shown that, being a part of the eco-system, cultural activities can, besides their impact on site improvement, also deliver additional jobs, provide a platform for communication and exchanges of ideas, and thereby favour creativity and innovation processes. It is worth mentioning a useful and quite interesting taxonomy of cultural assets in local contexts provided by Capello et al. (2020).

In this connection, researchers have also focused their attention on concentrations of creativity in certain places. Some of them investigate determinants of creative industry locations (Serra 2015, 2016), others devote their attention to the spatial and agglomeration patterns of their location and co-location (Boix et al. 2014, Coll-Martínez, Arauzo-Carod 2017). However, there is a gap in the literature linked to the economy of agglomerations and creativity density in the less developed regions and those under crisis.

As a summarising remark in this literature review, it can be safely concluded that creativity does clearly influence economy and locality (Florida 2002, Bakhshi et al. 2008, Cerisola 2018, Capello et al. 2020, Comunian 2019, Australian Academy of the Humanities 2019, UNCTAD 2010, 2022), and vice-versa (Figure 1).

However, the UNCTAD (2010) document also indicates a fourth component – technological creativity. For the purposes of the present study this was considered as a part of economic creativity and is not treated as a separate type of creativity. Instead, the UNCTAD (2010) scheme has been modified in such a way to highlight the regional context (Figure 1), which provides (or fails to provide) possibilities for the economy and creativity to be integrated and mutually benefit from cooperation and/or co-existence. The latter is an important dimension in the framework of the present study.

The combination of the various different effects and impacts of creativity on the economy as a whole, in terms both of their possible two-sided interaction as well as their individual direct contribution, leads to a more creative, culturally oriented, flexible,



Source: Modified by the author from UNCTAD (2010, 2022), Cerisola (2018)

Figure 1: Cross-influences between economy, creativity and regional context

responsive and viable economy. Such an economy is better embedded in the local context and, in turn, generates more support for different types of creativity.

However, the author wishes to draw the overall conclusion that at present there is no holistic understanding of the relationship between the economy and creativity, and vice-versa, because of their diversified applications in specific fields and territories, as is confirmed by many researchers and reputable institutions (Pratt 2008, Capello et al. 2020, UNCTAD 2022).

There is also no agreed understanding of the level of flexibility and endurance of these relations in turbulent economic circumstances; this has become particularly critical in the context of a crisis and a volatile economy resulting from global catastrophes, natural disasters, pandemics and wars.

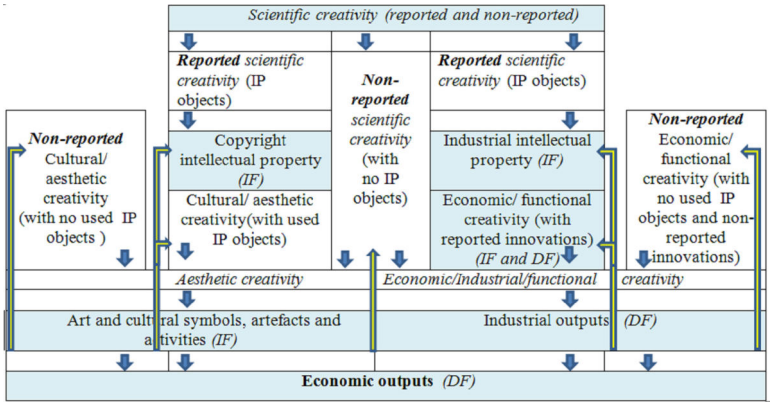
3 Data and Methodology

Various methodologies and tools to measure the impact of creativity on economic development have been previously suggested by a number of institutions and researchers (UNCTAD 2010, UNESCO-UIS 2012, Boix-Domènech, Rausell-Köster 2019), but many documents as well as Cerisola (2018) and a recent report by UNCTAD (2022) have still mentioned uncertainty with regards to accessing the relevant data. For the purposes of the present study the author used mainly an econometric approach; the methodology was constructed in the following sequence: the structural conceptualization of the links between creativity domains and the economy, the definition of the relevant parameters, and the selection of analytical tools.

The structural conceptualization combined several approaches and within the overall framework a complex model for defining creativity was further elaborated, which allowed a multidimensional view on the relations between the economy and creativity, specifically using several of the models analysed above (UNCTAD 2010, 2022, Cropley 2011, Cerisola 2018, Capello et al. 2020) and including the three components of creativity (cultural (aesthetic), scientific and economic creativity) (Figure 1 and 2).

Thus, the conceptual scheme (Figure 1) was further developed within a focus on the visibility and measurability of different types of creativity objects and the possibility to evaluate them (Figure 2). The view of UNCTAD (2022) on the integration between creativity and innovations is also covered.

Non-reported creativity is hard to discern, as it is a result of personal, group or local/ regional tacit knowledge (O'Connor 2004, Kucharska, Erickson 2021). Separately, or in combination with reported creativity, its results are ultimately embedded in final creativity objects which contribute to economic outputs. In turn, economic outputs provide more possibilities for establishing the evidence both for reported and non-reported creativity. The present study was focused on measurable creativity objects (marked as dependent and independent factors, Figure 2), preliminary tested for their impact on economic results, using correlation and regression analysis.



Note: IF – independent factor; DF – dependent factor; coloured cells illustrate availability of measured indicators. *Source*: Modified by the author and based on UNCTAD (2010, 2022), Cropley (2011), Cerisola (2018)

Figure 2: Structure of creativity domains and links to economic outputs

For these reasons, for the purposes of the present study, two groups of parameters were included in the analysis using conceptual schemes developed (Figures 1 and 2). On the one hand, the parameters of economic outputs (dependent factors) and, on the other, a group of independent creativity parameters covering: (1) scientific creativity (intellectual property objects), (2) cultural creativity (material cultural objects), and (3) economic /industrial creativity. In this paper we compared the size and the structure of the suggested groups of parameters across a regional distribution in Ukraine, as well as the correlation, regression and clustering links between them, using selected indicators which were collected through accessible official sources.

The use of correlation and regression analysis is motivated by a need to reveal the density and the depth of the relational impact between dependent and independent parameters (Figure 2). This part of the research is focused on investigating the relations between various economic indicators and the group of creativity indicators, using coefficients of correlation and regression equations.

For these purposes, the following sets of economic indicators (*the dependent parameters*) were identified: (1) economic output indicators (the number of enterprises (total, large, middle, small, microenterprises and innovative ones), gross regional product, industrial and innovative production); (2) economic input parameters (FDI and domestic investments, number of tourists); (3) HR (the number of employees in general, in the research sector, in tourism, and the number of students).

Several working groups of the selected *independent parameters* were used: (1) scientific creativity indicators covering the number of applications for inventions, utility model applications (from national applicants) and the number of publications; (2) indicators of culture, including the number of cultural objects (museums, theatres, clubs, libraries, memorials and monuments) and festivals; (3) economic creativity indicators (innovative production, new to market innovative production).

The initial set of 54 economic and creativity indicators covered regionally distributed average indicators for the period 2014-2018 (State Statistics Service of Ukraine 2019) and the number of cultural objects (Ministry of Culture and Information Policy of Ukraine 2019). Selected indicators were used in different calculations as absolute values, shares, fractional ranks and transformed values where necessary for regression modelling.

The correlation density and regression features were defined using SPSS programming with the following calculations: assessment of asymmetry and normality, data transformation (if necessary), correlation analysis, and selection of significant links of high density. In our case, logarithmic (simple, double or triple) transformations were used for dependant factors of economic indicators, since the results of asymmetry and normality analysis were not sufficient for the initial data sample and, thus, the next step of correlation calculations were not ready to be undertaken. This means that all revealed pairs of cases

with a proper level of correlation have non-linear relations; they are more sophisticated for cases with double and triple transformations.

A clustering approach is used for the purpose of defining common groups of regions in Ukraine with the same level of economic and creativity concentrations. Although there is much recent research on the clustering and mapping of creativity and culture objects and activities (Higgs et al. 2008, Boix et al. 2014, Serra 2015, 2016, Coll-Martínez, Arauzo-Carod 2017, Chapain, Sagot-Duvauroux 2018, Brydges, Hracs 2019, Comunian, England 2019), this research is distinctive in terms of its cross-regional approach and the parameters and their characteristics used to complete the tasks defined above. Clustering as a tool is particularly useful in finding the stability of relations between parameters in different regional samples. For the purpose of clustering, fractional ranks of indicators analysed were involved. All calculations were processed by SPSS.

4 Results

4.1 Recent trends in the studied sectors in Ukraine

The recent report by the Ukrainian Government has indicated a significant more than three times increase of the total value added by creative sectors during 2013 – 2018 and thus reaching a level of almost 4% of their share in the in-summing amount of all industries. At the same time the number of units in these sectors grew in almost two times, and the number of employees – by almost 23% (Ministry of Culture and Information Policy of Ukraine 2020).

But which regions are more creative than others? Are there any particular areas that show concentration of creativity and economic development? Do economically leading regions differ from creative and cultural ones?

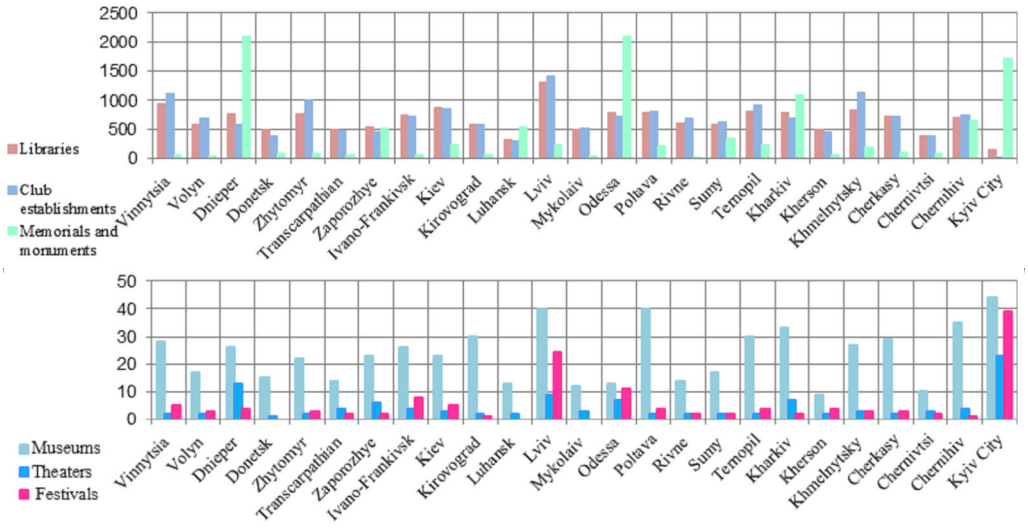
Ukraine is well-known for its cultural objects, although their role in, and impact on, the economy definitely has not been investigated fully enough. In the country as a whole, there are about 11000 memorials and monuments, 17000 club establishments, 16000 libraries, 600 museums, more than hundred theatres and almost 150 officially registered festivals, running annually (Ministry of Culture and Information Policy of Ukraine 2019). As was mentioned in connection with the Governmental report on creativity, during 2013-2018 selected cultural objects (libraries and objects of cultural heritage) and their activities transformed significantly: the number of objects grew just by 103.4%, employment by 113,4%, but value added increased almost fivefold (472,7%) (Ministry of Culture and Information Policy of Ukraine 2020).

Naturally, cultural heritage objects and activities are not distributed equally from region to region (Figure 3). There are certain leaders in cultural activities, among them Kyiv, which has the largest number of memorials and monuments, museums, theatres, and festivals. In general, the visible cultural centres are also Dnipro, Lviv, Odessa and Kharkiv.

As will be shown below, the cultural centres are also leaders in economic activities, and especially in innovative outputs (Figure 4). Thus, Kyiv City prevails in all types of enterprises; its number of micro-enterprises is about twenty times larger by comparison with some of the economically less developed regions, and the analogical proportion of large enterprises could be up to forty-five times.

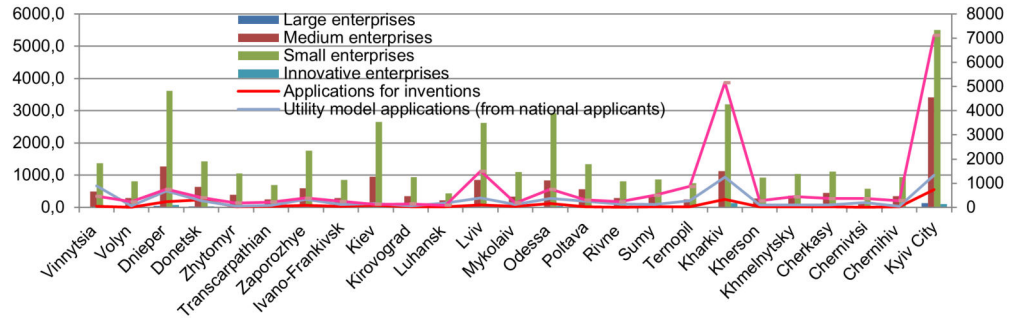
The same is true for other cultural centres. For example, Dnipro is second in terms of the number of all types of enterprises; it also has a comparatively high level of intellectual property indicators, although equal with Kharkiv, which has a comparatively high number of enterprises. Odessa leads in small and micro-enterprises, ranked third in utility model applications (from national applicants) and fourth in publishing output. By comparison, Lviv is ranked third in publications and fifth in utility model applications.

It should be noted that there are also regions with good economic production but with a somewhat lower level of cultural indicators, for example, Zaporizhzhia, however this didn't result in reaching an outlier status, as was the case with Kyiv city. Thus, the differences occurred within the acceptable dispersion of variables evaluated (see subsequent parts of this paper).



Source: developed by author, data by Ministry of Culture and Information Policy of Ukraine (2019)

Figure 3: Regional distribution of cultural objects and activities in Ukraine



Source: developed by author, data by State Statistics Service of Ukraine (2019)

Figure 4: Regional distribution of the number of enterprises and intellectual property in Ukraine

Even though this study did not aim to describe the regional distribution of IT activities as a separate part of the paper, it is worth highlighting their national trends in this analysis, because of the enormous increase in their share in creativity industries and in the economy as a whole, and their impact on other sectors' development through diffusion into other activities. During the period 2013-2018 the number of IT firms more than doubled (at 226,6%); employment grew by 182,0%, value added increased by 504,0% (Ministry of Culture and Information Policy of Ukraine 2020). In the following periods the general trends of their growth were strong as well (State Statistics Service of Ukraine 2019). They are also attractive sectors for international outsourcing contacts: more than 200 000 IT professionals are in international markets, more than 60% of Ukrainian talents are outsourced, the value of IT exports in Ukraine in 2019 reached more than 4 billion USD, and more than 20 000 IT graduates annually enter the market (Aridi et al. 2021, Ideamotive 2022). As stated in some reports, Ukraine hosts more than 110 research and development centres for multinational tech companies and is a home for operations of such global giants as Apple, Boeing, Ericsson, IBM, Microsoft, Samsung Electronics, Siemens, Skype, and Oracle (Divakova 2022). During the ongoing war, many IT companies have been relocated to western regions of Ukraine, creating IT clusters and hubs there. Many moved abroad and many stayed, where possible, in their places of origin, and this allowed them to continue working, being employed and in some cases contributing to the Ukrainian economy as well.

Therefore, such facts and coincidences in the dynamics of economic and creativity

indicators are good reasons for a deeper investigation of the relations between creativity and the economy as a whole.

4.2 The relational picture of dependencies between economy and creativity

This part of the study covers two dimensions: the investigation of the correlation and regression between dependent (1) output and (2) input indicators, on the one hand, and creativity factors, on the other. The results of the analysis were used for further regional clustering.

It was found that some independent factors showed high connectivity with almost all dependent parameters, they are: $\mathbf{I_{nv}}$, applications for inventions with the highest representation in elaborated models and also with the highest elasticity coefficients (about 0.7 – 0.75) in some models; $\mathbf{N_{tht}}$, theatres; $\mathbf{N_{fest}}$, festivals; while $\mathbf{U_{tm}}$, utility model applications from national applicants and $\mathbf{N_{publ}}$, the number of publications were involved with reduced frequency.

Conversely, the number of different types of enterprise has the most precisely defined functional links with creativity and cultural factors, all of them highly correlate with three factors: applications for inventions ($\mathbf{I_{nv}}$), the number of theatres ($\mathbf{N_{tht}}$), and in some cases supplemented with the number of festivals ($\mathbf{N_{fest}}$) with the highest correctness of results in some formulas at the level of 70-74% (R^2) of the sample.

The dependent parameters of production and investment showed a good relationship with the same factor of applications for inventions ($\mathbf{I_{nv}}$), but supplemented with the utility model applications from national applicants ($\mathbf{U_{tm}}$) and the number of museums ($\mathbf{N_{mus}}$), with the highest correctness of results for 71-73% (R^2) of the sample. And finally, HR parameters including employees in research and development and tourist sectors, also demonstrated some sufficient level of correlation with applications for inventions ($\mathbf{I_{nv}}$), the number of theatres ($\mathbf{N_{tht}}$), and the number of festivals ($\mathbf{N_{fest}}$), but the correctness of results fell down to 59-67% (R^2) of the sample.

Therefore, applications for inventions ($\mathbf{I_{nv}}$) appeared to be the most frequently occuring factor with the highest presence in equations, followed by the number of theatres ($\mathbf{N_{tht}}$), which was present in more than a half of equations, after that the number of utility model applications ($\mathbf{U_{tm}}$), festivals ($\mathbf{N_{fest}}$), and museums ($\mathbf{N_{mus}}$) followed.

Interestingly, and quite expectedly, in the output models the elasticity of scientific creativity is relatively higher in comparison with Beta for parameters of culture, with the exception of tourism indicators, where the situation is the opposite. The same is true for the HR models, but again, with the exception of employment in tourism. The elasticity of scientific creativity indicators was found to be very similar to that of the enterprise number and investment input equations.

4.3 Regional clustering, based on parameters of economy and creativity

The aim of the next step was to define the similarities among regions in terms of co-locations of economy and creativity. For this, regional clustering was completed with the use of fractional ranks of parameters that were preliminarily selected from the correlation and regression analysis, and therefore with an already revealed level of their relational density.

Thus, regional clustering was done in several steps:

1. normality analysis of fractional ranks (FR) of the parameters;
2. correlational analysis for revealing FR's correlational density;
3. hierarchical clustering as a preliminary step;
4. k-clustering with a predefined number of clusters from the hierarchical grouping;
5. testing comparisons of clusters using different grouping methods and the respective number of regions involved in certain clusters.

For the purpose of this study at the phase of clustering, four sets of regionally distributed data were formed, with the aim of revealing the possibilities for different policy applications (Table B.1 in Appendix B and Figure 5):

1. two sets of six parameters, based on their *gross (set G6) and respective per capita (set C6) regional values*, with two indicators equally for representing the groups of economic outputs (involving GRP and FDI), creativity and cultural infrastructure;
2. two sets of nine parameters, based on their *gross (set G9) and respective per capita (set C9) regional values*, with three indicators equally for representing the groups of economic outputs (involving number of enterprises, labour and tourist parameters), creative activities and cultural infrastructure.

The results of descriptive statistics of a sample of 25 regions revealed the existence of a statistical outlier (Kyiv city), and that was quite obvious due to its extensive embodiment of the parameters analysed. This also means that Kyiv city may represent the separate single-unit cluster in all factorial groupings used for analysis. The following asymmetry and normality testing of a 24-regions-sample (excluding Kyiv city) showed that fractional ranks (FR) of selected indicators meet the necessary formal requirements and could be used for further clustering. Subsequently, the correlation testing allowed us to confirm, through checking of the sets formed of six and nine parameters, the absence of a significant density of links, which justified moving to the next phases of clustering.

At the next step, the hierarchical clustering helped to define the substantiated number of groups for the following k-centres clustering. Using the results obtained, four to six clusters was found to be the most appropriate number for the purpose defined.

Then, k-centres clustering was also done with four to six groups following a comparison of these results against hierarchical clustering. The distribution of regions into clusters using both approaches showed a good percentage of proving similarity (from 70,8% to 83,3%), confirming that the clusters are formed in correct ways (Table B.2, Appendix B).

Therefore, taking into account the above and also the obvious desire to have a more equal distribution among clusters, a four-cluster grouping was ultimately chosen for further policy development (remembering that Kyiv city remains as the additional single-unit cluster). In the analysis done, four-cluster grouping also avoided situations when clusters have only one element (with the exception of Kyiv, which was preliminarily excluded from groupings), in contrast to what we found in five- and six-cluster groupings.

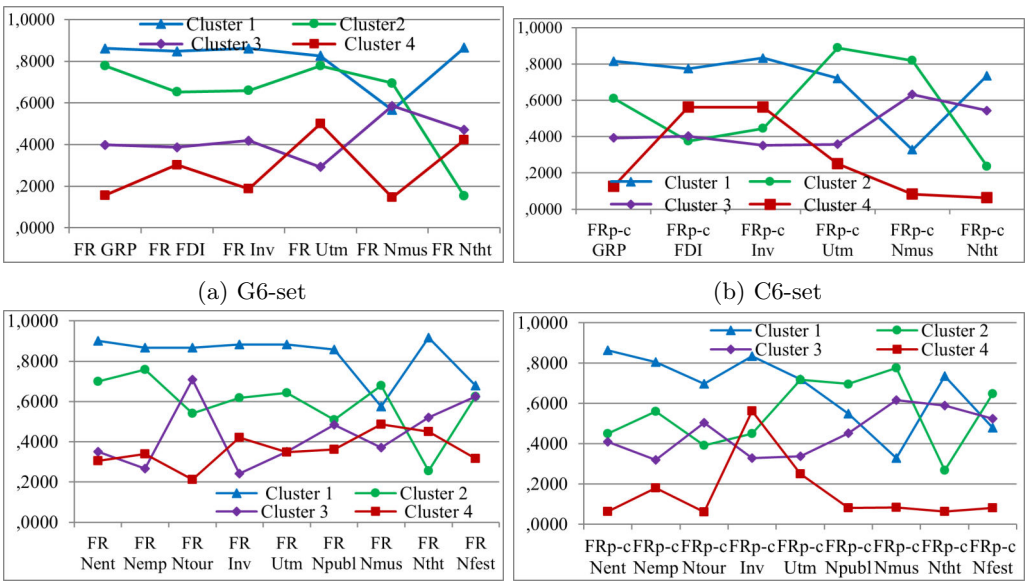
Further analysis was concentrated on clustering results. Thus, comparing the results we can conclude that cluster *number 1* is very stable and keeps almost the same set of regions under many clustering methods and with different combinations of indicators. It also possesses the highest level of summarised values of the cluster centres and consolidates the regions with almost all of the highest k-centres of parameters (Figure 5).

This cluster covers Dnipro, Zaporizhzhya, Lviv, Odesa and Kharkiv oblasts; in the case of the G6-, C6- and G9-sets it additionally involves the Kyiv region and in the case of the C6- and C9-sets it covers the Mykolayiv region. The same similarity for the core regions in each cluster is observed in other groupings of regions. The mentioned cluster clearly integrates the regions with higher parameter values and at the same time they are ones with a higher concentration of agglomerations on their terrains.

More visualisation on the disparities between clusters appeared when the clusters were compared using both the k-centres and absolute values of considered parameters in relation to the average indicators in Ukraine (Figure 6). Because the developed clusters are based on different sets of indicators and cover different regions (Figure 5), it is not possible to compare them directly; however, the results obtained illustrate quite well the general tendencies within the same regional sample (Figure 6 and 7).

Kyiv city, previously extracted from the research as a statistical outlier, was added to these comparative diagrams, and, otherwise, the general format of clusters was kept the same as developed with k-centres approach. Kyiv city (cluster 5) demonstrates its unique competitive position in all parts of the developed graphics and mapping, despite its comparatively small area (Figure 6 and 7).

As a single-unit-cluster, it differs significantly from other clusters, and comparing it with an average region and with the average per capita from other clusters, the revealed

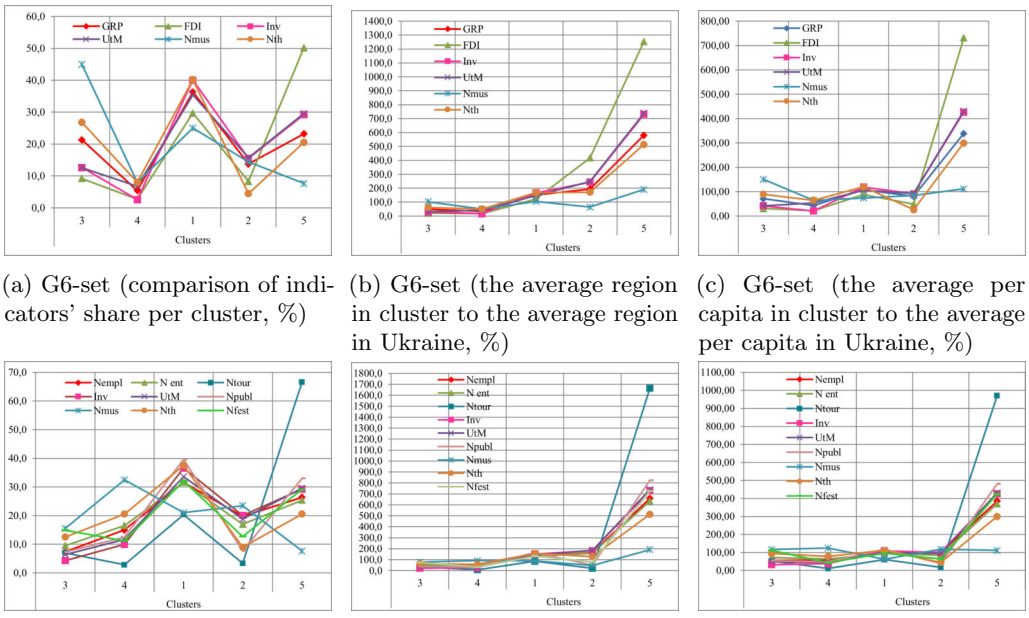


(a) G6-set (b) C6-set

(c) G9-set (d) C9-set

Source: Developed by author using SPSS modelling, acronyms: Table B.1, Appendix B

Figure 5: Comparative consolidation of k-centres of analysed indicators in each cluster



(a) G6-set (comparison of indicators' share per cluster, %)

(b) G6-set (the average region in cluster to the average region in Ukraine, %)

(c) G6-set (the average per capita in cluster to the average per capita in Ukraine, %)

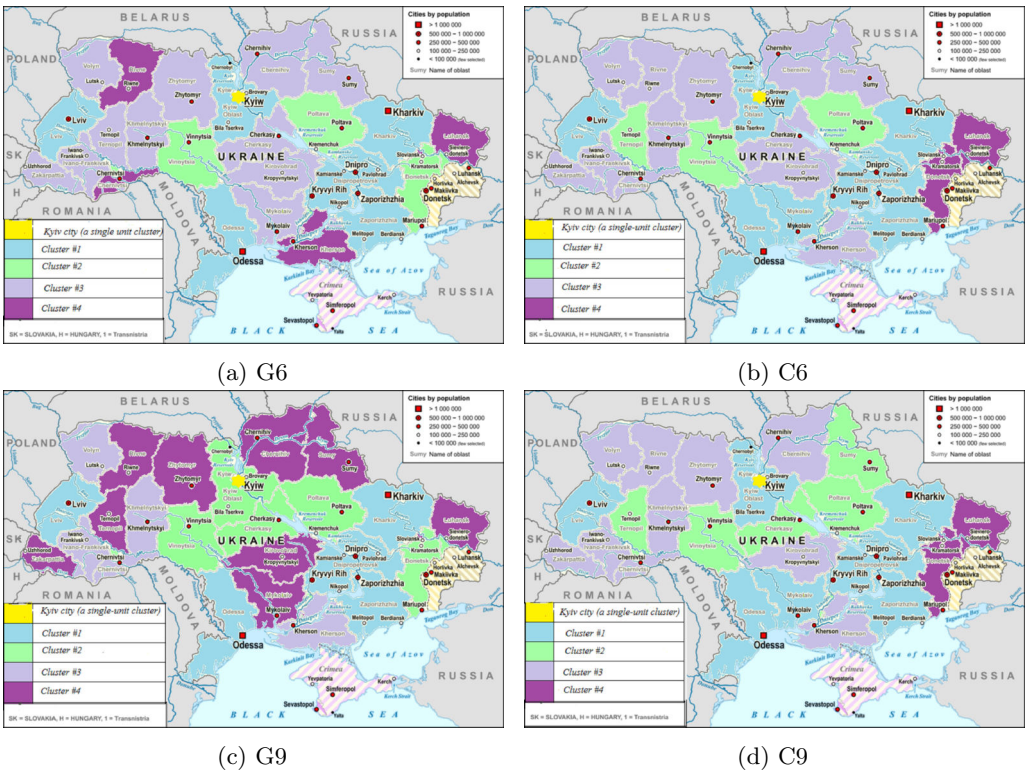
(d) G9-set (comparison of indicators' share per cluster, %)

(e) G9-set (the average region in cluster to the average region in Ukraine, %)

(f) G9-set (the average per capita in cluster to the average per capita in Ukraine, %)

Source: Developed by the author; acronyms: Table A.1, Appendix A

Figure 6: Comparative distribution of shares and absolute values of analysed indicators in each cluster



(a) G6 (b) C6

(c) G9 (d) C9

Source: developed by the author, based on Figures 5 and 6

Figure 7: Mapping of clustered regions in Ukraine depending on the parametric sets used

difference is very large (Figure 6: b, c, e and f). As a separate region, Kyiv city possesses the highest FDI share (50% of Ukraine, Figure 6: a, d). Its FDI is 12 times greater than in the average region in Ukraine (Figure 6: b, e), and its FDI per capita is 7 times higher than the average FDI per capita in Ukraine (Figure 6: c, f). In almost all other indicators, Kyiv city also exceeds the average region.

Mappings of the geographical locations of regional clusters (Figure 7) were based on the results of grouping analysis (Figure 5 and 6) with a clear indication of their power weights, and thus, with a clear indication of the significant regions-stakeholders in Ukraine depending on the parameters used for grouping.

4.4 Theoretical contributions

The research results contribute mainly to the theorisation of regional comparative analysis and the relationship between the economy and creativity through defining regional clusters and their weights, hierarchy, and roles within different multiparametric sets, with special attention paid to their specific behaviour in regions directly linked to the war crisis. It emerged that in most cases, economic and creativity concentrations are localised together within the defined parameters. Crisis regions showed evidence of a degree of misbalance in the links between economy and creativity or low indicators in general.

The results can be used for general analytical and planning purposes.

4.5 Policy recommendations

The results obtained from the regional clustering with four different sets of indicators and the dynamics of some regions within the clustering process were taken into account for the development of the final regional groupings (Table 1, Figure 8).

The differences in gross and per capita indicators in regional distribution were considered important for changing the place of a given region, when it was decided to move it to lower or higher clusters within the same set of indicators, for example comparing G6

Table 1: Final groupings of regions based on cross-clustering results

Final suggestions for grouping	War crimes against objects of cultural heritage*
1) Single-unit champion: Kyiv city (25)	Kyiv city: 5
2) Stable leaders:5 regions Dnipro (3); *Zaporizhzhia* (7); *Lviv* (12); *Odessa* (14); *Kharkiv* (19)	*Kharkiv:104;* Lviv:1; Zaporizhzhia:18; Dnipro:5; Odessa:4
3) Practical creators: 6 regions Vinnytsia (1); *Kyiv(region)* (9); *Poltava* (15); Mykolayiv (13); Ternopil (18); Cherkasy (22)	*Kyiv region:79;* Mykolayiv: 10; Vinnytsia: 2
4) Learning creators: 11 regions Volyn (2); *I.-Frankivsk* (8); *Khmelnytsky* (21); Zhytomyr (5); Transcarpathia (6); Kropyvnytsky (10); Rivne (16); Sumy (17); Kherson (20); Chernivtsi (23); Chernihiv (24)	Chernihiv: 38; Sumy: 28; Zhytomyr:6; Kherson:6;
5) In need for alignment:2 regions Donetsk (4); Luhansk (11)	*Donetsk: 129;* Luhansk: 57

Source: developed by the author; numbering of regions are shown in Table B.2, Appendix B
* Ministry of Culture and Information Policy of Ukraine (2022a)

Source: developed by the author

Figure 8: Final mapping of regions based on cross-clustering results *(before invasion)*

and C6; G9 and C9.

However, as a result of the Russian invasion of Ukraine many economic and cultural objects were either wholly ruined or partly destroyed (Table 1).

Symbolic economic objects (as a part of economic culture) and cultural artifacts are very important for identity, including national and economic identity. Sadly, but not surprisingly, they were targeted by Russia as those to be destroyed first (the plane "Mriya", the metallurgical plant "Azovstal" etc), and cultural objects (Opera Theatre in Mariupol, Museum of Bohdan and Varvara Khanenky, some buildings of Taras Shevchenko University etc) (Destroyed cultural heritage of Ukraine 2022).

Although statistics on economic objects are somewhat restricted during war time, the damage to cultural objects was possible to track on the site of the Ministry of culture and informational policy of Ukraine. For example, from September to October 2022 the number of damaged objects grew from 492 to 540 (Ministry of Culture and Information Policy of Ukraine 2022a,b, Destroyed cultural heritage of Ukraine 2022). It has to be stressed here that these are not the final figures; some sources have already revealed 971 damaged objects (Ministry of Culture and Information Policy of Ukraine 2022a).

All this may dramatically change the classified positions of some of the oblasts that were invaded; especially there is a concern in regard to the regions that are closely located to the Russian border as the reconstruction there will be longer and more unpredictable. The affected cities and communities in the Donetsk, Kharkiv and Luhansk regions are

examples of this.

The displacement of human resources also changed the places generating intellectual property. However, the Ukrainian regions, suffering heavily from the Russian invasion, where many economic as well cultural sectors have been significantly destroyed, are strongly motivated to use creativity in a broad sense for their economic revival.

In terms of the positions of clusters, the results obtained gave enough evidence to suggest that Kyiv (city) will remain unique with its high level of analysed indicators, which are practically unreachable by other regions (Figure 6, the fifth cluster). This is to be expected for a capital city, and means that it is best designated, for the purposes of grouping, as a *single-unit cluster*. It is also expectable that Kyiv's position would be maintained despite the invasion and consequent damage, even though it is a continued target for possible new Russian aggression.

The second cluster, the Stable Leaders, closely aligns with the position of Kyiv, but at the macro-regional level. These regions are excellently distributed geographically (with the exception of Zaporizhzhia, closely located to Dnipro), representing the regional driving centres very well. Like Kyiv city, their infrastructure is capable of supporting sophisticated high-tech, art and manufacturing projects. As was mentioned earlier, Kharkiv could potentially be moved to the subsequent group; this could also be caused by other regions' positions in the group being strengthened by the arrival of displaced enterprises. At the same time, Kharkiv, which, more than many other regions possessed a strong innovative image before the invasion, is a leading candidate for a unique creativity path in its economic revival during and after the current war in Ukraine. Having more creative sectors would lead to higher incomes and possibly allow for a decline in the share of capital intensive industries in the economy. In turn, this would improve the overall readiness for relocations if needed, and thus overall economic stability.

The third cluster, the Practical Creators, features a high level of utility model applications, especially Vinnytsia (which occupies the subsequent position after Kyiv city and Kharkiv and consistently represents this cluster in all grouping variations), Poltava and Kyiv region. As good practical applicators, they are strong candidates for the possible reception of inventions and utility models from other regions, thus, they are good partners for cooperation in knowledge exchange chains and for contributing to it too. They have also been less affected by military actions due to their geographical locations, and therefore this group may keep this position among regions in the future.

The fourth cluster, Learning Creators, represents the largest number of regions with a moderate number of indicators. These regions have demonstrated ongoing development and growth, but still require greater effort in creating economic and creativity agglomerations necessary to transfer into the third group. Potential investments and new openings should be supported under smart specialisation programs with high added value as a base for future growth and the improvement of regional economic structures. Some regions from this group that were invaded and which have suffered comparatively greater losses, could possibly move to the fifth group, especially those that will remain less safe due to their proximity to the Russian border.

The fifth cluster currently consists of only two regions (Donetsk and Luhansk) that both show quite a low level of most per capita indicators (Figure 7b, 7d, and 8). However, the Donetsk region has the third highest gross number of applications for inventions (after Kyiv city and Kharkiv), but by contrast has a smaller number of utility model applications. This is a unique position among many other regions in Ukraine, where the situation is quite the opposite. The Donetsk region occupies the fourth position in total FDI after Kyiv city, Dnipro and Kyiv region, and also in per capita indicators. These two regions (Donetsk and Luhansk) were both involved in the war conflict in the East of Ukraine from 2014, and the situation with indicators is quite understandable as the shrinkage that has occurred in their economic and cultural sectors is enormous. They are also among the regions that have suffered most since the invasion in 2022. As mentioned above, this group could possibly see the inclusion of oblasts that have experienced huge damages during the invasion and thus will be not able to recover quickly.

Apart from what has been described above, the analysis completed so far is a good source for cross-regional stakeholder analysis and policy development. For example, it

greatly helps to explain, why Kyiv city and the South-Eastern belt of regions (predominantly the stable leaders), as the most significant players, attracted special attention and were thus the first to be invaded in 2022.

From another perspective, comparisons of some regional positions (Figure 7) demonstrate that several oblasts possessing small portions in the national economy in terms of G9 indicators, show membership in the better clusters for G6 indicators (gross regional product and FDI), demonstrating the comparative efficiency of their economic structures and activities (for example, by such regions as Mykolayiv, Ternopil, Transcarpathia, Zytomyr and some others (Figure 7). Their development patterns are also a subject for deeper explorations of possibilities to use creative activities for faster advancement to higher positions in the hierarchy of clusters.

5 Discussion and conclusions

The research here presented has revealed that a large portion of attention in recent literature in the analysed field has been focused on the direct contribution of creative activities to the economic results. At the same time another part of literature has indicated that creative activities also impact the economy indirectly, providing more creative outputs and an environment for better economic results (i.e., more locations of enterprises, more employees, and forming better sites with greater attractiveness for investments, tourists and students). Therefore, the literature review, designed to highlight cross-disciplinary peculiarities, made room for the possibility of looking at creativity types as multifocal resources, which contribute directly and indirectly to the economy, and support development in many aspects; and vice versa. As a result, on the basis of selected research findings of UNCTAD (2010, 2022), Cropley (2011) and Cerisola (2018) the modified concept of relations between economy and creativity was developed by including (1) a regional context and (2) a reverse economic impact between components. It was also stressed that creativity has increasingly become a focus of concern in many emerging and developing countries with specific attention being paid to the role of new technologies for creative activities (UNCTAD 2022). This approach was extremely useful for Ukraine before the invasion, and has been even more so after it.

The research results have demonstrated a high density of correlation and functional regression links between many analysed indicators. The deepest relationship was revealed between, on the one hand, the different size of enterprises, investments (both FDI and domestic ones), GRP, number of employees, students, tourists and, on the other, creativity indicators, and some cultural objects, especially theatres and festivals. It is of certain interest that for static cultural objects, like monuments and museums, a much lower level of density of relations was found. Thus, an obvious conclusion is to suggest an increase of activities around static cultural objects, where possible, for example, in regard to museums ("performing museums").

The regression equations obtained have demonstrated their complicated non-linear structure, in fact, some modifications of exponential function. The independent parameters that were mostly involved, representing creativity and culture in regressions, are applications for inventions and theatres. It can be safely assumed that they are not the only parameters impacting upon economic development, but they are clearly some kind of reflection of the general state of them, which means they appear in an environment that is already well advanced and well provided with a supporting sophisticated infrastructure. Put simply, any artificial location of, for example, a theatre in some remote place would certainly not serve to boost economic growth there. On the other hand, the indicators of creativity and culture, among others, could clearly be used as generalised indicators of site attractiveness for certain types of investments.

The results regarding regional clustering support the above conclusion, demonstrating that regions with better indicators of creativity revealed involvement into the groups with higher k-centres' sums of economic indicators too. This conclusion is based on the reverse nature of the general model (Figure 1) in the theoretical part, and was supported by the regression functions and clustering results. From a practicality standpoint, it also means that a higher density of certain types of creativity are more likely to appear in regions

with better economic results, and vice versa.

In terms of clustering methodology, it was found that, first, using gross and per capita values as separate concurrent groupings gives a better picture with a deeper understanding of a region's position and behaviour; and, second, using several different sets of indicators gives valuable findings on the stability of clustering results, stable clusters and stable regions within the certain cluster. This method by itself is very useful for regional policy differentiation and gives the necessary information on regional convergence/divergence. Its applications could be diverse depending on the aims and indicators selected.

Finally, the clustering analysis of the positions of regions directly involved in war actions provided additional arguments for the possibility of them to achieve greater mobility and safety through implementing a creative development path. Implementing modern creative activities in crisis-stricken or less developed regions is a reliable way to improve their economic positions too. However, it requires sufficient skills and levels of education, which in turn can be improved by strong cultural values. Thus, in such places its culture serves as an engine driving core activities for developing increased creativity and a healthier economy. This is fundamentally true for any system.

In terms of future research, it is worth analysing a wider variety of indicators, specifically related to creativity, the latter including innovations and changes in industrial structure and its dynamics. Some additional analysis should be focused on the survival capacity and balance between creativity and economy in certain societies. Further differentiation within the research sample between cities and communities might well reveal more particular interesting details with regards to economy and creativity concentration and the respective links to regional areas. Lastly, special attention could be also given to deepen an understanding of the functionality of defined relations in crisis conditions and variations of relations between parameters in countries with different levels of development.

Limitations of research. The present research is limited to the sets of parameters used and to the scope of cultural indicators that are represented here mostly by the numbers of units and not by the activities. It should be kept in mind that war behaviour is highly unpredictable, and further developments can readily change some of assumptions made in this paper.

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A Appendix A: Correlation analysis

Table A.1: Selected indicators and respective variables

N	Acronym	Meaning
Economic indicators		
1	N ent	number of all enterprises
2	N larg	number of large enterprises
3	N mid	number of middle enterprises
4	N s-m	number of small and microenterprises
5	N sml	number of small enterprises (without micro)
6	N micr	number of microenterprises
7	N inn	number of innovative enterprises
Financial indicators		
8	GRP	gross regional product
9	Q tot	total sales
10	Q ind	total industrial production
Economic creativity indicators		
11	Q inn	sales of innovative products
12	Q inn-mark	sales of new to market innovative products
Tourist indicators		
13	Q tour	revenue in tourism
14	Ntour	number of tourists
R and D indicators		
15	R and D tot-exp	total internal R and D expenditures
16	R and D fund-exp	internal expenditures for fundamental research
17	R and D appl-exp	internal expenditures for applied research
18	R and D tech-exp	internal expenditures for technical developments
Investments		
19	FDI	foreign direct investments
20	I d-cap	domestic investments
Human resources		
21	N empl	number of employees
22	N RandD-emp	number of employees in research sector
23	N stud	number of students
24	N tour-emp	number of employees in tourist sector
Scientific creativity indicators		
25	Inv	applications for inventions
26	Utm	utility model applications (from national applicants)
27	Npubl	number of publications
Cultural indicators		
28	N hist	number of monuments of history
29	N arh	number of monuments of archaeology
30	N arc	number of monuments of architecture
31	N sc-tech	number of monuments of science and technology
32	N c-build	number of monuments of city-building
33	N mon-art	number of monuments of monumental art
34	N mus	number of museums
35	N tht	number of theatres
36	N fest	number of festivals

Source: developed by the author

B Appendix B: Clustering

Table B.1: Sets of clustering indicators

N	Acronyms (absolute; per capita)	Indicators
G6 and respectively C6 (G6 per capita) fractional ranks of indicators:		
1	FR GPR; FR p-c GPR	GRP (gross and per capita)
2	FR FDI; FR p-c FDI	FDI (gross and per capita)
3	FR Inv; FR p-c Inv	number of applications for inventions (gross and per capita)
4	FR Utm; FR p-c Utm	number of applications for utility models (gross and per capita)
5	FR Nmus; FR p-c Nmus	number of museums (gross and per capita)
6	FR Ntht; FR p-c Ntht	number of theatres (gross and per capita)
G9 and respectively C9 (G9 per capita) fractional ranks of indicators:		
7	FR Nent; FR p-c Nent	number of enterprises (gross and per capita)
8	FR Nemp; FR p-c Nemp	number of employees (gross and per capita)
9	FR Ntour; FR p-c Ntour	number of tourists (gross and per capita)
10	FR Inv; FR p-c Inv	number of applications for inventions (gross and per capita)
11	FR Utm; FR p-c Utm	number of applications for utility models (gross and per capita)
12	FR Npubl; FR p-c Npubl	number of publications (gross and per capita)
13	FR Nmus; FR p-c Nmus	number of museums (gross and per capita)
14	FR Ntht; FR p-c Ntht	number of theatres (gross and per capita)
15	FR Nfest; FR p-c Nfest	number of festivals (gross and per capita)

Source: developed by the author

Table B.2: Regional k-clustering and respective testing analysis with hierarchical clustering

K-clusters	1	2	3	4	%
Total gross indicators (set G6):					
$\mathbf{NR}_{\mathrm{ECC}}$[1]	2;5;6;8;10;13; 17;18;21;22;24	11;16;20;23	3;7;9;12;14;19	1;4;15	
Sum $\mathrm{CC}_{\mathrm{abs}}$[2]	2.5492	1.7135	4.8264	3.7153	
FRNM[3]	1;18 (4)	2;6;11;13;16;20; 23 (2)	3;4;7;8;9;12;14; 19 (3)	5;10;15;17;21; 22;24 (1)	70.8
MM[4]	1;10;15;18;21; 22;24 (1)	2;5;6;11;13;16; 17;20;23 (2)	3;7;8;9;12;14;19 (3)	4 (4)	70.8
Per capita indicators (set C6):					
$\mathbf{NR}_{\mathrm{ECC}}$	2;5;6;8;10;16; 17;20;21;22;23; 24	1;15;18	3;7;9;12;13;14; 19	4;11	
Sum $\mathrm{CC}_{\mathrm{p\text{-}c}}$[2]	2.6788	3.3750	4.2054	1.6458	
ABGM[5]	2;5;6;8;10;11; 13;16;17;20;21; 23;24 (1)	1;18 (2)	3;7;9;12;14;15; 19;22 (3)	4 (4)	83.3
CM[6]	1;2;5;6;8;10;11; 13;16;17;18;20; 21;22;23;24 (1)	3;7;9;12;14;19 (3)	4 (4)	15 (1)	83.3
Total gross indicators (set G9):					
$\mathbf{NR}_{\mathrm{ECC}}$	5;6;10;11;13;16; 17;18;24	2;8;20;21;23	3;7;12;14;19	1;4;9;15;22	
Sum $\mathrm{CC}_{\mathrm{abs9}}$[7]	3.2384	3.9167	7.4292	5.3250	
AIGM[8]	2;5;6;10;11;13; 16;17;20;23;24 (1)	1;8;15;18;21;22 (2)	3;7;9;12;14;19 (3)	4 (4)	70.8
WM[9]	1;4;8;9;15;17; 18; 22 (4)	5;6;10;11;13;16; 20;21;23 (1)	3;7;12;14;19 (3)	2;16;20;21;23 (2)	83.3
Per capita indicators (set C9):					
$\mathbf{NR}_{\mathrm{ECC}}$	2;5;6;8;10;16;20; 21;23;24	1;15;17;18;22	3;7;9;12;13;14; 19	4;11	
Sum $\mathrm{CC}_{\mathrm{p\text{-}c}}$	4.0813	4.9543	6.0106	1.4208	
AIGM	1;5;10;15;17;18; 22;24 (2)	2;6;8;20;21;22; 23 (1)	3;7;12;13;14;19 (3)	4;11;16	79.2
MM	1;2;5;6;8;10;15; 16;17;18;20;21; 22;24 (1)	3;7;9;12;13;14; 19 (3)	4;11 (4)	23 (2)	75.0

Source: Developed by author, using SPSS modelling
Notes: [1] $\mathbf{NR}_{\mathrm{ECC}}$ — number of clustered regions. [2] Sum $\mathrm{CC}_{\mathrm{abs}}$, Sum $\mathrm{CC}_{\mathrm{p\text{-}c}}$ – sum of cluster centres' values for absolute and respectively per capita values of six economic, creativity and culture indicators. [3] FRNM – Full link method (most remote neighbour). [4] MM – Median link method. [5] ABGM – Average link method (between groups). [6] CM – Centroid method. [7] Sum $\mathrm{CC}_{\mathrm{abs9}}$ – sum of cluster centre values for absolute values of nine economic, creativity and culture indicators. [8] AIGM – Average link method (in-group). [9] WM – Ward method. Numbers in parentheses are the number of clusters assigned by hierarchical clustering
Regions: 1:Vinnytsia; 2:Volyn; 3:Dnipro; 4:Donetsk; 5:Zhytomyr; 6:Transcarpathia; 7:Zaporizhzhya; 8:I.Frankivsk; 9:Kyiv (region); 10:Kropyvnytsky; 11:Luhansk; 12:Lviv; 13:Mykolayiv; 14:Odessa; 15:Poltava; 16:Rivne; 17:Sumy; 18:Ternopil; 19:Kharkiv; 20:Kherson; 21:Khmelnytsky; 22:Cherkasy; 23:Chernivtsi; 24:Chernihiv; 25:Kyiv (city)

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The geographical dimension of income and consumption inequality: Evidence from the Attica Metropolitan Region of Greece

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Abstract. This paper aims at examining interpersonal income and consumption inequality within the Attica Metropolitan Region, which includes Athens, the largest metropolis of Greece. It also aims to make comparisons between Attica and the rest of the country. The analysis is based on income and consumption microdata from Greek Household Budget Surveys (HBS) over the period 2008-2019, encapsulating the period from the commencement of the economic crisis until the year before the outset of the COVID-19 pandemic. Results indicate that income inequalities are systematically higher than consumption inequalities. From a spatial comparative perspective, the results show that the Attica Metropolitan Region exhibits a higher degree of income and consumption inequality relative to the rest of the country. Furthermore, the economic crisis increased income inequality in Athens and in the rest of the country, while consumption expenditure inequality increased in the Athens metropolitan area only. Finally, the distance between socio-economic groups, which stands as a measure of the degree of social polarization, increased during the economic crisis. However, this does not hold true for consumption inequality. Overall, the analysis demonstrates the sensitivity of inequality outcomes to the selection of the welfare indicator (income or consumption), as well as a number of noticeable differences in inequality outcomes between the Metropolitan region of Attica and the rest of the country. The paper unveils facets of inequality which necessitate the implementation of more people and place-targeted policies aimed at more inclusive and balanced welfare conditions in metropolitan regions and across the country.

JEL classification: P25, R58, D31, D63, O15

Key words: income inequality, consumption inequality, intra-regional inequality, urban inequality, Athens, Metropolitan Region of Attica.

1 Introduction

The discussion over the interaction between urbanization and inequality has gradually attracted a growing surge of interest which culminated at the beginning of this century (OECD 2016, 2018a, United Nations 2020). Increasing population density in large metropolitan areas across the globe has triggered a voluminous body of scientific research on the centrifugal/agglomeration factors in relation to the centripetal/dispersion

factors in action as drivers of this process. Poor living conditions and inequality constitute one significant counterbalancing centripetal factor towards agglomeration. The economic crisis exacerbated this trend. Large metropolitan areas (i.e. those with more than five million inhabitants in 1990) experienced the most rapid population growth, outpacing those with less than one million inhabitants (OECD, European Commission 2020). Such developments imply that, in the future, trends in inequality at the national level may depend even more on trends of inequality in densely populated areas for every single country across the globe (United Nations 2020).

The importance of the concentration of population in large urban conurbations and metropolitan areas is widely acknowledged and acclaimed as one of the primary determining factors shaping overall income and wealth inequality. However, there seems to be a degree of relative ambiguity regarding the interlinkages and the direction of causality between concentration and inequality. Following the arguments of the neoclassical approach, free mobility and market size in most agglomerated/urbanized areas of a country could offer a larger spectrum of opportunities to individuals, thus providing a better fit between human capabilities and wage maximization. In effect, this could contribute to higher social mobility and declining inequality. However, other strands in the literature, such as the Keynesian and Rawlsian proponents, claim that the urban arena provides unequal opportunities among individuals and unequal access to opportunities, and thus that the dynamics of inequalities supersede the benefits of better fits in job market. The benefits of agglomeration economies are not shared equally among individuals and across localities, and thus feed social groups and geographical areas disproportionally. Following this trajectory, growing concentration might increase inequality between the most well equipped and competitive individuals compared to those who are less so, as well as those living on the social and geographic margins (Hamnett 1994). Thus, the faster the pace of agglomeration, the higher the degree of interpersonal and intraregional inequality.

The empirical investigation of the relationship between agglomeration and income inequality has been studied extensively in the literature. Using different data, measures, estimation techniques, and levels of geographical aggregation, the majority of empirical studies argue that inequality increases with concentration. A comparative investigation of the level of inequality among 216 OECD metropolitan areas found that larger metropolitan areas demonstrate, on average, higher income inequality (Boulant et al. 2016). Similarly, a study of socioeconomic segregation in 12 European cities concludes that socioeconomic segregation after the turn of the new century has increased (Musterd et al. 2017). Finally, income inequality in US cities has increased, denoting that skills appear to be the stronger driving force in explaining the variation of inequality across American metropolitan areas (Glaeser et al. 2009).

The aim of this paper is to examine income and consumption inequality trends in the Attica Metropolitan Region, which includes Athens, the largest urban concentration in Greece and to make comparisons between Attica and the Rest of the Country (RoC)[1]. This research has some distinctive attributes which could contribute to an enrichment of the scientific literature.

First, this research provides evidence from the Metropolitan Region of Attica which includes Athens, the largest metropolitan area in Greece. Furthermore, inequality trends in Attica are compared with the trend of inequality at the national level as well as that of the rest of the country. This comparative investigation provides a benchmark analysis that makes it possible to introduce the geographical scale of analysis as an essential part of our understanding of inequality at different geographical subsets than the entire country. The geographical scale of the analysis contributes to the analysis of spatiality

[1]According to the 'Kallikratis reform' (Law 3852/2010) the Metropolitan Region of Attica and the Metropolitan Unit of Thessaloniki are established as parts of the administrative structure of the country (Council of Europe 2018). The appointed Metropolitan Region of Attica corresponds to both NUTS-1 and NUTS-2 level classification. However, according to Eurostat, Metropolitan regions are NUTS-3 regions, or a group of NUTS-3 regions, which represent all agglomerations of at least 250,000 inhabitants (Eurostat 2023). Regarding Attica, there are six identified adjacent NUTS-3 Metropolitan Regions, excluding West Attica, while Thessaloniki metropolitan area consists of a single NUTS-3 Region. The population size of Attica Metropolitan Region amounts to 3,792 thousand inhabitants and accounts for the 37% of the population of the country (Census data 2021). Due to the structure of the dataset the article adopts the 'Kallikratis reform' definition of the Attica metropolitan area.

in income inequality.

Second, the estimation of inequality is based on income and consumption expenditure. Inequalities in income do not necessarily coincide with inequalities in consumption, nor do income or consumption inequalities express similar behavior in different geographical subsets. The comparative investigation of income and consumption inequality in different geographical contexts constitutes another novelty of this research attempt.

Third, total inequality has been broken down into two components, the share of total inequality that is attributed to between groups inequality, and the share of inequality that is attributed to within groups inequality. This makes it possible to trace the trends in social polarization in the metropolitan region of Attica *vis-à-vis* the RoC over the study period. This research aims at making a contribution to the literature that concerns the trends of social polarization in cities.

Fourth, the study period is quite interesting since it begins in the first year after the commencement of the economic crisis and terminates the year before the eruption of the COVID-19 pandemic. Greece was under a spotlight for almost the entire study period. Greece was a country that found itself in the 'eye of the hurricane' during the Great Recession. Strict fiscal consolidation measures were applied within the framework of three consecutive Memoranda (2010, 2012, and 2015), which were signed by the Greek governments and the European Commission on behalf of the Eurogroup, the European Central Bank (ECB) and the International Monetary Fund (IMF). Skyrocketing unemployment, salary cuts and tax increases, as well as the capital controls that were imposed, made the case of Greece and the study of the Attica region a 'laboratory' for the study of policy impacts on living conditions, segregation and inequality. These issues could be of interest to a broader audience that extends beyond the specific case study.

This research also has some caveats. The selection of Attica as a separate geographical unit of analysis on the one hand, and the rest of the country on the other, is very restrictive. However, this choice was driven by statistical data availability, as the geographical information that it is available in the Household Budget Survey datasets up to 2015 refers only to the NUTS-1 level. Attica constitutes the only Greek region where the geographical level NUTS-1 coincides with the NUTS-2. Isolating Attica as a study subject makes it possible to examine the spatiality of inequality in a large metropolitan region, given the relative weight that the region of Attica has in the sorting of people and economic activities in the country. Pursuing research on inequality in more disaggregated geographical levels such as municipalities, cities and regions, could be an extension of this work.

Research estimating income inequality and its trends in Greece is overwhelmed with studies at the national level. The investigation of the effect of the economic downturn and the fiscal consolidation on the level and the structure of inequality in Greece has attracted the attention of many researchers over the past decade (inter alia Andriopoulou et al. 2018, Giannitsis, Zografakis 2015, Kaplanoglou, Rapanos 2018, Leventi, Matsaganis 2016, Mitrakos 2014). However, evidence available at the regional level still remains quite limited (Pantazis, Psycharis 2016, Panori, Psycharis 2019, Psycharis, Pantazis 2016), and the same can be claimed for the metropolitan area-focused research on Athens (see Arapoglou et al. 2021, Maloutas, Spyrellis 2019). Within this framework, the present empirical analysis seeks to add value by testing to what extent many of the stylized facts regarding the aspects of inequality in Greece at the national level still hold when the analysis distinguishes the metropolitan region of Attica from the RoC.

The research questions that are posed in this paper can be summarized as follows:

- Does the hypothesis for higher income inequality in Metropolitan regions hold true in the empirical analysis for the Metropolitan Region of Attica vis-à-vis the rest of the country?
- How robust is the emerging picture of inequality when using alternative welfare indicators such as household income vis-à-vis household consumption expenditure inequality?
- What was the effect of the economic crisis on the level and the structure of inequality in the metropolitan region of Attica and how different is the

corresponding picture for the RoC?

The paper is organized as follows. After Section 1, the introduction, Section 2 provides a review of the literature that concerns the spatiality of inequality with a focus on income and consumption inequalities in large metropolitan regions. Section 3 provides clarification regarding the dataset and data sources that are used along with the methods of statistical analysis. Section 4 presents the results which are accompanied with interpretations. Finally, the last section of the paper (Section 5) provides a synopsis of the findings along with a reflection on policy challenges and recommendations.

2 Income inequality and cities – Theoretical Background and Literature Review

Cities and metropolitan areas represent the level of geographical aggregation that the spatiality of inequality has studied the most. This trend is arguably attributable, at least in part, to the urbanization trends that have been witnessed in the global population over the last decades. Urbanization reached a milestone at the turn of the century when it was determined that the majority of the global population lives in cities.

It was also at the turn of the century, with the high and growing urban concentration across the globe, when increasing inequalities in income, wealth, and living conditions regained momentum. Given the prominent role of cities and metropolitan regions in the metropolitan century, the urban context became the prominent terrain for delving into inequality research (OECD 2015a, van Ham et al. 2021).

The revival of interest in income inequality appeared at the turn of the century. In most of the relevant literature, inequality was predominantly examined within the boundaries of the national state. Spatial aspects of inequality had been rare and seen as beyond the disciplines of regional economic analysis. Geographers, and sociologists examined aspects of social construction in urban as well as in rural areas in most cases (Coates et al. 1977, Johnston 1976). However, during the process of urbanization and the evolution of inequalities in urban contexts, scientific research was gradually evolving along with demands for policy action.

A number of studies focus on the role of the diversity of labor skill levels, which is quite evident in metropolitan areas, in explaining the relationship between spatial concentration and income inequality (Glaeser et al. 2009, OECD 2016). Moreover, the socio-economic residential segregation of higher and lower income earners that is often observed in large metropolitan areas is also a factor related to higher income inequality (OECD 2018a). Another set of determining factors of income inequality – although on a broader spatial scale – includes the level of economic development, a country's trade openness, the level of fiscal and political decentralization, the level of linguistic and ethnic segregation (Ezcurra, Rodríguez-Pose 2017), as well as internal conflicts (Kanbur, Venables 2005).

The theoretical background on the association between area size and the level of inequality documents two different and contradictory general perspectives. Firstly, according to the less prominent one, the increasing size of an urban area is considered to create specific advantages that lead to more balanced interpersonal income distribution. According to Castells-Quintana et al. (2020), larger cities are associated with the provision of more opportunities, which could provide benefits for low-income workers. Murray (1969) and Richardson (1973) argue that as the size of an urban area increases, the transformations of certain characteristics of the labor market will decrease income inequality through raising average incomes. There are also claims that in larger urban areas, capital markets are expected to facilitate investment in human capital, which in turn, might reduce inequality (Burns 1976).

However, most of the relevant literature suggests a negative relationship between the size of an urban area and equality in the distribution of income (OECD 2018a). Increasing city size may trigger income inequality either through a change in the occupational and wage structure of the urban labor market; or through a widening of the distribution of labor skills (Nord 1980). Moreover, Haworth et al. (1978) refer to the growth of a city as a cause for monopoly rents to rise, a development that is likely to favor the citizens

asymmetrically, while Henderson (2010) expects the enlargement of the city to potentially affect the distribution of income through change in its industrial structure. Furthermore, according to Behrens, Robert-Nicoud (2014) and Milanovic (2005) the concentration of the more productive firms and sectors in larger cities due to agglomeration economies is a fundamental factor in the greater income inequalities observed therein.

The proposition that the size of the population of a city relates positively to the degree of income inequality is confirmed for a sample of various sized cities in Latin America and the Caribbean, in the period 2009-2010, where the Gini coefficient diminished according to their population size (UN-HABITAT 2014). This also holds true for China (Chen et al. 2018), whereas a positive relationship between the size of cities and wage inequality is established in the United States (Baum-Snow, Pavan 2013). Castells-Quintana (2018) found that increases in the average city size of a country are associated with higher inequality from a certain point onward. Finally, Castells-Quintana et al. (2020) claim that higher inequality is driven by rich and large cities, and furthermore, as large cities grow, it is the inequality among the relatively rich that increases.

Turning to the discussion on whether inequality increases during an economic crisis, the available evidence appears to be unequivocal. Economic crises have been associated with an increase of economic inequality (Bodea et al. 2021, Heathcote et al. 2010). Income inequality tends to increase in recessions, since the bottom of the earnings distribution falls off substantially relative to the median. Even though disparities generally widen during economic crises, it is pointed out that during the recessions at the end of the 2010s, there were EU Member States in which, contrary to what might have been expected, income inequality narrowed (De Beer 2012).

The hypothesis that inequality rises during economic crises, is well supported by the empirical findings of several studies that examined the evolution of the level of inequality since the onset of the economic crisis in Greece. In particular, existing evidence, either from studies that measure income inequality (Andriopoulou et al. 2018, Leventi, Matsaganis 2016, Mitrakos 2014), or from studies that examined consumption expenditure inequality (Kaplanoglou, Rapanos 2018, Kaplanoglou 2022), suggests that inequality increased in Greece during the first years of the economic crisis, while it declined from 2015 onward. The increase in income inequality over the period 2009-2014 is very closely correlated with the sharp increase in unemployment over the same period, and it can be attributable to the decline in the income share of the lowest two income deciles (i.e. poorest 20 percent) as well as of the top (richest) 10 percent (Andriopoulou et al. 2018, Leventi, Matsaganis 2016). On the contrary, examination of consumption expenditure shows that inequality is caused by a great loss in the consumption share of the middle class (the middle 60 percent of the distribution of the consumption expenditure) over the same period (Kaplanoglou, Rapanos 2018, Kaplanoglou 2022). As regards the findings on the structure of inequality in Greece, existing evidence suggests that over 85 percent of the overall inequality in Greece can be attributed primarily to within-group rather than to between-group disparities (Mitrakos 2014, Mitrakos, Tsakloglou 1998, Tsakloglou 1993). The economic crisis appears to have exerted some influence on the structure of inequality according to Andriopoulou et al. (2018), who provide evidence indicating that the proportion of the overall inequality that can be attributed to disparities between socio-economic groups rose during the economic crisis in Greece.

3 Data and Methods

The empirical analysis of the present paper uses microdata of the Household Budget Survey (HBS) for Greece over the period 2008 to 2019, compiled by the Hellenic Statistical Authority (EL.STAT.). From 2008 on, the HBS is carried out by EL.STAT. on an annual basis, providing very detailed information on household consumption expenditure, covering, in addition, a wide range of demographics (including *inter alia* age; gender; household size and composition), residential area (region, population density), as well as a number of socio-economic characteristics (for instance, household income, educational level and activity status, among others). The availability of information on both household consumption expenditure and household income (obtained both from

the same national representative survey – the HBS – offers a unique opportunity to robustly analyze inequality based on both household income and household consumption distribution.

Given the primary focus of the present analysis of the geographical dimension of inequality in the Metropolitan Region of Attica, a dummy variable has been created which is equal to one if the household resides in the Attica region. Otherwise, it is equal to zero. Of course, the RoC category is a rather heterogeneous group. The population of the area of Thessaloniki surpasses one million inhabitants, while the third largest Greek city (Patras) has a population of approximately 200,000 inhabitants. Moreover, the RoC economic activity is neither homogeneous nor static. For example, tourism contributes to a great extent to the GDP of the country, while it is affected by seasonality and it takes place mostly on the islands. Taking these considerations into account, it would be certainly useful to control for the metropolitan area of Thessaloniki, as well as for the islands, when applying the empirical analysis. Nevertheless, this option could not be applied in our analysis, as the geographical information that it is available in the HBS datasets up to 2015 refers to the NUTS-1 level, which includes the following categories: i) Northern Greece; ii) Central Greece; iii) Attica; iv) Crete and the Aegean Islands. Given this limitation, it was not feasible to distinguish the area of Thessaloniki from the broader 'Northern Greece' category – as well as the islands from the broader 'Crete and Aegean Islands'. For these pragmatic reasons, and since the main focus of the present analysis has been to benchmark the outcomes of Attica *vis-à-vis* the rest of the country, we have not created a proxy dummy for Thessaloniki, as it would include not only Thessaloniki, but also other smaller cities with significantly different economic characteristics.

With regard to sample size, the HBS sample for 2008 contains information for 3,460 households, 1,219 of which (i.e. 35.2 percent) are located in the Attica region. In 2014 and 2019 the sample size appears to be even larger (containing 5,888 and 6,180 households respectively; again, almost one-third of them are in the Attica region). Table 1 presents the sample size and a brief picture of characteristics of the HBS sample that has been used for the analysis of inequality for the years 2008, 2014 and 2019.

When dealing with welfare indicators at the household level, it has to be taken into account that household size and demographic composition vary across households. A widely used approach that deals with both size and composition effects is the use of equivalence scales. The equivalence scale used in this application is based on the OECD modified equivalence scale, which assigns a weight of 1.0 for the head of the household, 0.5 for other adults and children over thirteen years of age and 0.3 for other children. Having controlled for differences in household size and composition, the two main welfare indicators for the measurement of inequality have been derived. These are: (i) the equivalent per capita consumption expenditure (defined as the total equivalent household consumption expenditure – including the value of the goods and services that the household bought or received in kind from their own production, excluding the expenditure for rents) and (ii) the equivalent per capita income (defined as the total household equivalent income -including income in kind, but excluding imputed rents). For the measurement of inequality, the present analysis utilizes two inequality indices, namely: (i) the Gini coefficient and (ii) the Theil's T index. These two indices satisfy the standard criteria of mean independence, population size independence, symmetry and the Pigou-Dalton Transfer sensitivity.

$$\text{Gini} = \frac{1}{2n^2\bar{y}} \sum_{i=1}^{n} \sum_{j=1}^{n} |y_i - y_j|$$

Theil's T index is part of the family of Generalized Entropy measures (when $a = 1$) and can be estimated as follows:

$$\text{GE}(1) = \frac{1}{n} \sum_{i=1}^{n} \frac{y_i}{\bar{y}} \ln \frac{y_i}{\bar{y}}$$

Theil's T index satisfies further the decomposability axiom, which in turn allows for assessing the contribution to overall inequality of inequality within and between differ-

Table 1: Sample size and sample characteristics of HBS data

Greece: Sample characteristics of HBS data	2008		2014		2019	
	Attica	RoC	Attica	RoC	Attica	RoC
Sample size						
Number of households	1,219	2,241	1,979	3,909	2,054	4,126
(% of the total sample)	35.2	64.8	33.6	66.4	33.2	66.8
Socio-demographic characteristics						
Household size (# persons)	2.68	2.65	2.51	2.62	2.47	2.54
Household's main source of income (% distribution of all households)						
Wages or salary	50.2	36.5	46.9	29.9	45.2	34.7
Income from self-employment	12.3	20.7	6.5	16.8	9.0	15.6
Property income	1.7	2.2	1.1	1.3	1.5	1.1
Pensions	30.7	35.4	37.7	45.6	38.3	42.1
Social benefits	5.2	5.3	7.9	6.4	6.0	6.6
All households	100.0	100.0	100.0	100.0	100.0	100.0
Activity status of household's head (% distribution of all households)						
Manual worker	21.5	17.6	19.1	12.1	17.8	16.7
Non-manual worker	24.0	14.4	21.6	11.0	23.1	13.9
Self-employed and farmer (or agricultural worker)	14.2	23.1	9.0	19.9	11.7	18.2
Unemployed	1.4	2.0	7.1	4.8	4.9	4.0
Retired	27.3	32.8	32.2	41.3	33.1	37.0
Other inactive	11.7	10.2	11.1	10.9	9.3	10.2
All households	100.0	100.0	100.0	100.0	100.0	100.0

Source: authors' estimates, HBS data

ent sub-groups of the population. Decomposing total inequality by population groups (Bourguignon 1979, Cowell 1980, Litchfield 1999, Shorrocks 1980, 1982, 1984), Theil's T index can be expressed as the sum of the within-group component of inequality and the between-group component of inequality, defined as follows:

$$T = \sum_j \left(\frac{Y_j}{Y}\right) T_j + \sum_j \left(\frac{Y_j}{Y}\right) \ln\left(\frac{Y_j/Y}{N_j/N}\right) \tag{1}$$

where the first term of equation (1) stands for the within-group inequality, while the second term for the between-group inequality (Ferreira et al. 2008, Heshmati 2004, Jenkins 1995). The inequality decomposition technique provides a fruitful way to approach the structure of inequality. To this end, a decomposition technique, as described above, is employed by the present empirical analysis in order to assess the relative importance of the between-group and the within-group component of overall inequality.

4 Results

The starting point of the recession in Greece can be traced back to 2008 when GDP growth turned negative (0.4 percent) for the first time in many years. The recession became worse in the years that followed, especially in 2010, 2011 and 2012 when GDP declined by 5.5, 10.1, and 7.1 percent respectively (OECD 2018b)[2]. Since 2016, there has been a reversal in the macroeconomic environment, showing signs of recovery, which became more noticeable with the positive growth rates of the economy in 2017, 2018 and 2019. In order to match inequality outcomes with the overall macroeconomic environment

[2]According to OECD (2015b), income inequality constitutes an aggravating factor for the GDP growth. Since income inequality is claimed to increase during recessions, this can be perceived as a self-reinforcing downward spiral process.

Table 2: Sample size and sample characteristics of HBS data

HBS, Greece	*Median value (in €)* 2008	2015	2019	*% change* 2008-15	2015-19	2008-19
			Income			
Attica	14000	9360	10800	-33.1	15.4	-22.9
Rest of Country	11333	7800	8488	-31.2	8.8	-25.1
			Expenditure			
Attica	16158	11451	12820	-29.1	12.0	-20.7
Rest of Country	13589	10333	10096	-24.0	-2.3	-25.7

Source: authors' estimates, HBS data

in the analysis that follows we have applied a periodization of the whole period of 2008-2019 that distinguishes between: a) the recession period (defined as the period from 2008-2015) and the recovery period (defined as the period from 2016-2019).

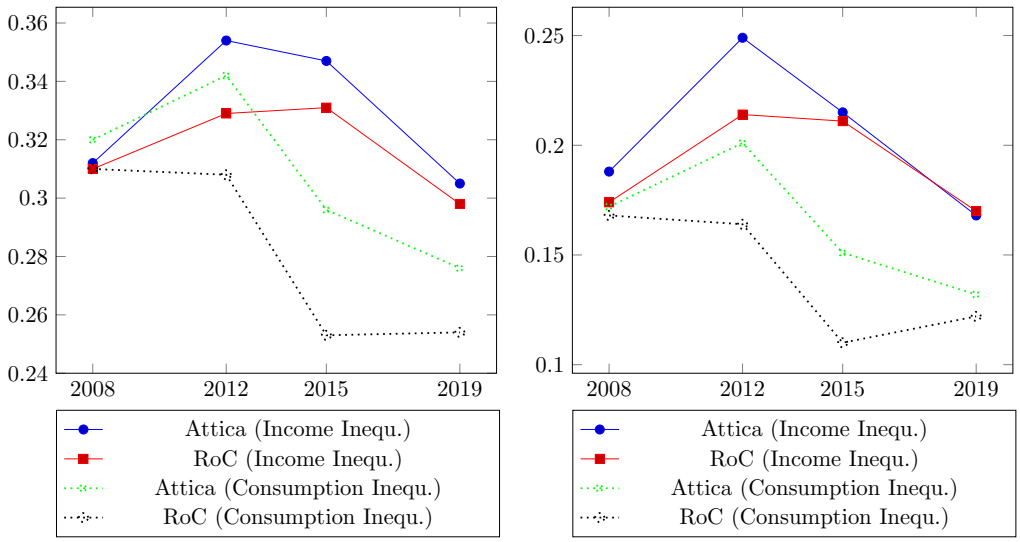
The severity and the depth of the economic crisis in Greece as reflected by several macroeconomic indicators can also be seen in the trends in welfare indicators at the household level (Panori, Psycharis 2018). Trends in household income reveal that the recession (2008-2015) led to a decline in incomes of one third in both Attica and the RoC (Table 2). However, during the recovery period (2016-2019), Attica benefited twice as much compared to the RoC. As a result, Attica's income decreased by 22.9 percent over the period 2008-2019, slightly less than that of the RoC (25.1 percent).

An analogous picture appears when examining changes in household expenditure: over the period 2008-2015, Attica experienced a relatively higher decrease in household expenditure (29.1 percent) compared to the RoC (24 percent). Nevertheless, Attica regained 12 percent over the period 2015-2019, whereas the RoC experienced a further decrease of 2.3 percent. It is also worth mentioning that throughout the recession (2008-2015), the decrease in household expenditure was somewhat lower compared to the corresponding change in household income -possibly due to a dissaving behavior of the households. Overall, in the period 2008-2019 the RoC experienced a 25.7 percent decrease in both household income and expenditure, whereas the corresponding decrease in Attica was lower (20.7 percent) for both welfare indicators.

Commenting on the regional differences, before the crisis Attica was in a significantly better position in terms of the level of household income and expenditure compared to the RoC. During the 2008-2015 recession, income and expenditure decreased slightly more in Attica (compared to the RoC), but over the recovery (2016-2019) increased significantly more in Attica, as compared to the RoC. These trends resulted in higher regional disparities (between Attica and the RoC) in 2019, relative to the 2008 level, as regards the level of household income and expenditure.

The research hypothesis stating that the level of inequality is higher in metropolitan areas compared to the national average appears to be supported by the empirical evidence of the present research for Greece. According to the estimated inequality indices (Gini and Theil's T indices) presented in Figure 1, Attica seems to constantly display a higher level of inequality compared to the RoC. In fact, the emerging spatial differences between Attica and the RoC regarding the incidence of inequality appear to be even more pronounced in the case of consumption inequality, as compared to the corresponding spatial differences in the incidence of income inequality.

Turning to the effect of the crisis on inequality, the emerging picture portrays an increase in the level of inequality during the first years of the economic downturn (from 2008 to 2012), followed by a decrease that was more noticeable from 2015 onwards (i.e. during the recovery period). This "inverted-U" pattern as regards the trends in the level of income inequality over the period 2008-2019 is clearly discernible for both Attica and the RoC, irrespective of the choice of the inequality index. Attica's Gini index of income inequality increased from 0.31 in 2008 to 0.35 in 2012 remaining at this level until 2015, before it falls again in 2019 to its pre-crisis level. An analogous pattern indicating a rise



(a) Gini Index, Greece (b) Theil's T Index, Greece

Source: Authors' estimates based on HBS data

Figure 1: Inequality measures based on per capita income and consumption, Greece

Table 3: NUTS-1 level estimates on inequality measures based on per capita income and consumption, Greece

	Gini Index				Theils' T index			
Greece	2008	2012	2015	2019	2008	2012	2015	2019
			Income Inequality					
Attica	0.312	0.354	0.347	0.305	0.188	0.249	0.215	0.168
RoC	0.310	0.329	0.331	0.298	0.174	0.214	0.211	0.170
Northern Greece	0.317	0.314	0.318	0.291	0.183	0.172	0.180	0.153
Central Greece	0.292	0.328	0.328	0.290	0.149	0.223	0.186	0.155
Aegean Islands & Crete	0.316	0.373	0.362	0.321	0.189	0.334	0.318	0.228
			Consumption Inequality					
Attica	0.320	0.342	0.296	0.276	0.172	0.201	0.151	0.132
RoC	0.310	0.308	0.253	0.254	0.168	0.164	0.110	0.122
Northern Greece	0.318	0.315	0.248	0.260	0.176	0.168	0.104	0.134
Central Greece	0.288	0.284	0.253	0.239	0.143	0.138	0.109	0.100
Aegean Islands & Crete	0.324	0.324	0.265	0.255	0.183	0.189	0.125	0.122

Source: Authors' estimates based on HBS data

of income inequality (although to a lesser extent compared to Attica) during the first years of the recession becomes evident in the case of the RoC – where the Gini index increased from 0.31 in 2008 to 0.33 in 2012 followed by a decrease from 0.33 in 2015 to 0.30 in 2019.

The "inverted-U" pattern in the evolution of the level of inequality throughout the period 2008-2019 also becomes evident when estimating inequality indices based on the distribution of consumption expenditure - albeit in this case only for Attica, but not for the RoC. Interestingly enough, the well-documented evidence implying an adverse effect of the economic crisis on the level of inequality by a number of studies focusing either on income inequality or on consumption inequality at the national level does not appear to be the case for the RoC when consumption inequality is examined. In other words, while the economic crisis appears to have increased income inequality both in Attica and the RoC, a rather differentiated geographical pattern as regards the impact of the crisis on the level of inequality is depicted when measuring household expenditure inequality. On the one hand, inequality increased in Attica household expenditure over the 2008-2012 period, while in the RoC it remained rather stable (and it decreased at a rather remarkable rate of change since 2012). Table 3 benchmarks Attica's outcomes to those of the RoC portraying the trends in the inequality indices at NUTS-1 level as well.

Table 4: Decomposition of inequality based on Theil's T index by household socio-economic status: households with household head in active labor market status

Greece	2008		2012		2015		2019	
Theil's T	Attica	RoC	Attica	RoC	Attica	RoC	Attica	RoC
			Income					
Total	0.204	0.176	0.228	0.225	0.251	0.221	0.204	0.221
Within-group	0.176	0.156	0.177	0.199	0.192	0.199	0.156	0.182
Between-group	0.028	0.019	0.051	0.024	0.059	0.022	0.047	0.038
% of the between-group	13.8%	11.0%	22.3%	10.7%	23.4%	10.0%	23.2%	17.3%
			Expenditure					
Total	0.171	0.156	0.236	0.164	0.171	0.126	0.152	0.140
Within-group	0.137	0.137	0.196	0.146	0.141	0.115	0.126	0.123
Between-group	0.034	0.018	0.040	0.018	0.030	0.011	0.026	0.017
% of the between-group	19.9%	11.7%	16.9%	11.0%	17.8%	8.6%	16.9%	12.4%

Source: Authors' estimates based on HBS data

Having depicted the changes in the level of inequality during the economic crisis, we turn our attention next to an investigation of the changes in the structure of inequality in Attica and the RoC over the same period. Therefore, a decomposition technique is employed to provide estimates of the two components of total inequality: the one that can be explained by the between-group inequality (the between-group component), and the other that can be attributed to the within-group inequality (the within-group component). The sample of the analysis is restricted to households in which the head of the household is active in the labor market (i.e. employed or unemployed, but not inactive), classifying households into four groups: (i) manual worker; (ii) non-manual worker; (iii) self-employed and farmer (or agricultural worker); (iv) unemployed. The decomposition results presented in Table 4 appear to be quite suggestive. While the between-group income inequality accounted for 13.8 percent in Attica in 2008, the corresponding figure for 2012 reached 22.3 percent and remained at this level over the next years. These findings imply that in Attica, the economic crisis not only exerted an influence on increasing the level of income inequality, but it also resulted in structural changes in income inequality. This is in line with the findings of other studies relating to the national level (Andriopoulou et al. 2018). In the RoC, the relative importance of the differences between the defined socio-economic groups in overall inequality appears to be less pronounced compared to Attica; nevertheless, the between-group component of income inequality accounts for 17.3 percent of the overall income inequality in the RoC in 2019 (compared to 11 percent in 2008).

More striking, however, are the estimated coefficients of the decomposition analysis based on the distribution of household consumption expenditure. The emerging picture does not support the proposition that the between-group component of inequality increased during the crisis. On the contrary, both for Attica and for the RoC, the share of the between-group inequality did not exhibit remarkable fluctuations during the economic crisis. This finding suggests that structural changes in household expenditure inequality were much more limited, when compared to the structural changes in income inequality.

The present analysis did not intend, and indeed cannot, extract generalized conclusions for the nature of inequality over different urban spatial structures. Such an undertaking would be very interesting; however, it is beyond the scope of the present analysis (and in terms of data, it would require different resources than those available). Indeed, it was several of Greece's idiosyncrasies (i.e. the depth and the duration of the economic recession; the relatively high pre-crisis inequality and poverty rate outcomes) that justified the special focus of the analysis on Greece. To this end, the rationale of the present analysis is built on a methodology that aimed to capture the special idiosyncrasies of Greece over the past years, rather than to provide a case study that was representative of (and "applicable to") other European countries over the same time period.

5 Conclusions

Focusing on Greece, as a prominent example of a country that has experienced a severe (in terms of depth and duration) economic downturn over most of the decade of the 2010s, and selecting Attica Region as a case study of a metropolitan area, the present paper aimed at testing two research hypotheses. These are: (i) the hypothesis that inequality appears to be higher in metropolitan areas compared to less populated areas, and (ii) the hypothesis that inequality increases during economic crises.

Starting from the trends in the level of income and household expenditure, the empirical findings revealed that both Attica and the RoC have experienced significant declines in both the level of income and consumption expenditure over the period 2008-2015. However, during the recovery period (2016-2019) Attica seems to have benefited more than the RoC, which resulted in higher regional disparities in terms of the level of household income and consumption expenditure (between Attica and RoC) in 2019, compared to the level in 2008.

Attica's income and consumption expenditure stand at a higher level compared to the RoC; nevertheless, the same seems to be the case with regard to the level of inequality, confirming the research hypothesis that metropolitan areas exhibit higher inequality compared to the national average. This finding seems to be quite robust – irrespective of the choice of either the inequality index or the welfare indicator – and it appears to be even more pronounced in the case of the consumption expenditure distribution.

The distribution of income appears to display greater inequality – both in Attica and in the RoC – over the period of the economic downturn, thus confirming the research hypothesis that economic crises are associated with greater inequalities in income distribution. Indeed, the level of income inequality seems to follow an "inverted-U" over the period 2008-2019 documenting an increase over the period 2008-2015 followed by a decrease over the period 2015-2019. However, in the case of the distribution of consumption expenditure, the emerging picture appears to be quite mixed: on the one hand, the "inverted-U" pattern regarding the evolution of the inequality over the period 2008-2019 seems to be confirmed in the case of Attica, but the RoC displayed greater resilience, as consumption expenditure inequality did not increase throughout the economic downturn.

Finally, the crisis appeared to exert an influence on the structure of income inequality – particularly in the case of Attica. This change is mostly reflected in the sharp increase in the relative contribution of the between-group component to the overall income inequality in Attica since the onset of the crisis. When consumption expenditure inequality is examined, the emerging picture of the structure of inequality appears to be quite stable for both Attica and the RoC. As in the case of the changes in the level of inequality, the distribution of household consumption expenditure reveals a more resilient pattern as regards the evolution of the structure of inequality, especially in the RoC. This is possibly a result of a number of parameters ranging from dissaving behavior to the role of self-consumption. Recall that Greece experienced capital controls for quite some time (starting in 2015). During the same period, Value-Added Tax (VAT) increased as well. As pointed out by an anonymous referee, these two factors taken together are likely to have affected the consumption habits of individuals while not necessarily affecting their income level. This might be an explanation behind the finding that for the RoC an "inverted-U" pattern is observed only for the case of income but not for the case of consumption expenditure.

Overall, the present paper aimed at contributing to a growing literature on the effects of the economic crisis on inequality, by seeking added value through two dimensions. First, from a methodological perspective, it tested the robustness of the impact of the economic crisis on inequality by measuring inequality both in terms of income and consumption expenditure. Second, it employed a rather geographical perspective, by focusing on the metropolitan area of Attica. Both these two dimensions have been useful in providing some noteworthy findings, contributing to the existing evidence on the interplay of the economic downturn with inequality in Greece.

In particular, the well documented evidence provided by a number of recent studies that the structure of inequality has changed over the past decade, is not supported by the

present paper when examining inequality based on the consumption expenditure distribution. In turn, this highlights that inequality outcomes during the economic downturn in Greece appear to be quite sensitive to the choice of the welfare indicator. In terms of policy making, this implies that policy recommendations which are based on income inequality might neglect aspects of inequality when the latter is examined in terms of consumption expenditure and vice versa.

The geographical emphasis of the analysis employed demonstrated that inter-regional disparities in the level of income or consumption expenditure have increased recently as the metropolitan area of Attica has gained more during the recovery period (2016-2019) relative to the RoC. At the same time, however, the present analysis provided evidence suggesting that the metropolitan area of Attica exhibited a higher level of inequality compared to the RoC during the economic downturn -and it still does. In turn, this highlights that intra-regional inequalities (especially in large metropolitan areas) have to be addressed as high policy priority issues, a need that became more urgent with the strong effects of the recent COVID-19 health crisis and imposed by the Sustainable Development Goals of the UN 2030 Agenda. In terms of policy recommendations, these findings imply that in addition to the objectives of tackling the existing inter-regional disparities, policy measures of a comprehensive cohesion policy strategy should also include an additional mixture of policy interventions aiming at addressing social polarization within regions, and intraregional inequalities. Additional means-tested (in cash but also in kind) benefits designed by, and provided at, the local administrative level might provide a fruitful supplement to the existing national-wide policy instrument in tackling intra-regional inequality.

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Financial Development and Human Development in Nigeria

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Abstract. This study examines the relationship between financial development indicators and human development in Nigeria from 1990-2019. It investigates the effect of broad money supply/Gross Domestic Product (GDP) on Human development; it examines the impact of credit supply/GDP on human development and assesses the link between market capitalization and human development. The study employs expo-facto research design and Autoregressive Distributed Lag to examine the relationship between Financial Development and Human Development. Previous studies in Nigeria had focused on financial development and economic growth, financial deepening and economic growth. Therefore, this study is a response to the dearth of relevant empirical studies on financial development and human development in Nigeria. From the results, the long run net effect of broad money supply/GDP on human development is negligible and positive. M2/GDP in Nigeria only account for the extent of monetization rather than financial intermediation. The long run net effect of credit supply/ GDP on human development is negligible and positive. The long-run effect of M2/GDP, CPS/GDP are statistically significant but has no power to substantially influence human development in Nigeria. The study suggests that banks should effectively perform their intermediation roles and effort should be made by the policy makers to widen/broaden the Nigeria capital market activity. Policy makers should concentrate on financial system and their roles for effective money supply and credit supply while implementing economic policies.

JEL classification: E5,I00,O10

Key words: Financial development, Human Development, M2, CPS, GDP, ARDL

1 Introduction

The idea of human development was first looked into by Aristotle who believes that policymakers should identify the needs of individual so as to improve their living conditions (Kuriakose, Iyer 2015). In the early 1960s there were increasing clamour and calls not to put too much importance on GDP, because in the past, economic performance (GDP) had become both the leading objective, and indicator of economic development in many nations despite that GDP was never intended to be used as an indicator of welfare. From 1970s to 80s economic development experts considered using alternative measure for development as against GDP that is narrow in perspective. Hence, experts

considered putting emphasis on employment, income redistribution and meeting of basic necessity of life as indicators of development and these argument helped to give room for the human development approach, which is about broadening the quality of human life, instead of simply the growth of the economy in which human beings live.

According to UNDP (2017a), "the Human Development Index is based on three parameters which are: Long life, measured by life expectancy at birth, education or skills, captured by a combination of adult education, the total primary, secondary and tertiary enrolment and the living standard measured by real GDP per capita". In Ranis, Sewart (2004), human development was used interchangeably with human capital to indicate a two way relationship between economic growth and human development. Economic growth is a subset of human development and it is expected that human development is accorded the maximum priority but development experts continue to treat economic growth as both the leading objective and an indicator of economic development (Solow 1956). Human development is multidimensional while economic growth is a single achievable objective that is capable of driving human development indicators (Sala-i-Martin, Pinkovskiy 2010). It is surprising that not until 1990s when UNDP and Organisation for Economic Cooperation and Development (OECD) made human development the world's central reference point for development, previous emphasis have been on economic growth and GDP per capita. The current level of poverty, income inequality in Nigeria and the claim by the World Bank that Nigeria is the Capital city of Poverty is further confirmation that all is not well with the country in the area of human development and a signal that Nigeria is far from achieving Sustainable Development Goals (World Bank 2022).

However, the debates on how financial development could enhance human development now become new national focus and remain a tensed issue without any moderate consensus in Nigeria. Overcoming human development challenges requires access to financial resources, whereas access to finance requires a procedurally complicated process as a result of various risks and the general cost of transactions. To appreciate the role of financial development, leading development economists like King, Levine (1993) and Park et al. (2018) have re-emphasized that "higher levels of financial development is positively correlated with faster rates of economic growth, physical capital accumulation, and economic efficiency both before and after controlling for numerous country and policy factors". According to World Bank (2014), financial development is a private sector driven strategies that enhances economic growth and human welfare and play important role in human development in both developed and developing countries. Investment, loans and interest rate contribute to human development because these are key macroeconomic factors that drive economic growth and development (Asongu 2011). Notwithstanding that financial development can do more to reduce both economic and social challenges, access to finance remain a major challenge to both individuals and private sector in Nigeria and Africa in general (Tchamyou 2017).

To appreciate the novelty of the above statement of the research problem in view of current developmental challenges facing Nigeria, it is better to situate the importance of financial development within the framework of the United Nation General Assembly adopted plan of action for people, prosperity and planet under Sustainable Development Goals (SDGs). The UNDESA report elaborated on how access to finance can help to combat poverty, hunger, and ensure good health, quality education, gender balance, decent work, economic growth, reduction in inequality through savings, access to credit, digital micro-insurance, digital flexible saving and loan facilities, digital wallets, MSME digital payment (ITU 2015, UNDESA - UNESCO 2014, UNDP 2017a,b).

Based on above narratives, this research work focuses on financial development and human development in Nigeria.

2 Statement of the Problem

The motivations for this study are: Firstly, the dearth of relevant empirical literature on financial development and human welfare in Nigeria. Also, the World Bank report of 2015 on meeting the Millennium Development Goals (MDGs) gave a clearer picture that poverty is reducing in all parts of the world except African continent which does not in

any way getting closer to meeting the MDG extreme poverty target (World Bank 2015). The above narration is a clear departure from the claims that African continent has experienced over two decades of growth from 1990s (Fosu 2015). The fact remains that African nations and especially Nigeria experiences economic growth that does not translate into human welfare. Hence, the need to shift the debates from GDP to education, health and general human welfare so as to understand the recent human development trends and challenges in African nations (Kuada 2015).

Secondly, despite the fact that finance is crucial for investment, recent findings revealed that financial development has become a major economic challenge in Nigeria because recent revelation during naira re-designation has further confirmed that huge proportion of money in the Nigerian economy which should be channel into investment and development is currently outside the banking system resulting in allocation inefficiency and ineffective financial intermediation (CBN 2015, 2023, Saxegaard 2006, Owoundi 2009, Asongu 2014a,b, Tchamyou 2017).

Thirdly, there is a dearth of empirical researches on the nature of the relationship between financial development and human development by the development economists in Nigeria. Lastly, despite of the fact that many studies (Shaw 1973, McKinnon 1973, Roubini, Sala-i-Martin 1991, Qi, Teng 2006, Onaolapo 2015, Babajide et al. 2015, Ogwumike, Afangideh 2008, Beck, Levine 2007, Ogwumike, Afangideh 2008, Asongu 2017) have confirmed the positive effects of financial sector development on economic growth and development, Poverty and inequality (inclusive growth) have eroded the gain from economic growth in Nigeria (Wright 2017). This is because any growth that fails to create jobs and develop the economy cannot be sustained (Alege et al. 2016). It is against this belief that this study intends to examine the link between financial development and human development.

The broad objective of the study is to investigate the relationship between financial development and human development in Nigeria while the specific objectives are to:

1. investigate the impact of Money supply/GDP on human development in Nigeria.
2. examine the effect of Credit supply/GDP on human development in Nigeria.
3. evaluate the relationship between market capitalization and human development in Nigeria.

3 Literature Review

The World Economic Forum in 2011 precisely describes financial development as the indicators, guidelines, practices and institutions that would engender effective financial intermediation, markets, deepening access to capital and financial services (World Economic Forum 2011). Similarly, Levine (1999) suggests that an ideal measure of financial development focuses on the ability of the financial sector to conduct researches on firms, discover profitable ventures, institute corporate control, manage risk, mobilize savings, and ease transactions. According to Levine (1997), a nation's financial sector would be ranked as more developed than that of other countries if its costs of bringing the surplus unit and deficit unit together are cheaper and if it improves the productivity of capital allocation amid rival projects. On the other hands, Human development as measured by human development index (HDI) focused on income, education and life expectancy and is regarded as a more comprehensive indicator of human welfare (Alkire 2002, Alkire, Foster 2011, UNDP 2010, 2017b). Empirical literature on human development reveals that educated individuals are less risk-averse, knowledgeable and are high savers. Thus, improving the percentage of people with education provides new opportunities for empowerment of people. Knowledge and skills also enable individuals to change from informal to formal sector opportunities which permit them to access formal financial services. Financial sector development by way of credit channels often result in the accumulation of human capital which influences economic growth (Sarwar et al. 2021).

3.1 Theoretical Framework

From the extant literature review, there are two separate theories on the relationship between financial development and human development. There are views that financial development is necessary for growth and development. Financial difficulty such adverse selection, moral hazard, monopolies of knowledge and a procedurally complicated process as a result of various risks and the general cost of transactions can restrict the poor from accessing the required finance. It therefore suggests that combating human development challenges through efficiency allocation of capital would enhance access to finance by the poor to finance profitable investment and raise average income (Perroti 1993, Galor, Tsiddon 1996).

The end result from ease of access to finance would be improvement in human welfare due to increasing economic growth and reducing income inequality (Beck et al. 2009, Beck, Levine 2007, Demirguc-Kunt, Levine 2009, Galor, Tsiddon 1996).

The opposing views argue that financial development benefits the upper class. According to these theorists, the poor depends on the remittances and informal financial sectors for capital (Beck et al. 2009, Gupta et al. 2009). The pro arguments and anti-arguments on the link between financial development and human development have been harmonized by accepting that there are exceptions to pro and anti-arguments on the nature of the relationship between finance and development. The last strand of argument view that finance and inequalities are inversely related and asserted that there is an inverted U-shaped relationship between GDP per capita income and inequality (Greenwood, Jovanovic 1990) and this is consistent with the hypothesis of Kuznets (1955) which claims that U-shaped relationship occurs as a country goes through the various phases of economic development.

The bottom-line of this hypothesis is that when the economy is still in the adolescent stages of development, the inequality gap widens as the financial markets develop due to a poor financial inclusion or greater exclusion of the low-income group.

The above separate theoretical perspectives are interconnected with the intensive and extensive margin theories which postulates as follows;

The views of the intensive margin theories access to finance affect inclusive growth and human development unmediatedly and mediatedly by improving the financial service experience of private organizations and individuals that have been financially included (Chipote et al. 2014). On the other hand, the extensive margin theory postulates that financial access improves financial service experience and usage of financial services of both the private organizations and individually who have been experiencing financial exclusion due to financial constraints (Chiwira et al. 2016, Odhiambo 2014, Orji et al. 2015).

3.2 Empirical Studies

Obviously, studies on the linkage between financial development and human development are scanty in Nigeria and the vast number of studies in this area focused on developed world. The pioneering work of Schumpeter (1911), (Bageout 1873), King, Levine (1993), McKinnon (1973) and Shaw (1973) laid strong foundation for the study of finance and growth and investigate the relationship between financial development and economic growth with claims that there exist a linear and positive relationship between finance and growth. Similarly, theoretical literatures by Beck et al. (2009), Levine (1997), Demirguc-Kunt, Levine (2009) and Galor (2011) suggest that financial development improves human welfare by increasing economic growth and reducing income inequality.

Subsequently, many recent studies continentally have lent credence to the role of financial development in promoting human welfare. For instance, Sethi et al. (2019) report that high level of financial sector development and big market size led to a rise in human development in South Asia. Likewise, Sehrawat, Giri (2017) argue that financial development and human development are key driver of economic growth and further assert that financial development with low human development result in poor economic growth while Monacelli et al. (2011) cross-country study provide evidence that financial system promote human development. Monacelli, Lovino and Pascucci's study which use data from

68 countries and cover 1990-2005 reveal that financial market and financial architecture influenced the Human Development Index; a composite indicator of health, education and income. The positive linkage between finance and human capita was detected by Sarwar et al. (2021) who investigate the relationship between financial development and human capital development with a claim that financial development and human capital have positive and significant effect on developing countries' economic performance.

Asongu (2011) investigates the factors that determine human development from the financial development index using time series data of 38 developing countries. The author asserts that financial activity, size, and depth (in decreasing order) are statically significant for inequality-adjusted human development whereas financial allocation efficiency significantly depletes human welfare and conclude that financial allocation efficiency does not drive human development. The study of Hakeem, Oluwatoyin (2012) examines the relationship between Human Capital and financial development in South Africa for the period of 1965-2005 and the result of the study shows that there is a weak relationship between financial development and all the proxies of Human Capita used with the exception of life expectancy at birth and secondary school enrolment.

Akhmat et al. (2014) extend the existing researches by examining the links that exist among the economic growth, financial development and human development using a sample of four countries taken from South Asian Regional Cooperation Organization (SAARC) countries. The finding of their study reveal that there is a sustainable long-run relationship among financial development, economic growth and human development in the SAARC region. Study by Filippidis, Katrakilidis (2015) investigate the role of institutions and human development on financial development in the beginning and developing stages of the economic growth, using data from 52 developing economies and cover the period of 1985-2008. The researchers decomposes and disentangles institutional variables economically, politically and socially to comprehensively assess which institutional variables significantly explain human development reported that institutional quality explained the cross countries variances in the extent of development in the banking sector. The study also shows that economic institutions and human development are significant for the development of the banking sector while the legal system exhibit dominance among economic institutions.

Kaya (2018) examine the effect of the financial markets development on human development and measured the level of development of financial markets with the Borsa Istanbul 100 Index (BIST) growth rate and use Human Development Index developed by UNDP to represent the level of human development. The study use Johansen-Juselius Cointegration test to determine the existence of long-term relationship between the variables and Granger Causality test was used to determine the causal relationship between the variables of interest. The study discovered that both dependent and independent variables are related in the long term and the HD index granger caused the BIST index.

Raichoudhury (2016) conducts an empirical analysis of the nexus between financial inclusion and human development across countries. The author measures financial inclusion using a cross country data set from Financial Access Survey (FAS) and the index of financial inclusion (IFI). The study discovered that the levels of human development and financial inclusion in a country moved concurrently with each other, with minor exceptions. The correlation coefficient for IFI and HDI values were calculated to be 0.82 and 0.85 indicating that significant positive correlation between the two indices. The findings of study revealed that income level and financial inclusion in a country moved concurrently with each other. All the high income countries are also the high IFI countries.

Kilic, Özcan (2018) examine the impact of financial development on human capital in developing countries between 1990 and 2015. The study specified two different panel data models including different measures for human capital. Results of the study reveal that financial development positively influenced the level of human capital level in developing economies and causal linkages exist between financial development and human capital indicators.

Asongu, Rexon (2021) examine the direct and indirect nexus between financial development and inclusive human development in African countries using panel data and

regression. The study employs Two-Stage Least Squares, Fixed Effects, Generalized Method of Moments and Tobit regressions for the analysis. Human development was proxy by inequality adjusted human development index while financial development was proxy by all financial development indicators as developed by World Bank. The result of the findings indicate that financial institution and financial market depth and efficiency improve inclusive human development, but the banks failure to perform its intermediating roles by channelling savings into credit for private individuals and firms due to information asymmetry has negative effects on inclusive human development. The study recommends that effort should be made by policy makers to improve credit accessibility to the individual households and firms through efficient and effective policy making. The study also suggests that eliminating or minimization of information asymmetry will limit idle cash which could have been invested by households and firms.

Tekin (2020) investigates the causal relationship between financial development and human development using health and welfare indicators in developing countries purposely to know whether the financial developments of the countries affects the basic human development of the individuals and whether human development indicators impact on financial development. The data for the study covers the period 1970- 2016. Pedroni and Kao test of cointegration and Dumitrescu and Hurlin panel causality analysis were conducted by the researcher. The results of the study show that there is long-run link between financial development and human development and a causal link between financial development and human development in developing nations.

Ferraz et al. (2020) use Data Envelopment Analysis (DEA) to capture absolute capability values and the social efficiency of 129 Brazilian meso-regions, considering their heterogeneous financial means and identified a new indicator called Capability Index Adjusted by Social Efficiency (CIASE) to examine the human development performance of regions based on their extreme levels of poverty as well as their social efficiency in translating limited financial resources into human development. The study also develops a Deprivation and Financial Responsibility based Prioritization Index (DFRP) that assisted in identifying key regions for higher government spending in human development. The findings of the study for Brazil show that many poor regions did relatively well in the area of social efficiency than in the area of human development. On the contrary, many wealth regions did relatively poorly in the area of social efficiency than in the area of absolute values.

3.3 Research Gap

Evidently, studies on the linkage between financial development and human development are scanty in Nigeria and the vast number of studies in this area focused on developing and developed world

4 Methodology

4.1 Model Specification

This research work uses a single aggregate index termed HDI which was developed by UNDP in 1990 to capture human development while M2 to GDP, CPS to GDP and Market Capitalization are used to capture Financial Development. The basis for limiting our independent variables to three was due to data availability and the need to be cautious of data proliferation, number of observations and the effect of degree of freedom on our observations. The choice of these variables was also motivated by the foundational work of Bageout (1873), Schumpeter (1911), Hicks (1969) and financial development framework developed by McKinnon (1973) and Shaw (1973), King, Levine (1993) which laid strong foundation for the nexus between Financial development and human development but we defer by limiting our independent variables to three key measures of financial development due data availability and econometric factors. Levine and King's model would be adapted because of its succinctness and its simplicity for empirical confirmation of the link between finance and development.

Table 1: Sources and measurement of variables

Variables	Definition/Meaning	Sources
HDI	Human development index	United Nation Development Programme Report (1990-2019)
$\frac{m2_t}{gdp_t}$	Ratio of money supply to GDP	Central Bank of Nigeria Statistical Bulletin (1990-2019)
$\frac{cps_t}{gdp_t}$	Ratio of credit to private sector to GDP	Central Bank of Nigeria Statistical Bulletin (1990-2019)
$\frac{mkcap_t}{gdp_t}$	Ratio of market capitalization to GDP	The market values of companies' share in any currency

Based on Levine and King's theoretical and conceptual views, the adapted empirical model for this study is specified as:

$$hdi_t = f\left(\frac{m2_t}{gdp_t}, \frac{cps_t}{gdp_t}, \frac{mkcap_t}{gdp_t}\right) \tag{1}$$

where[1] $\frac{m2_t}{gdp_t}$ is the ratio of broad money supply to GDP (financial deepening), $\frac{cps_t}{gdp_t}$ is the ratio of credit to private sector to GDP (financial deepening), and $\frac{mkcap_t}{gdp_t}$ is the ratio of the market capitalization to GDP (capital market activity).

4.2 Method of Data Analysis

The study used the ARDL model for the analysis. The flexibility and suitability of ARDL for 1(0) and 1(1) order of integration, and its capability to test for long run association and perform better when the sample is less than sixty observations is appealing to the researchers (Granger, Yoon 2002).

According to Pessaran et al. (2001), the ARDL model is specified as:

$$\begin{aligned}\Delta HDI_t = {} & \alpha + \sum_{i=1}^{n} B_{1i}\Delta HDI_{t-i} + \sum_{i=0}^{n} B_{2i}\Delta \frac{M2}{GDP}_{1t-i} + \sum_{i=0}^{n} B_{3i}\Delta \frac{CPS}{GDP}_{2t-i} + \\ & \sum_{i=0}^{n} B_{4i}\Delta \frac{mkcap_t}{gdp_t}_{4t-i} + C_1 HDI_{t-1} + D_1 \frac{M2}{GDP}_{t-1} + D_2 \frac{CPS}{GDP}_{t-1} + \\ & D_4 \frac{mkcap_t}{gdp_t}_{t-1} + e_{it}\end{aligned} \tag{2}$$

where Δ represent first difference, HDI is the dependent variable, t is period, α denotes the intercept, $\frac{m2_t}{gdp_t}$, $\frac{cps_t}{gdp_t}$, $\frac{mkcap_t}{gdp_t}$ are expressed in form of k by 1 vector of regressors, C_1, D_1, D_2, D_3, D_4 represent long run coefficients while B_1, B_2, $B_3, \ldots\ldots$ represent short run coefficients , $t-i$ represent optimal lags for the dependent and independent variable, e_{it} represents the error term.

5 Results of the Diagnostic Test

The choice of the most suitable unit root test is difficult. Researcher employed Augumented Dickey Fuller, Kwiatkowski-Phillips-Schmidt-Shin unit root tests to examine numerically and statistically the stationarity nature of the variables since using these two unit root test would enhance the credibility of the unit root test results (Enders 1995). The result of unit root is presented in Table 3.

Selecting an appropriate lag order is a prerequisite for a dependable regression analysis because empirical evidences have shown that chosen lag arbitrarily would result in

[1]See Table 1 for data sources and measurement, and Table 2 for the expected signs.

Table 2: A priori expectation

Variables	Definition	Expected Sign	Supporting Literature
HDI	Human development index	+	Sarwar et al. (2021)
$\frac{m2_t}{gdp_t}$	Ratio of money supply to GDP	+	Beck et al. (2009), Beck, Levine (2007), Demirguc-Kunt, Levine (2009) and Galor (2011)
$\frac{cps_t}{gdp_t}$	Ratio of credit to private sector to GDP	+	Asongu, Rexon (2021)
$\frac{mkcap_t}{gdp_t}$	Ratio of market capitalization to GDP	+	Asongu, Rexon (2021)

Table 3: Unit root test

Variable	ADF	KPSS
HD	1(1)	1(1)
CPS/GDP	1(1)	1(1)
LM2/GDP	1(1)	1(1)
MKTCAP/GDP	1(1)	1(0)

Author's computation

autocorrelation. Hence, the researcher based their lag selection on AIC, FPE AND HQ. ARDL selects Lag 2 for human development, M2/GDP, CPS/GDP and lag 0 for Market capitalization. From the ARDL model, we estimated the long-short run information and the response of HDI to Financial Development indicators instantaneous and constant shocks. Table 4 depicts the estimated ARDL (2, 2, 2, and 0) model. It can be seen from the Table 4 that, all the variables except market capitalization are statistically significant. From the ARDL, the level of Human development in the past appears to be important in explaining current human development in Nigeria which is an indication that previous year's health, education and income conditions significantly influence current human development and the result is in line with study of Sarwar et al. (2021). Conversely, Money supply to GDP has both negative and positive effects on human development. The negative effect may be due to contractionary policies and inflationary influence of expansionary policies. However, the net-effect of M2/GDP on human development is weak and positive indicating M2/GDP is not strong enough to influence human development in Nigeria. Credit supply to GDP exhibit both negative and positive effect (mixed effect) on human development but the net-effect of CPS/GDP is negative indicating that the injection or withdrawal of credit into Nigeria economy yield negative effect human development and this is in line with Asongu (2011). Market Capitalization has positive and insignificant effect on human development in Nigeria and this support the study of Sethi et al. (2019) and Asongu, Rexon (2021).

We proceeded to test for the existence of long-run effects among the variables. Table 5 reveals the ARDL bound test result. The calculated F-statistics of 5.4 at 5% p-value is far greater than the critical values and we may conclude that the long run relationship among human development index, M2/GDP, CPS/GDP and Market capitalization has been empirically confirmed and the result support the study by Tekin (2020).

Table 6 shows the long-run parameters estimate. The result shows that the accumulated (long run) net effect of broad money supply/GDP on human development is negligible and positive while the accumulated (long run) net effect of credit supply/real GDP on human development is also negligible and negative and the result is similar to what is obtained by Kilic, Özcan (2018). Also the accumulated long run effect of market capitalization on human development is neutral and insignificant indicating that capital market activity in Nigeria is very narrow. The long-run effects of money supply/GDP and credit supply/GDP are statistically significant. The results further show that an improvement in the present human development enhances future human development

Table 4: ARDL (2,2,2,0) estimated parameters

Dependent variable: HDI, *Method*: ARDL				
Variable	Coefficient	Std.Error	t-Statistic	Prob.
HDI(-1)	1.136026	0.191003	5.947674	0.0000
HDI(-2)	-0.353562	0.164624	-2.147689	0.0456
M2_GDP	0.006384	0.002682	2.380072	0.0286
M2_GDP(-1)	-0.004747	0.004016	-1.182245	0.2525
M2_GDP(-2)	0.009819	0.003091	3.177116	0.0052
CPS_GDP	-0.0041	0.002244	-1.826596	0.0844
CPS_GDP(-1)	0.003184	0.003358	0.948134	0.3556
CPS_GDP(-2)	-0.004974	0.002567	-1.937744	0.0685
MKT_CAP	9.39E-08	1.10E-06	0.085513	0.9328
Constant	-0.004082	0.035826	-0.113937	0.9105
R^2	0.962524	Mean dependent var		0.4580
Adj. R^2	0.943786	S.D. dependent var		0.0684
S.E. of regr.	0.016209	Akaike info criterion		-5.1340
Sum resid^2	0.004729	Schwarz criterion		-4.6583
Log likelihood	81.87662	Hannan-Quinn criter.		-4.9886
F-statistic	51.36777	Durbin-Watson stat.		2.1279
Prob(F-stat.)	0.0000			
Observations	30			

Selected Model: ARDL(2, 2, 2, 0)
Source: Author's Computation

Table 5: ARDL Bounds Test

Test Statistic	Value	K
F-statistic	5.415142	3
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61
Observations: 30		

by 35% (that is HDI exhibit 35% improvement on itself). The effect of credit supply and money supply on human development in Nigeria is negligible but statistically significant and this similar to the result obtained by Hakeem, Oluwatoyin (2012) and Asongu, Rexon (2021). The findings from the analysis reveal that money supply/GDP accounted for 5% improvement in human development in the long-run. The weak positive effect of M2/GDP on human development is not surprising because M2/GDP in Nigeria is a measure of the extent of monetization rather than financial intermediation or financial depth and it further confirms that Nigeria lack financial depth. A percentage change in CPS/GDP depletes human development by 2.7% and this may be as a result of the bank failure to perform its intermediating roles by way of channelling savings into credit for private individuals and firms due to information asymmetry and result further confirm the view of Asongu, Rexon (2021). Market capitalization appears to have insignificant positive effect on human development.

Table 7 depicts the short run parameters estimates. The result shows that the instantaneous effect and the one previous period's consecutive effects of Money supply/ GDP are negative in the short-run. The instantaneous effect and the one previous period's effect of credit supply/GDP are positive. Due to the fact that zero lag is selected for the

Table 6: Long Run Coefficients

Variable	Coefficient	Std.Error	t-Statistic	Prob.
M2_GDP	0.052663	0.021347	2.466989	0.0239
CPS_GDP	-0.027076	0.014988	-1.80648	0.0876
MKT_CAP	0.0000	0.000005	0.086268	0.9322
Constant	-0.018764	0.168082	-0.111636	0.9123
Observations: 30				

Source: Author's Computation

Table 7: ARDL (2, 2, 2, 0) short run estimate

Dependent Variable: HDI, *Method*: ARDL Cointegrating And Long Run Form

Variable	Coefficient	Std.Error	t-Statistic	Prob.
D(HDI(-1))	0.353562	0.164624	2.147689	0.0456
D(M2_GDP)	0.006384	0.002682	2.380072	0.0286
D(M2_GDP(-1))	-0.009819	0.003091	-3.177116	0.0052
D(CPS_GDP)	-0.0041	0.002244	-1.826596	0.0844
D(CPS_GDP(-1))	0.004974	0.002567	1.937744	0.0685
D(MKT_CAP)	0.0000	0.000001	0.085513	0.9328
CointEq(-1)	-0.217536	0.062586	-3.475816	0.0027
Observations: 30				

Source: Author's Computation

market capitalization by the information criterion, it will naturally vanish in the error correction equation through the algebraic process. The short run (instantaneous) effect of market capitalization on human development is equivalent to the estimated coefficient (0.000000009) in table 4 above. We can see that this value is positive but not significant and this is in line with the study by Hakeem, Oluwatoyin (2012).

6 Conclusion

Since the short run estimates of ARDL is not strong enough to paint the clear picture of all the necessary dynamics, it would be a suicidal attempt to base policy recommendation on the short run result of the ARDL. The long run estimates reveal that the accumulated (long run) net effect of broad money supply/GDP on human development is negligible and positive which imply that money supply has no strong power to influence human development due failure of the financial system in performing the intermediation functions and this is line with the study by Asongu, Rexon (2021). Money supply/GDP which is a measure of the extent of monetization rather than financial intermediation or depth also triggers inflation which worsen human development and the result is similar to Uddin et al. (2020). The accumulated (long run) net effect of credit supply/GDP on human development is negligible and positive which implies that private credit has positive effect on private sector development only and the proportion of the private institutions that enjoys credit is negligible in Nigeria due to stringent credit condition, dominance of informal sector, cash outside the banking system, poor financial intermediation and the result is in support of Asongu, Rexon (2021) and CBN (2021), which reported that oversized cash outside banks left the lending capacity of the financial institutions at less than its full capacity, with negative consequences on economic growth, employment and distort the effectiveness of monetary interventions. Market capitalization has no significant short run or long run effects on human development which is an indication that the activity of the Nigeria capital market is very narrow and also a pointer to the fact that the Nigeria financial system weakly influence human development and the result further affirm the findings of Hakeem, Oluwatoyin (2012). The long-run effects of money

supply/GDP and credit supply/GDP on human development are statistically significant but has no strong power to influence human development because the Nigeria financial sector lack depth, face high cost of capital, keep excess liquidity and fail to perform its intermediation roles and this is in line with the Africa Competitiveness Report of 2017 by the World Economic Forum (2017). The results further shows that an improvement in the present human development lead 35% improvement in future human development (that is HDI exhibit 35% improvement on itself) and the result is in support of study by Sarwar et al. (2021). The main finding is that in Nigeria, money supply and credit supply have mixed and negligible effect on human development. The study affirms that money supply and credit supply affect human development more than the market capitalization. Therefore, banks should effectively perform their intermediating roles and effort should be made by the policy makers to widen/broaden the Nigeria capital market activity. Policy makers should concentrate on financial system and their roles for effective money supply and credit supply while implementing economic policies.

Competing Interests

We declared that the manuscript is original and has never been published anywhere or currently being considered for publication. There is no conflict of interest associated with this publication. No financial support from individuals or organization or Government body for this study that could have influenced the outcome of this research work. As a corresponding author, I confirm that the manuscript has been read and approved by co-authors for publication.

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