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A Territorial Reference Framework for Europe

Annex 2: Modelling Results

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1 Theoretical Specification of the Model

The distinguishing feature of econometric models with respect to other operational models is not an underlying theory (as in the case of, for example, input-output models or economic base models), but the way the model is specified (e.g. based on an underlying theoretical framework) and the way coefficients are estimated (e.g. based on a method of estimation) (Nijkamp et al., 1986; Hewings et al., 2004).

MASST is not an exception in this respect. The purpose for which it is built is to *create territorial scenarios* (and not forecasts) under different assumptions about the main driving forces of change that will act in the future. In a scenario-building of this kind, the presence of the MASST model guarantees that the results are neutral against the assumptions, since they are based on the structural relationships that hold together the economic system in an objective way (estimates). Used with such a purpose, it is not a short-term forecasting tool, but a long-term quantitative foresight model.

The theories behind the MASST model explain its intrinsic structure. In particular, the MASST model is deeply rooted in endogenous development theories in which the competitiveness of an economic system depends on the presence of structural elements (like human capital, knowledge, labour force) and on the ability of the economic system to accumulate them over time through endogenous and self-reinforcing mechanisms.

Among these elements, a role is attributed to intangible features, in particular social capital in the form of trust and sense of belonging, which gives the economic system, *ceteris paribus*, a competitive edge. However, the MASST model also draws on recent theoretical reflections, starting with neoclassical growth models (Mankiw et al. 1992) that implicitly assume that technological progress is characterized by a worldwide global interdependence among economies which depends on their geographical connection with other economies (Lòpez-Bazo et al. 2004; Ertur and Koch 2007). The inter-regional link is at the basis of a cumulative and self-reinforcing local growth process *à la* Myrdal-Kaldor-Krugman (Myrdal, 1957; Kaldor, 1970; Krugman, 1991). In line with endogenous growth theories, the MASST model highlights an endogenous law of accumulation for the population expressed in a long-term neoclassical view as a resource for production development which should not be wasted on emigration.

Last, but not least, the MASST model refers to growth theories claiming that regions are part of a wider economic system. Much of their growth depends on national factors, such as: i) institutional features like the efficiency of the legislative, judicial and governmental functions of the nation state; ii) organisational factors like the quality of services of general interest like education, transport, communication, health, and security services; iii) economic factors like general fiscal pressure, effectiveness of public expenditure, pervasiveness of environmental regulations, the efficiency of contract enforcement procedures, and general price-competitiveness in the case of less advanced countries. Moreover, national economic dynamics are linked to the overall performance of regional economies through close inter-regional, within-country integration, in terms of the exchange of goods, services and production factors, due to proximity effects and the absence of institutional or linguistic barriers. Besides the national component, a crucial role in explaining regional performance is played by each region's internal development capability, and its endogenous capacity to turn threats stemming from higher competition into growth opportunities.

Nowadays, regional growth is in most recent theories (territorial endogenous growth theories) the result of:

- a *competitive process*, based on supply rather than demand elements, like quality (and quantity) of local resources, product and process innovation, technological advances, local knowledge. Pure demand driven growth models are therefore non-appropriate;
- a *social process*, since it is based not only on material production factors, but also on non-material resources. Social elements (like social capital à la Putman, relational capital à la Camagni, trust à la Becattini, leadership à la Stimson and Stough[1]) give rise to local cumulative processes of knowledge creation, to processes of collective and interactive learning, reinforcing decision-making processes of local actors[2]. These elements have an active and vital role in defining local economic competitiveness and growth. Traditional local growth models based merely on resource endowment have a limited interpretative power in this respect;
- a *territorial and spatial process*, interpreting territory as an autonomous production factor, rather than the mere geographical place where development occurs. Territory generates increasing returns, cumulative self-reinforcing mechanisms of growth in the form of dynamic agglomeration economies; in this perspective, local economic growth is also the result of spatial processes, rather than of a mere efficient resource allocation or of an increase in resources endowment. A-spatial local growth models are for this reason non-appropriate;
- an *interactive process* of the local economy within the wider national and international economic system. Pure bottom-up models refrain from the opportunity of measuring national-regional linkages, and have therefore to be avoided.

The specification of our MASST (Macroeconomic, Sectoral, Social and Territorial) model reflects two specific needs. The first need has a *theoretical nature*. The MASST model wishes to keep the above-mentioned theoretical elements into account; it has first of all to be a *territorial* model, where spatial linkages among regions (like proximity effects) and the territorial structure of regions (urbanised, agglomerated, rural structure of regions) find a role in explaining local growth. At the same time, it has to be a *social and sectoral* model where the sectoral and social elements find a place in explaining growth. Moreover, it has to be a *local competitive* model, in which the dynamics of the local economy is merely explained by supply elements like quality and quantity of resource endowment; last, it is a *macroeconomic*

[1] On this issue: Becattini, 1900; Camagni, 1991; Putman, 1993; Stimson and Stough, 2004.

[2] On these concepts, see Lundvall, 1992; Keeble and Wilkinson, 1999; Camagni and Capello, 2002.

model, since it has an aggregate approach to growth, where aggregate macro-economic components play a role.

The second need has a *practical nature*, since it is strictly related to the use we want to make of the model. The MASST model is intended to be a predictive model, in which the main spontaneous and normative driving forces of change that will characterise the dynamics of the European Economy in the next fifteen years have to find a role. For this reason, the MASST model has to incorporate:

- macroeconomic elements, in order to model macroeconomic tendencies and policies;
- institutional elements, in order to measure future policy choices concerning the "deepening" or "widening" of the present institutional agreements;
- strategic economic resources, recognised to have a crucial role in the future of the European Economy either by official governmental documents (like human resources in science and technology or infrastructure endowment in the Lisbon agenda), or by their intrinsic nature (like energy use);
- territorial elements, in order to obtain differentiated territorial scenarios.

The way in which we coupled with these requirements in our model is presented in the next section, which contains the logical and analytical structure of the model.

2 The new structure of the MASST4 model

In this ESPON project, a new version of MASST has been built. It is both an updated version in terms of estimations, and an enlargement of the structure of the model. The basic structure of MASST4 clearly reflects prior versions. The model is a regional econometric growth model comprising two main subcomponents, viz. a national and a regional sub-model. The units of observation are European Union's 28 countries, observed at the NUTS2 level.[3] While national GDP growth is built on aggregate demand-side features, regional differential growth depends mostly on supply-side elements. Both the national growth rate and the regional differential growth rate feed regional growth.

In order to generate future growth rates, the MASST model first estimates structural relations among exogenous and endogenous variables; next, the equation parameters thus identified are exploited to calculated predicted values for the dependent variables, with both exogenous and endogenous variables, the former tending to previously predetermined targets. Target values are set according to internally coherent sets of assumptions of possible future combinations of context conditions that depict specific scenarios. Advances have been introduced both in the estimation and in the simulation procedure.

The new structure of the MASST4 model is graphically summarized in Figure 2.1 below, where the cause-effect structural economic relationships, on which the MASST model is based, are represented. Figure 2.1 shows the national component of the MASST4 model on the left-hand side, and the regional component on the right-hand side. The sum of the two provides regional growth rates. The MASST4 model endogenizes six national equations and eleven regional equations.[4]

On the demand, macroeconomic side, the novelties of MASST4 rest on the longer time series on which estimates are run. Time dummies differentiating the impacts of different exogenous variables on the exogenous ones allow to highlight if structural breaks exist in the long term relationships of macroeconomic variables. Structural relations are estimated by means of heteroskedasticity-robust Ordinary Least Squares, or Fixed Effects (where appropriate), respectively. Among the main alternatives, seemingly unrelated regressions would on the one hand take account of the likely correlation among structural equations errors, thus allowing increasing efficiency and precision in the estimates; however, misspecification in one equation could easily transmit to other model relations.

As anticipated in Section 1, another alternative would entail resorting to dynamic models such as vector auto regressions (VARs) or vector error correction models (VECMs), as frequently done in competing forecasting models. This second choice would imply two major advantages

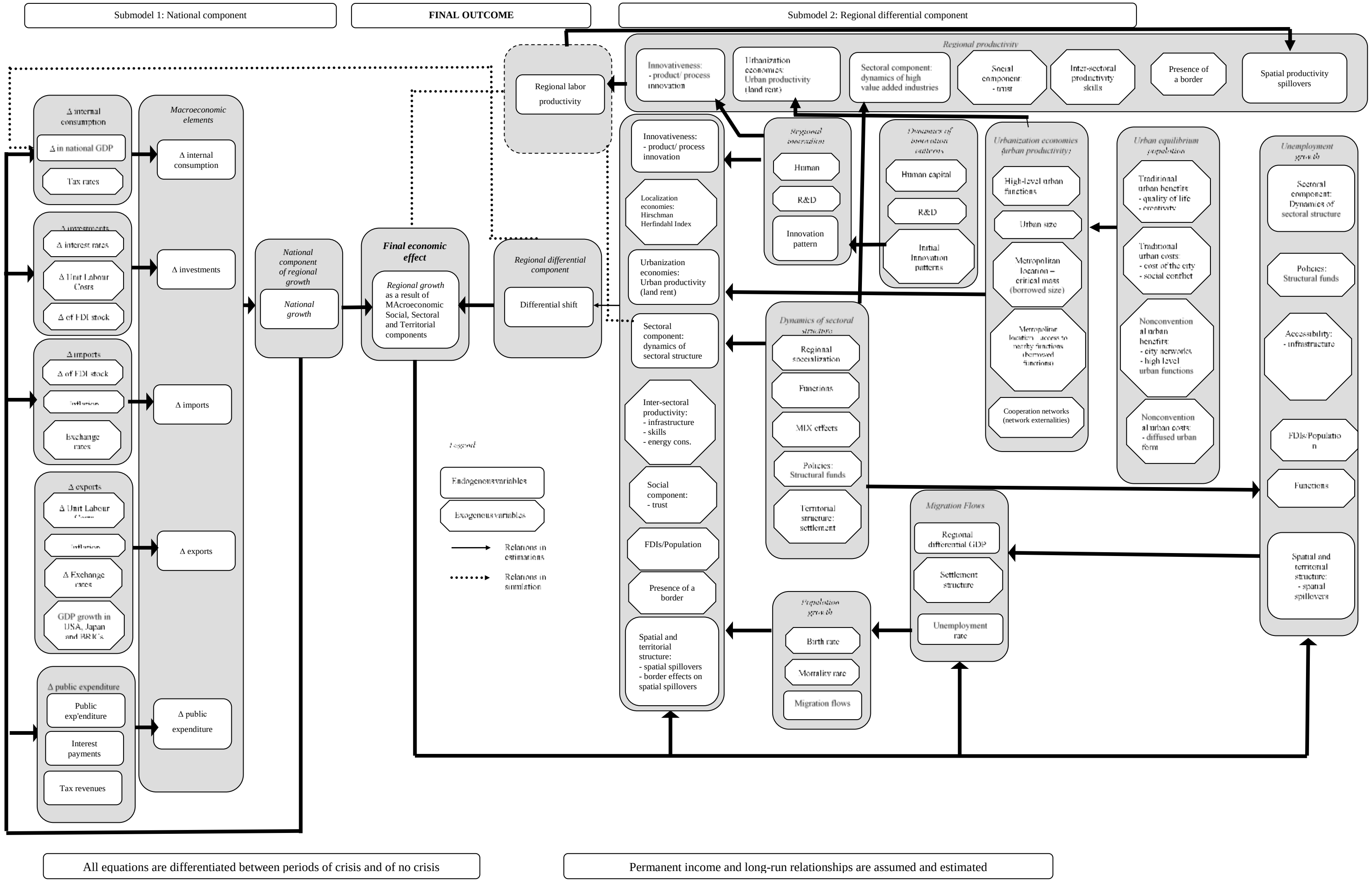
[3] NUTS (Nomenclature of Territorial Units for Statistics) is the European Union's classification of regional units, comprising a hierarchical structure form Countries (NUTS0) to the rough equivalent of US counties (NUTS3) (EUROSTAT, 2016a).

[4] For a comprehensive list of endogenous and exogenous variables, see the Technical Appendix.

with respect to the structural equations model here built, viz. (i.) a superior performance in short-fun forecasting, and (ii.) a better capacity to assess single-policy exogenous shocks in the modeling exercise. Both advantages would not be needed within our empirical framework, though, because the MASST4 model is built to produce long-run forecasts based on coherent sets of assumptions, i.e. a scenario. In this sense, VECMs would not allow the set-up of complex scenarios with combinations of conditions subsumed under the same theoretical umbrella.

Changes at the macroeconomic level are not reflected in a new structure for the model, whereas advances in the regional sub-model are clearly detectable. A new equation is included for the explanation of productivity levels. The spatial heterogeneity in the fall of productivity subsequent to the first economic shock in 2008 causes several issues in MASST3 because productivity, previously included in the model as exogenous parameter, would call for assumptions on the side of the modeler. Adding a new after-crisis period, in which the heterogeneity of regional productivity is larger than ever, called for endogenizing this variable. Sectoral composition, innovation capacity, agglomeration economies, human capital, social capital are sources of productivity; the latter, in its turn, explains regional differential growth.

Figure 2.1: Structure of the MASST4 model



Source: Authors' elaboration

A second additional equation models urbanization economies. MASST3 considered equilibrium urban size as the unique source of agglomeration economies. MASST4 maintains this element but makes a step forward. Agglomeration economies now depend on functions hosted, on city-networking skills, one the size of cities located nearby ("borrowed size" in Alonso, 1973, reprised in Meijers, 2013), and the functions hosted by nearby cities (the "borrowed functions" concept introduced in Camagni et al., 2016). The physical size, interpreted as an equilibrium size, is maintained in explaining agglomeration economies as the result of the balance between benefits and costs.

An additional advance of MASST4 lies in the introduction of an equation explaining the probability for a region to move to different, more complex, innovation modes. Increases in human capital and in R&D activities push regions to innovation modes based on new knowledge, produced within the region, rather than on knowledge or innovation produced elsewhere, and brought into the region through different channels. The new innovation modes that a region experiences explain, in their turn, the degree of product and process innovation developed, and, ultimately, regional growth differentials.

A last and interesting advance in this version of the model is the role attributed to international borders within the EU. This border effect is not included through a single equation; therefore, it does not appear in Figure 2.1 as an additional equation. We instead proceed as follows. First, we introduce a dummy variable equal to 1 when the region shares an international border, and zero otherwise. This dummy is interacted with growth assets in different equations and, when significant, maintained in the model. Next, growth spillovers are calculated on the basis of a geographical distance and a commercial proximity matrix between region pairs.[5] The two matrices (geographical and trade flows) are then used to discount GDP growth of other regions before summing GDP growth of all other regions as the growth spillover of a specific region. In the simulation stage, the two matrices can be modified according to the assumptions on the role of borders. Lastly, at the simulation stage we can make different assumptions on the year when Brexit will actually take place, by drastically increasing the geographical and commercial matrices between single European regions and UK regions. As a consequence of these assumptions, growth spillovers decrease, thus capturing the losses that both UK regions and EU regions suffer from re-establishing international borders between the UK and the EU.

All these advances have been achieved without altering the original characteristics of the MASST model. The MASST4 model is simultaneously generative, and distributive. It is a generative growth model, in that regional growth is interpreted mainly as a competitive process (Richardson, 1973). In this class of models, regional growth is seen as a "*zero-sum allocation and distribution of production*" (Harris, 2011, p. 914), and a region's growth takes

[5] The regional sectoral input-output table has been made available by the JRC group responsible for the Rhomolo model in Seville. We would like to thank the colleagues in Seville for sharing their Input-Output matrix.

place at the expense of another's (Richardson, 1978, p. 145). In the MASST4 model, the economic performance of a region depends mainly on its institutional context, i.e. on the national performance. Institutional features, organizational quality, and competitiveness in international trade influence regional economic performance; in the MASST4 model, the global economy acts as a trigger to regional economic performance through the increase in the demand for Country's products, within a classical Keynesian aggregate demand setting.

The MASST4 model remains also distributive; national growth rates are distributed to single regions depending on their factor endowments, which explain regional differential shifts (Garcilazo and Oliveira Martins, 2015). In this sense, regional differential performance is mostly a supply-side mechanism, with both tangible (accessibility; regional policy expenditure; energy efficiency) and intangible (trust; human capital; quality of governance) assets making regions more competitive with respect to the Country mean.

Exogenous variables tend instead to reach in the long run predetermined targets whose value is set depending on the set of assumptions underlying a scenario.

A final important remark on the MASST4 model is related to the important effort in building a comprehensive data base covering the universe of EU NUTS2 regions. In the 2013 version, these comprise 276 administrative units, with a panel structure covering the period 2000 through 2017 for the national model and comprising for the first time a full panel structure for the regional model as well. For this last data base, Table 2.1 shows a full list of data sources, indicators, and time availability for each variable included in the estimates discussed in the rest of the paper. Thus, the first year for which MASST4 produces simulated growth rates is 2018, and the simulation process reaches 2035. A longer simulation would lose credibility in that constant coefficients in the estimated structural equations would become less and less meaningful as the economic structure itself of EU regions adjusts.

A specific mention is due to the construction of the urban database. Building on Camagni et al. (2016), we collected data for all EU NUTS2 regions matching each largest city within each NUTS2 region to the region in the data base. Among explanatory variables, we measure high-level functions with the share of high-level professions in each region, calculating the share of labor force employed in the ISCO 88 aggregate category 1, including "*legislators, senior officials and managers*".

Borrowed size is instead calculated as the spatially-lagged population living in nearby metro areas discounted by physical distance (Eq. 1):

$$borrowed\_size_c = \sum_{j=1}^{n} \frac{pop_j}{w_{geo_{c,j}}}, \forall c \neq j \qquad (1.)$$

where c and j indicate two cities, w_{geo} is an nXn distance weight matrix formalizing the geographical interdependence between city pairs,[6] and *pop* represents city population levels.

Borrowed functions are calculated as the spatially-lagged high-level functions in other cities, discounted by network distance (Eq. 2):

$$borrowed\_functions_c = \sum_{j=1}^{n} \frac{functions_j}{w_{networks_{c,j}}}, \forall c \neq j \qquad (2)$$

In their turn, long-distance networks are measured with the number of Framework Programme co-participations of research institutions located in each NUTS2 region, for the 5^{th}, 6^{th}, and 7^{th} rounds of the programme.

We also control for the effects of functions located in close geographical proximity by calculating the spatial lag of functions discounted by the geographical weight matrix.

Lastly, it is worth stressing that the dependent variable, urban productivity, is measured with urban land rent. "*Urban rent is usually interpreted as the rent paid to the house owner. However, house prices represent the capitalized rent over time, and for this reason may be chosen as a proxy for urban rent. Land rent is measured here as the average prices of apartments located in the Central Business District of the cities analyzed*" (Camangi et al., 2016, p. 146. Since urban land rent is a very space-specific indicator, we calculated average house prices for apartments located in the CBD of the largest NUTS3 region within each NUTS2, and then matched these values to each NUTS2 in the data base.

Sections 3 and 4 discuss the main advances and the results of the estimates, with a particular focus on the changes in the structural relationships in national and regional economies.

[6] The spatial connectivity definition adopted is based on simple geodesic distance between centroids.

Table 2.1: Data sources, indicators, and time availability

Indicator	Variable	Years available	Source
Regional differential shift	Difference between regional and national compound GDP growth rate	Average 2002-2006; 2006-2010; 2010-2014	Own elaboration on EUROSTAT data
Product or process innovation	Share of firms engaged in product and/or process innovation	Average 2002-2004; 2004-2006	Own elaboration on CIS data
Urban land rent	Real prices of average residential units	Average 1998-2002; 2002-2006; 2006-2010	Own database
Regional trust		1990; 2000; 2008	European Value Study, own elaboration
Energy consumption	Energy consumption in GWh	Average 1998-2002; 2002-2006; 2006-2010	ESPON
Dummy, =1 if NUTS2 region borders other EU countries		Constant	'Collecting Solid Evidence to Assess the Needs to be Addressed by Interreg Cross-Border Cooperation Programmes', Framework Contracts 2014CE16BAT010/2014CE16BAT011/2014CE16BAT012 (Service Request 2015CE160AT044).
Regional FDIs	Count of	Average 1998-2002; 2002-2006; 2006-2010	ORBIS data base, Laura Resmini; own elaboration
Differential manufacturing employment growth (Country mean=0)		Average 2002-2006; 2006-2010; 2010-2014	Own elaboration on LFS data
Differential service employment growth (Country mean=0)		Average 2002-2006; 2006-2010; 2010-2014	Own elaboration on LFS data
Multimodal accessibility		Average 1998-2002; 2002-2006; 2006-2010	ESPON
Regional Quality of Governance	Principal Components for	Average 2008-2011, and 2015	University of Gothenburg
Specialisation (EU28's value added=100) in NACE 2digit industries		2007-2017	Own elaboration on LFS
Relative specialisation (EU28's value added=100) in NACE 2digit industries		Average 1998-2002; 2002-2006; 2006-2010	Own elaboration on LFS data
Relative specialisation (EU28's value added=100) in ISCO 1-digit professions		Average 1998-2002; 2002-2006; 2006-2010	Own elaboration on LFS data
Allocations and expenditures in EU Structural Funds in different classes		2000-2006; 2007-2013; partial count 2013-2014	Own elaboration on EU Cohesion data; SWECO, 2008
Settlement structure		Constant	ESPON 1.1.2 project
Population of the largest NUTS3 region within each NUTS2 region		Average 1998-2002; 2002-2006; 2006-2010	Own elaboration on EUROSTAT data
City networks	Framework Programme 5, 6,	Average 1998-2002; 2002-2006;	Own elaboration on EUROSTAT data

	and 7 participations by NUTS2 region	2006-2010	
Borrowed size		Average 1998-2002; 2002-2006; 2006-2010	Own elaboration on EUROSTAT data
Spatial lags of high-level functions		Average 1998-2002; 2002-2006; 2006-2010	Own elaboration on EUROSTAT data
Borrowed functions	Relational lag of high-level professions	Average 1998-2002; 2002-2006; 2006-2010	Own elaboration on EUROSTAT data
Structure of the urban system	Slope of the rank-size relationship within each NUTS2 region	Average 1998-2002; 2002-2006; 2006-2010	Own elaboration on EUROSTAT data
Number of bed places		Average 1998-2002; 2002-2006; 2006-2010	Own elaboration on EUROSTAT data
Number of assualt and petty crimes		Average 1998-2002; 2002-2006; 2006-2010	Own elaboration on EUROSTAT data
Research and Development		Average 1998-2002; 2002-2006; 2006-2010	Own elaboration on EUROSTAT data
Share of college graduates		Average 1998-2002; 2002-2006; 2006-2010	Own elaboration on EUROSTAT data
Unemployment rate		Average 1998-2002; 2002-2006; 2006-2010	Own elaboration on EUROSTAT data

Source: Authors' elaboration

3 Advances in the National Sub-model

The national sub-model is based a traditional Keynesian structure, each component of the aggregate demand depending on its standard macroeconomic components, as with previous versions. All components have been re-estimated with the inclusion of a third period, covering the after-crisis years, but no significant variation with respect to the estimates shown in Capello et al. (2017) has been detected, except for the investment growth function.

With the inclusion of the third period, evidence exists that this variable behaves differently in the three periods. In order to better highlight these differences, we both run a baseline model with a breakdown in two periods, as done in Capello et al. (2017), and then re-run with the three periods. Results are reported in Table 4.1.

Table 3.1: Determinants of investment growth for the pre-crisis period

Dependent Variable	*Investment growth rate 1995-2012*	*Investment growth rate 1995-2016*
Constant	-1.29** (0.55)	0.435 (0.514)
FDI growth rate (t-1)	0.01 (0.00)	0.189** (0.087)
GDP growth rate (t-1)	0.68*** (0.18)	0.387** (0.151)
Interest rate	-0.49*** (0.00)	-0.018*** (0.002)
Unit labour cost	-0.15*** (0.02)	-0.001 (0.001)
Crisis dummy	-0.07*** (0.01)	-0.076*** (0.011)
Investment trends	-1.15*** (0.10)	-0.807*** (0.102)
Speed of adjustment of investment to the long run trend	-0.41*** (0.05)	-0.427*** (0.039)
After-crisis dummy		-0.067*** (0.013)
GDP growth rate (t-1) in the after-crisis period		1.920*** (0.359)
Method of estimation	*Fixed effects*	*Fixed effects*

*Note: *= significant at the 90% confidence level; **= significant at the 95% confidence level; ***= significant at the 99% confidence level. Heteroskedasticity-Robust Standard Errors in brackets*

When only the pre-crisis and the crisis periods are taken into consideration, estimations (Table 4.1, column 1) provide evidence of a negative impact of the contraction period (2008-2012) on the growth of national investment; all else being equal, this slowdown is equal to a 7 per cent contraction on a yearly basis. All other relevant controls, with the exception of FDI intensity, are significantly associated to investment growth, with the expected sign. We included a control for lagged GDP growth, in a Keynesian fashion; the response to outstanding interest rates and the cost of labor; and an Error Correction Model (ECM) component.

Table 4.1 (second column) shows that an augmented equation taking the third (2012-2016) period into account highlights some relevant differences. While most other controls remain significant and hold the same direction of association (with the exception of Unit Labor Costs), the inclusion of the after crisis period dummy shows that some important differences emerge between the crisis and the after-crisis period, namely:

(i.) In the after-crisis period, investment growth has further slowed down, although at a slower pace with respect to the contraction period. The resurgence of this important component of the aggregate demand in EU economies is taking place at a very slow rate;

(ii.) In the aftermath of the great contraction, investments remain very volatile and their dependence on lagged GDP growth rates is roughly six times as large as in standard periods, as evidence by the interaction between the after-crisis dummy and the ECM component.

This result is in line with the stylized facts described in the Technical Appendix, showing that the economic performance of EU countries diverged quite substantially over the past two decades, and that the productivity slowdown of some of them dates back to well before the inception of the great contraction.

4 Advances in the Regional Sub-model

4.1 Structural changes in manufacturing employment growth

The importance of the fourth industrial revolution for the future of Europe's growth called for a particular importance to the manufacturing employment growth equation. The following equation has been estimated:

$$\Delta manemp_{r,T-t} = \alpha + \sum_{j=1}^{n}\sum_{t=1}^{3}\beta_{j,t} SPEC_{j,t} * d_t + \sum_{t=1}^{3}\gamma_t urban * d_t + \sum_{t=1}^{3}\delta_t rural * d_t + \\ + \sum_{t=1}^{3}\zeta_t CEEC * d_t + \sum_{t=1}^{3}\eta_t MHLF * d_t + \sum_{t=1}^{3}\vartheta_t MLF * d_t + \sum_{z=0}^{1} CEEC_z * W * \Delta manemp_{r,T-t} \qquad (3)$$

In Eq. (3.):

(i.) Specialization in different manufacturing industries (*SPEC*) measures the mix/demand component (a region grows in employment in sectors where demand is higher). Across different NACE 2-digit industries,[7] specialization is measured as the location quotient of each manufacturing sector with the EU28 as the common benchmark. Industries are included in alphabetical order. This order also (imperfectly) matches the increasing technological complexity of the involved manufacturing activities, as also testified by the high-tech and medium-high tech reclassifications of manufacturing activities discussed in EUROSTAT (2018) and regularly updated on the EUROSTAT data base

(ii.) *urban*, *rural*, and *CEEC* a NUTS2 region's settlement structure is mainly urban or rural,[8] or if the region is located in one of the Central and Eastern European Countries (CEECs), i.e. those joining the EU since 2004;

(iii.) Functions in the area (MHLF and MLF, respectively representing medium-high level and medium-level functions) measure qualified jobs that may occasionally be subject to unemployment more than non-qualified ones;

(iv.) Employment dynamics in neighboring regions which might influence employment growth; these are also interacted with a dummy equal to 1 if the region is located in CEECs, and 0 otherwise.

All over these estimates, we also introduce time dummies, capturing the differences in the effects in two periods (crisis and after-crisis period), keeping the pre-crisis period as the benchmark. Table 4.1 shows results of the estimates.

Results uniformly show a statistically significant positive impact of low-tech industries in the pre-crisis period, with a progressive decrease in this impact. At the same time, while initially (i.e. before the 2007-2008 crisis spread to Europe) manufacturing jobs were created despite regions being specialized in high-tech sectors, the crisis has again stressed the importance of focusing on technologically advanced manufacturing as means to shelter against the windfall of global economic turmoil. The differences in the estimates of this equation in the different periods demonstrate that a structural change is occurring, and that in the after-crisis period in most technologically advanced sectors a re-industrialization process is taking place, as suggested

[7] NACE is the Statistical Classification of Economic Activities in the European Community (the acronym coming from the French term "*nomenclature statistique des activités économiques dans la Communauté européenne*"). Presently at the second version, it has been established by Regulation (EC) No 1893/2006.

[8] A detailed definition of how agglomerated, urban, and rural regions are defined according to the ESPON 1.1.1 project is provided in the Technical Appendix.

by some literature (Wink et al., 2016). This supports the idea that a forecasting tool has to be able to grasp such structural changes if future growth trajectories have to be simulated.

Table 4.1: Determinants of manufacturing employment growth

Dep. variable	*Manufacturing employment growth*		
	β	Std. Err.	Significance level
Constant term	0.98	0.02	***
Specialization in rubber and plastics	0.01	0.003	*
Specialization in rubber and plastics in period 2	-0.01	0.005	**
Specialization in rubber and plastics in period 3	-0.01	0.004	*
Specialization in non-metallic minerals	0.02	0.005	***
Specialization in non-metallic minerals in period 2	-0.02	0.005	***
Specialization in non-metallic minerals in period 3	-0.01	0.005	***
Specialization in metals	-0.004	0.004	
Specialization in metals in period 2	0.005	0.005	
Specialization in metals in period 3	0.007	0.005	¥
Specialization in transportation devices	-0.007	0.004	¥
Specialization in transportation devices in period 2	0.004	0.004	
Specialization in transportation devices in period 3	0.01	0.005	*
Other manufacturing	0.01	0.01	¥
Other manufacturing in period 2	-0.01	0.01	¥
Other manufacturing in period 3	-0.02	0.01	¥
Structural funds supporting business creation	0.07	0.05	¥
Dummy urban region	0.02	0.003	***
Dummy urban region in period 2	-0.02	0.005	
Dummy urban region in period 3	-0.01	0.005	**
Dummy rural region	0.01	0.005	*
Dummy rural region in period 2	0.01	0.01	
Dummy rural region in period 3	-0.02	0.01	***
Dummy CEEC countries	-0.03	0.005	***
Dummy CEEC countries in period 2	-0.001	0.001	
Dummy CEEC countries in period 3	-0.02	0.01	*
Specialization in medium-high-level functions	-0.05	0.01	***
Specialization in medium-high-level functions in period 2	0.05	0.01	***
Specialization in medium-high-level functions in period 3	0.04	0.01	***
Specialization in medium-level functions	0.03	0.01	***
Specialization in medium-level functions in period 2	-0.03	0.01	***
Specialization in medium-level functions in period 3	-0.02	0.01	**
Employment growth spatial spillovers	-0.01	0.001	***
Employment growth spatial spillovers in CEECs	0.02	0.01	**
Number of obs.	572		
R^2	0.43		
Joint F-test	53.32***		
Country dummies	Yes		
Robust standard errors	Yes		
Method of estimation	Pooled OLS		

*Note: *= significant at the 90% confidence level; **= significant at the 95% confidence level; ***= significant at the 99% confidence level.*

4.2 Structural changes in urban growth

As explained above, the new version of the model estimates the advantages for regional growth stemming not only from city size, but from the type of function hosted, the degree of networking with other cities, the size of neighboring cities (borrowed size) and the functions hosted by other cities, discounted both by geographical distance and by the inverse of proximity in cooperation (these being labeled "borrowed functions"). This approach starts from Camagni et al. (2016) and is formalized as in Eq. (4.):

$$urban\_productivity_{c,t} = \alpha + \beta_1 * population_{c,t-1} + \beta_2 * population^2_{c,t-1} + \beta_3 * urban\_functions_{c,t-1} + \\ + \beta_4 * borrowed\_size_{c,t-1} + \beta_5 * W_{geo} functions_{c,t-1} + \beta_6 * borrowed\_functions_{c,t-1} + \\ + \beta_7 * network\_externalities_{c,t-1} + \varepsilon_{c,t} \quad (4.)$$

Results are presented in Table 4.2, and provide strong evidence of a time-varying role for the physical component of agglomeration economies, namely the pure density effect here captured by the linear and squared population terms. In the original model discussed in Camagni et al. (2016), these two terms suggested a monotonically increasing relationship between city size and urban productivity. This is in line with both the urban economics consensus (Segal, 1976; Ciccone and Hall, 1996; Combes et al., 2010) as well as with the theoretical predictions of the New Economic Geography (Krugman et al., 1999).

Table 4.2: Determinants of urban productivity

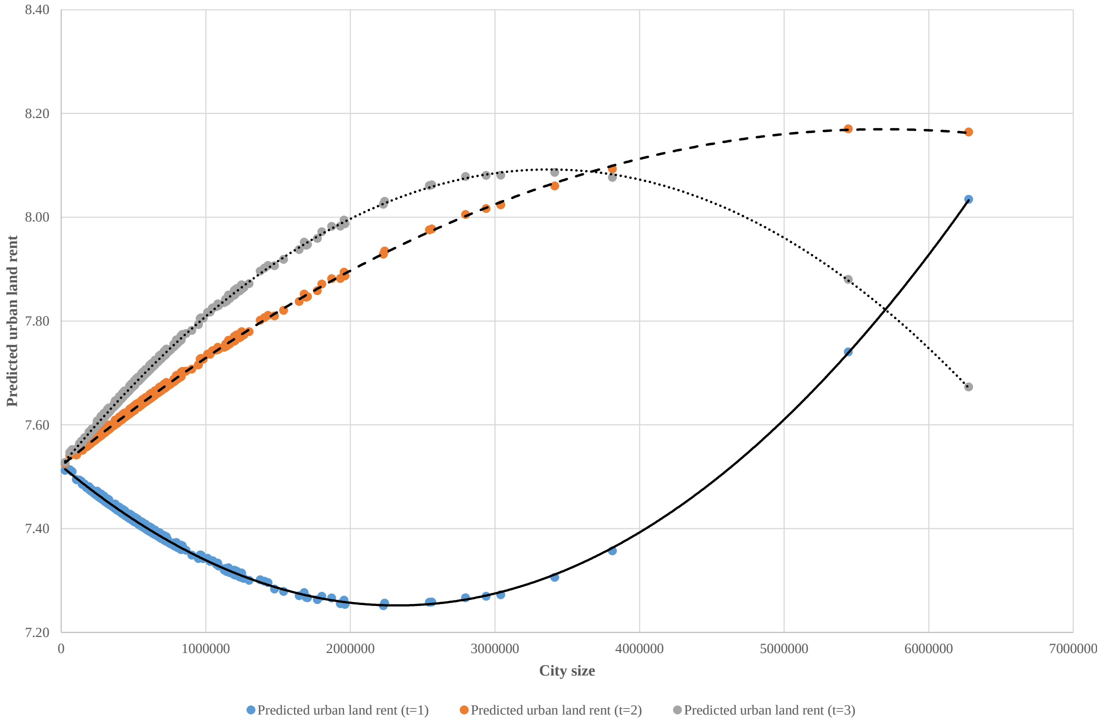
Dep. Variable	*Log urban land rent*		
	β	Std. Err.	Significance level
Constant term	9.94	0.69	***
Urban population (levels)	-0.24	0.09	***
Urban population in period 2	0.46	0.08	***
Urban population in period 3	0.57	0.13	***
Urban population (square)	0.05	0.02	***
Urban population (square) in period 2	-0.07	0.02	***
Urban population (square) in period 3	-0.10	0.02	***
High-level functions	0.09	0.05	*
Borrowed size	-1.93	0.91	**
City networks	0.1	0.01	***
Borrowed functions	0.33	0.08	***
Spatial lag of high-level functions	-0.31	0.15	**
Rank-size rule	0.001	0.03	
Number of obs.	828		
R^2	0.43		
Joint F-test	26.31***		
Country dummies	No		
Robust standard errors	Yes		
Method of estimation	Pooled OLS		

*Note: *= significant at the 90% confidence level; **= significant at the 95% confidence level; ***= significant at the 99% confidence level.*

MASST4 estimates contribute this interpretation by showing that this relationship changes over time, capturing structural changes in the way cities generate advantages to regional growth. In our results, the impact of the linear city size term significantly increases over time, while the squared population term decreases monotonically. Taken together, these two results suggest that some form of decreasing returns to scale are increasingly important for European cities, although pure size effects appear to crucially matter both during, as well as after, economic contractions. This result can be graphically represented as in Figure 4.1 below, where the solid line shows the relationship between city size and urban land rent for period 1, while the dashed and dotted lines refer to periods 2 and 3, respectively.

Figure 4.1 suggests that diseconomies of agglomeration have been emerging in the European context during the crisis. Costs of being located in large cities were during the crisis extremely high compared to the benefits: high unemployment, high social costs were not counterbalanced by higher amenities or growing wages. In the after-crisis period, the difference between advantages and disadvantages remains in favor of the latter. With respect to the crisis period, the situation is even worse; large cities achieve unexpectedly diseconomies of agglomeration for each city size higher than during the crisis period: this suggests that large cities are unable to play a propulsive role in regional economies when only size effects are considered.

Figure 4.1: Predicted agglomeration economies and city size in the three estimation periods



Source: Authors' elaboration

All other parameter estimates, while presenting no significant interaction with period dummies, are in line with results discussed in Camagni et al. (2016). Irrespective of the period, urban productivity is positively associated to high-level professions, urban networks, and borrowed functions. We find instead a negative and statistically significant relationship between borrowed size and urban productivity on the other hand. A negative estimate suggests the existence of what is commonly referred as *agglomeration shadow* (Burger et al., 2015; Partridge et al., 2009): in this case, cities close to large urban agglomerations tend to be, all else being equal, less productive than otherwise identical cities that are spatially more isolated from large cities. Instead, city networks have a positive and significant value: being linked to other cities makes a city, ceteris paribus, being more productive than others, as theoretically expected.

Moreover, results for the borrowed functions suggest a positive and significant association with urban productivity (Camagni et al., 2016; Capello, 2000); having access to a larger pool of high-level functions increases cities' productivity. A word of caution is here required. This variable has been calculated at NUTS2 level, by taking the NUTS3 level of each NUTS2 a city belongs to as an average value. This may introduce a bias in the estimates, since a city may have higher nearby functions only because it is part of a NUTS2 hosting other NUTS3 regions with many high-level functions. In order to correct for this potential bias, we introduced the spatial lag of high-level functions. Moreover, the negative estimate for the parameter of the spatially lagged high-level function variable provides evidence of the increasing relevance of concentrated location patterns for high-level urban functions: cities being close to hotspots of high-level professions tend, ceteris paribus, to be less productive than cities that are spatially sheltered from this potential competition.

Because data are collected at NUTS2 level, a second possible bias may occur in the estimates if the structure of the urban system is not controlled for. We therefore include a measure of the slope of the within-region rank-size rule to control for the fact that regions hosting large metro areas attracting large shares of the regional population may behave differently from those characterized by a network of medium-sized cities. This indicator is calculated as follows. For each NUTS2 region, population levels of each NUTS3 region are ranked in decreasing order. Next, a linear regression is performed to calculate the slope of the rank-size distribution. The estimated parameter is used as a measure of the slope of the urban hierarchy within each NUTS2 region.

The inclusion of this control does not modify the main results of the estimates. Moreover, the rank-size parameter is itself insignificantly associated to urban productivity (p-value=0.97). Taken together, these results suggest that agglomeration economies do not depend on the hierarchical structure of a particular region.

4.3 Endogenous regional productivity

Another crucial development of the most recent version of the MASST model is related to the explanation of regional productivity. Up to the third generation of the model, productivity growth was treated as an exogenous target, i.e. without an equation formalizing the theoretical expectations about its future growth. With the MASST4 model, this shortcoming has been amended and we need not formulate ex-ante expectations of future productivity growth rates any longer. Instead, the importance of different factors relevant for explaining productivity growth at the regional level are estimated, and their parameters used in simulation exercises.

Productivity depends on the following regional characteristics:

- Innovation, both product and process, activities (Capello and Lenzi, 2013);
- presence of cities as generators of agglomeration economies (Mitra, 1999; Clark et al., 2018). Despite the fact that both urban and regional productivity ultimately depend on spatial externalities, the literature on the former differs quite substantially from studies explaining the latter. On the one hand, agglomeration economies advantages decline quite rapidly with space (Rosenthal and Strange, 2003); on the other hand, at wider spatial scales, other factors may matter more than diversity in explaining spatial externalities (Caragliu et al., 2016). Moreover, productivity advantages at the firm level form externality fields that are best captured at the regional level (Caliendo et al., 2018);

- presence of high-value added activities, both in terms of functions and of production processes (industries; Porter, 2003);
- policies supporting entrepreneurship (Acs and Armington, 2004)
- intangible elements like trust, social capital and sense of belonging;
- presence of borders, that causes self-selection among productive and non-productive firms by hampering the exploitation of scale economies in a reduced-size market (Melitz, 2003; McCallum, 1995).
- presence of technological interdependences and knowledge exchange that, as suggested by Ertur and Koch (2007, 2011), through proximity effects can influence the performance of local areas. Proximity is not only geographical; knowledge may be exchanged through different types of proximity, like cultural, social and institutional proximities, that facilitate cooperation (Boschma, 2005; Torre, 2008; Caragliu, 2015). An interregional input-output matrix with industrial trade flows data proxies different types of proximities, and is in this sense used as a discount measure for productivity of other regions.

The estimated equation is therefore the following:

$$\begin{aligned} regional\_productivity_{r,t} &= \alpha + \beta_1 * innovation_{r,t-1} + \sum_{t=1}^{3} \beta_{2,t} * urban\_productivity_{r,t-1} + \sum_{k=0}^{1} \beta_{3,k} d_{k,t-1} * HT_{r,t-1} + \\ &+ \beta_4 * trust_{r,t-1} + \beta_5 * HLF_{r,t-1} + \beta_6 * SF_{r,t-1} + \sum_{z=0}^{1} \beta_{7,z} d_{z,t-1} * prod\_spillovers_{r,t-1} \beta_8 * trade\_spillovers_{r,t-1} + \\ &+ dummy\_outliers_{r,t-1} + \varepsilon_{c,t} \end{aligned} \quad (5.)$$

In Eq. (5.):

- *regional_productivity* is calculated as regional Gross Value added in constant 2010 Euros;
- *innovation* represents the share of product and/or process innovation generated by the regional innovation module (Section 4.4 below);
- *urban_productivity* is in its turn simulated as described in Section 4.2 above;
- *HT* stands for High-Tech industries, and represents, by means of a Location Quotient, the intensity of high-tech manufacturing and knowledge-intensive services in NUTS2 regions (EUROSTAT, 2016b);
- *HLF*indicates high-level functions (as described in Section 2);
- *SF* stands for structural funds supporting business formation;
- Lastly, *trade_spillovers* and *prod_spillovers* represent the spatially lagged values of regional productivity levels mediated by the trade and geographical weight matrices above described, respectively.

Results of these estimates are presented in Table 4.3.

All explanatory variables are found to be positively and statistically significantly associated to the dependent variable. In particular, productivity is explained by regional innovation (de Groot et al., 2006; Capello and Lenzi, 2013a), social capital (as captured by the average level of trust; Bjørnskov and Méon, 2015), the presence of high-level functions (Camagni et al., 2016), spending in structural funds dedicated to the support of business activities (Fratesi and Perucca, 2014), and specialization in high-tech industries.

Our estimates also suggest the relevance of border location in the exploitation of high-tech industries. In fact, a recent methodology to detect border effects in regional growth has been proposed in Capello et al. (2018b). This methodology focuses on regional supply-side border effects, decomposed in terms of border-related inefficiencies (in exploiting local resources: *efficiency needs*) and insufficient endowment of resources (*endowment needs*). While the latter are identified when growth-enhancing assets are poorly present in a region, the former are found when a territorial capital asset is negatively and significantly interacted with a border region dummy. In the estimates presented in Table 4.3, this is the case for the specialization in high-tech industries: all else being equal, regions specialized in high-tech activities but located on the border between two or more EU countries are less prone to fully reap the benefits of this crucial asset.

We also included two vectors of productivity spillovers, one calculated on the basis of a geodesic distance weight matrix, the other based on a trade flows matrix. The rationale of the former needs little explanation: being close to productive regions enhances the chances that a region becomes itself more productive, all else being equal (Ertur and Koch, 2007). More recently, however, interregional trade flows have been increasingly employed to open the black box of technological interdependence (Cortinovis and Van Oort, 2017). For this indicator, we exploit the latest (2010) interregional Input-Output (IO) table compiled by the EU Joint Research Centre in Seville, Spain. The IO table reports the value in constant Euros of trade flows from and to each EU NUTS2 regions. This matrix is then row-standardized and employed as a standard spatial weight matrix to calculate trade-mediated productivity spillovers.

Estimated spillovers parameters yield unexpected results. Geographic spillovers are found to be positively associated to productivity gains only in Central and Eastern European countries. In the rest of the EU28, being close to high-productivity regions is found to negatively affect a region's own productivity. While the two estimated coefficients are roughly equal in magnitude, the overall effect of geographic spillovers is slightly positive, although insignificant.[9]

Table 4.3: Determinants of regional productivity growth

Dep. variable	*Regional labor productivity*		
	β	Std. Err.	P-value
Constant term	24.02	5.73	***
Product or process innovation	18.35	5.92	***
Urban productivity	1.29	0.82	¥
Urban productivity in period 2	-0.15	0.12	¥
Urban productivity in period 3	-0.04	0.15	
Border regions dummy	3.36	1.47	**
Specialization in high-tech industries	199.6	40.38	***
Specialization in high-tech industries in border regions	-85.18	40.48	**
Trust	20.2	5.12	***
High-level functions	1.13	0.71	¥

[9] Results are not reported; they are available upon request from the authors.

Structural funds supporting business creation	0.03	0.01	***
Spatial Productivity spillovers	-0.001	0.000	**
Spatial Productivity spillovers in CEECs	0.001	0.000	***
Trade productivity spillovers	0.04	0.01	*
Dummy for productivity outliers (top 10% of the distribution)	23.63	4.00	***
Number of obs.		511	
R^2		0.93	
Joint F-test		42.66***	
Country dummies		Yes	
Robust standard errors		Yes	
Method of estimation		Pooled OLS	

*Note: ¥= significant at the 80% confidence level; *= significant at the 90% confidence level; **= significant at the 95% confidence level; ***= significant at the 99% confidence level.*

Trade-mediated spillovers are instead found to be positively and significantly (p-value<0.1) associated to regional productivity levels. By means of reverse-engineering imported products, trading partners get access to new technologies that can, through subsequent R&D processes, replaced with new local products and processes (Javorcik, 2004; van Pottelsberghe de la Potterie and Lichtenberg, 2001; Caragliu, 2015).

A more detailed discussion is due for the effects of urban productivity. In line with what implicitly suggested by the increasing relevance of agglomeration diseconomies (Section 4.2), results in Table 4.3 suggest that, while being positively associated to aggregate (regional) productivity gains, urban productivity's role may have been declining over the last decade, both during as well as after the end of the crisis. While only marginally significant (p-values< .2), results are nevertheless suggestive and call for further research: is the role of cities as engines of regional growth decreasing over time? We believe this to be a very fertile future research avenue.

4.4 Dynamics of territorial patterns of innovation

A well established literature has produced vast consensus on the role of regional innovation as a major driver of regional economic growth. The link between regional innovation and regional economic performance (originally conceived in terms of a linear relationship) has been advocated by works revolving around the idea that different types of localized externalities enhance the process of knowledge generation and diffusion among firms located in the same area. This is the case of the Milieu Innovateur (Aydalot, 1986; Aydalot and Keeble, 1988; Bellet et al., 1993; Camagni, 1991), the Learning Region (Lundvall and Johnson, 1994), and the Regional Innovation Systems (Cooke et al., 1997) theories. These externalities are often justified with the imperfect public nature of knowledge. What cannot be easily be codified (i.e., tacit knowledge) would be best conveyed by means of face-to-face contacts.

Over the last decade, this consensus has been partially replaced by a more nuanced picture. In particular, the literature brought consensus over the fact that innovation may take place in different ways, supported by different inputs (R&D activities, as well as knowledge created outside and brought into the region thanks to bright entrepreneurs) or can be the result of an imitative process. The different modes of innovation (termed *regional patterns of innovation*) are the result of local preconditions allowing a region to develop some types of learning process rather than others. For this reason, there is no superior type of regional pattern of innovation; instead, each of them represents the best way for learning processes for the context of a particular region (Capello and Lenzi, 2013a). These modes have been subsequently empirically identified on the universe of NUTS2 regions. Belonging to specific regional innovation patterns (e.g., the European Research Area) has been found to be associated to differences in the elasticity to innovation generated by R&D expenditure.

The MASST3 model already included the static version of this conceptual framework. However, it has however been recently recognized that regions may evolve from one pattern of innovation to another when the local functional and relational conditions allow them to move towards another mode of learning. The determinants of shifts across regional innovation patterns, previously neglected, have been identified, as it is a major element in capturing the evolution in the structural ways in which regions learn (Capello and Lenzi, 2018). In the MASST4 model another major improvement has been obtained, in particular including an equation estimating the determinants of changes in territorial patterns innovation patterns over time, a crucial aspect for a regional growth forecasting model in a period in which competitiveness is also based on the advent of a new technological paradigm, that of “Industry 4.0” (Capello and Lenzi, 2017). Following Capello and Lenzi (2017), the estimated equation is the following:

$$\begin{aligned}&\Pr(\text{CHANGE OF INNOVATION PATTERN}_r) = f(\text{R \& D}_r, \text{HC}_r, \text{LQ}_{\text{HIGHTECHr}},\\&\text{POPULATION DENSITY}_r, \text{TECHNOLOGICAL DIVERSIFICATION}_r,\\&\text{IIA}_r, \text{SCDA}_r, \text{STAA}_r,)\end{aligned} \tag{6.}$$

In Eq. (6.), IIA_r (Imitative innovation area), $SCDA_r$ (Smart and creative diversification area) and $STAA_r$ (Smart technological application area) are dummy variables measuring whether a region belongs to one of those regional innovation patterns, the reference category being the Applied science area.
Results of these estimates are presented in Table 4.4.

Estimates are obtained as follows. First, the data base collected for the analyses presented in Capello and Lenzi (2017) has been integrated for all NUTS2 regions not initially in the data.[10] Next, the preferred model in the original analysis[11] has been run with the exclusion of non-statistically significant variables. In Table 6, results present the expected sign and significance. As with the original case, the interesting result is that the probability to change pattern is relatively higher for regions belonging to the imitative area, and decreases when moving towards more complex R&D-related patterns; the critical mass of R&D activities needed to achieve science-based learning processes is not easy to reach, and not really crucial for non-science based regions to get dynamic efficiency advantages from their learning modes.

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[10] In Capello and Lenzi (2017), the unit of observation is the NUTS2 region in the 2010 version.

[11] In Capello and Lenzi (2017), this is shown in Column 5 in Table 2, p. 7.

Table 4.4: Determinants of the dynamics of regional innovation patterns

Dep. Variable	*Probability to change territorial patterns of innovation*		
	β	Std. Err.	Significance level
Constant term	-1.60	0.15	***
R&D intensity	0.08	0.03	***
Human capital	0.02	0.00	***
Specialization in high-tech	0.21	0.05	***
Imitative Area	0.92	0.12	***
Smart and Creative Diversification Area	0.49	0.09	***
Smart Technological Application Area	0.29	0.09	***
Spatial lag of population density	1.60	0.13	***
Method of estimation	Spatial Error Model		
Lambda	-2.28	0.52	***
Number of obs.	242		
R^2	0.64		
Joint F-test	26.31***		
Country dummies	Yes		
Robust standard errors	Yes		

*Note: *= significant at the 90% confidence level; **= significant at the 95% confidence level; ***= significant at the 99% confidence level.*

Several robustness checks have also been performed. First, the exclusion of insignificant variables is run one by one, in order to verify that such exclusion does not affect our estimates; results of this first control suggest that indeed this is not the case.

Next, we also verified whether any of the explanatory variables suffers from border effects (see Section 4.3); again, none of the controls is found to be significant when interacted with a dummy variable capturing the border location of the NUTS2 regions in the sample.

4.5 Brexit and borders

A regional econometric growth forecasting model cannot ignore the relevant changes that are taking place at the institutional level in the EU. Among those, the rise of discontent and thereby populism takes a prominent role. Among the many political elections and referenda held on EU membership, by far the one that had to date the most relevant consequences is the UK's decision to quit the EU (henceforth, Brexit).

Several works have been recently trying to capture the likely long run effects of Brexit, but any such attempt clashes with the fact that as of today the way this process will actually take place (hard VS. soft Brexit, if any) is still unclear (Fingleton 2018; Dhingra et al., 2017). In the (for many, worst case) scenario whereby Brexit would indeed be effective as of April 2019 with a complete cancellation of all free trade and movement agreements previously signed by the UK and the rest of the EU, costs may be quite substantial. Beyond pure geographic distance, international trade has been consistently found to be remarkably lower than interregional one (Mc Callum, 1995; Capello et al. (2018b).

Building a common market, fostering intra-European trade, and allowing the free movement of people between EU countries has engendered relevant advantages that have been frequently advocated to call for a further integration of the countries joining the EU. Consequently, the partial or total reversal of the common regulations making up the common market would have major consequences (Cecchini et al., 1988). Estimates on the extent of the losses to the incomplete construction of a common EU market range from 2.2 per cent (Ilzkovitz et al., 2007) to 12 per cent of EU's GDP (Campos et al.2014).

In the MASST4 model we model Brexit's effects in the simulation part. Simulations are performed starting from 2018. Since Brexit is scheduled to happen in April 2019, the first year when its effects should be felt is 2020. Consequently, until 2019 included the UK is treated as a full-status EU member, in particular in terms of the geographic and trade-induced spillovers it engenders on, and it benefits from, the rest of the EU28. From 2020 onwards, we increase distance between UK and EU27 (EU28 minus the UK) in calculating geographic and trade spillovers and we set it to the maximum among the remaining sample. From a geographic point of view, this is the equivalent of fictionally relocating the UK in the Atlantic Ocean, where the most remote NUTS2 regions are. From a trade perspective, this is tantamount to assuming that UK's regions' trade decreases to the smallest trade flow registered between any other EU28's region couple. This allows us to decrease the intensity of technological interdependence between EU and UK regions, thus minimizing the process of knowledge diffusion that fosters regional productivity gains and enhances the regional shift component.

5 Conclusions of part A

The main innovations introduced in the model include the structurally diverging performance of groups of countries and the consequences of the choice of the UK to leave the EU (at the national level), and dynamic patterns of innovation, after-crisis structural changes in manufacturing employment, regional productivity determinants, and dynamic agglomeration economies (at the regional level).

These aspects cannot be left out of a regional growth forecasting model, given their importance in interpreting future development trajectories.

Moreover, the new built-up of the MASST model allows a more effective assessment of the relations whose structure has evolved as a consequence of the changes induced by the crisis. These can be summarized in terms of three major evolutions:

(i.) at the national level, investments have remained sensibly more volatile in the aftermath of the crisis, and their sensitivity to GDP growth signals is much higher than in the long and stable moderate growth period prior to the crisis;

(ii.) at the regional level, manufacturing employment shows a remarkably higher importance of high-tech manufacturing industries in shaping future manufacturing employment growth rates. The increased relevance of being specialized in advanced manufacturing activities already emerged during the crisis, but in the years following its end this has become ever more relevant;

(iii.) at the urban level, the link between city size and urban productivity shows clear signs of emerging agglomeration diseconomies, although pure size effects seem to matter increasingly more both during the crisis as well as in the subsequent period.

Taken together, these results pose relevant challenges both for academics as well as for policymakers. The former have remained solidly anchored to a theoretical and empirical toolbox interpreting regional economic growth as an equilibrium process; instead, the evidence suggests that off-equilibrium conditions may be a much closer representation of the true underlying mechanisms explaining regional performance. For policymakers, this point is even more relevant: acting on an ever-changing world represents a possibly tougher challenge with respect to thinking that crises just end leaving the world as it was before. In both cases, the MASST4 model can serve the aim of simplifying, and better understanding, these changing relations.

Lastly, on the basis of these findings, several future research avenues are wide open. The MASST4 model is a powerful tool capable of capturing the complexity of context conditions intertwined in comprehensive scenarios. The present conditions of the EU certainly call for many such exercises, and this model allows to formalize this attempt and provide sound evidence on the way the EU’s economy will likely evolve over the next couple of decades.

Part B: Modelling Scenarios

6 Definition of reference scenario and quali-quantitative assumptions

As a benchmark for an alternative scenario that the project aims at, a ***reference scenario*** has been built. The reference scenario differs from a sheer baseline scenario in that while the latter has to be interpreted as a trend-based scenario, the former is **not a simple extrapolation of past trends**. This latter approach does not seem meaningful in a context where numerous factors of strategic significance are changing. Therefore, a reference scenario takes into account the structural changes that have manifested themselves in the last period.

The reference scenario is based on the following qualitative assumptions (Table 6.1).

<u>Assumptions on macroeconomic trends</u>:

A series of pre-crisis conditions are unlikely to be replicated in the post-crisis scenario:

1) **high volatility of investments** of the post crisis period will continue;
2) a normal reactivity of investment growth to GDP growth will be replaced by **a high reactivity of investment growth to GDP growth, even if decreasing in the long term**;
3) free international trade between US and EU is replaced by the present risk of protectionist measures between US and EU, which leads to **a lower increase in export with respect to the past long term trend**;

Instead, some crisis trends are likely to continue in the future, namely:

4) Permanent controls on national deficits and debts;
5) Some controlled exceptions of public expenditures for low-growing and indebted countries (due to political risks, like the recent Italian elections showed);
6) low inflation rates;
7) expansionary monetary policy (quantitative easing) concludes by the end of 2018, as officially stated by the European Central Bank.

<u>Assumptions on industrial trends</u>:

8) a halt in the deindustrialization of the European economy, and instead an initial launch of high-tech industry in Europe, under the influence of the new technological paradigm «Industry 4.0»;
9) an increase in high-value added services related to the adoption of Industry 4.0 related technologies.
10) a slow catching-up in R&D expenditure and a slow increase in human capital in Central and Eastern European Countries, following the post-crisis trends.

<u>Assumptions on institutional changes</u>:

11) Brexit does take place in 2019, thus exerting its effects from 2020;
12) even if some regional independency requests take place, no regional independence takes place;
13) redistribution of the European budget in favour of new fields - security and migration - decreasing the share of budget devoted to cohesion policies and CAP, setting national shares to the levels decided in the document of May 29, 2018, and maintaining regional shares as in the 2014-2020 programming period.

Table 6.1: Qualitative assumptions, model levers and quantitative assumptions in the reference scenario

Qualitative assumptions	***Model's levers***	***Quantitative assumptions (targets in 2035)***
Assumptions on macroeconomic trends		
High volatility of investments, decreasing in the long run	Coefficient of investment trends	Lower value
High reactivity of investments growth to GDP growth, decreasing in the long run	Coefficient of GDP growth with respect to Investment growth	Lower value
Risk of protectionism and therefore lower export increase	Constant of export growth	Lower value
Permanent controls on national deficits and debts	Targets on deficits and debts	3% : Deficit / GDP 60%: Debt / GDP for Eastern countries 90% : Debt / GDP for Western countries 110% : Debt / GDP for Western countries belonging to cluster 1*
Some controlled exceptions of public expenditures	Targets on debts	110% : Debts over GDP on "problematic countries"
Low inflation rates	Inflation rate	2,5% Western countries 5% Eastern countries
End of the expansionary monetary policy (quantitative easing)	Interest rates	3% Western countries; 4% Eastern countries 4% Western countries belonging to cluster 1; 6% Eastern countries belonging to cluster 1
Assumptions on industrial trends		
Initial launch of high-tech industry in Europe	EU growth rate of High-tech industrial sectors	Increase of value added at European level for high-tech industries (+1.5% as an average with respect to the past)
Increase in high-value added services related to the adoption of Industry 4.0 related technologies	EU growth rate of High-tech service sectors	Increase of value added at European level for service industries (+1.5% as an average with respect to the past)
A slow catching-up in R&D expenditure in CEECs	R&D / GDP in CEECs countries	+ 0.5% with respect to the post crisis period in Eastern countries
A slow catching-up in human capital in CEECs	Human capital in CEECs countries	+2% with respect to the post-crisis period in Eastern countries
Assumptions on institutional trends		
Brexit from 2020	Regional input-output trade between UK NUTS2 and all other NUTS2 in Europe, applied as a distance for spillovers of growth Geographical distance between UK NUTS2 and all other NUTS2 in Europe	Trade distance increased to a maximum, limiting growth spillovers. Distance increased to a maximum, limiting growth spillovers.
Decrease in the cohesion policy expenditures	Expenditures of cohesion funds by NUTS2	National shares equal to the levels decided in the document of 29th May, maintaining regional shares as

		in the 2014-2020 programming period
Urban settlement related assumptions		
Increase in urban amenities in Western countries	Urban amenities	2% increase in large cities 1% 0.5%
Upgraded quality functions	High-value functions	Increase of: 3% large and medium cities in Western countries 1% small cities in Western countries 2% large cities in Eastern countries 1% medium cities in Eastern countries 0.5 small cities in Eastern countries
Cooperative behaviour among cities everywhere	Networking behaviour	10% large cities in Western countries 5% medium cities in Western countries 3% small cities in Western countries 8% large cities in Eastern countries 4% medium cities in Eastern countries 2 small cities in Eastern countries

Legend: * cluster 1 countries include Cyprus, Finland, Greece and Italy, i.e. the slowest-growth countries in the post-crisis period.

<u>Settlement structure-related assumptions</u>

14) increase in urban amenities in Western countries;

15) upgraded quality functions and cooperative behavior among cities everywhere.

The qualitative assumptions have been translated into quantitative levers in the fourth version of the MASST model, built and utilized for the first time in this project.

7 Aggregate results

Before presenting the results of the reference scenario, a word of caution in reading them is needed. Results depict the main tendencies, major adjustments to change, relative behavioural paths of regional GDP growth (and regional employment growth) in each region under the assumptions presented above. The numbers provided therefore represent tendencies of the variables and not precise forecasts. With this attention, we can read the results that follow.

Table 7.1 represents the results of the average annual growth rate between 2018 and 2035 for different economic variables. The Table reports the quantitative foresights for EU28, for EU without UK and for Eastern and Western countries respectively.

Table 7.1: Annual average GDP, productivity and employment growth 2018-2035

	Average GDP growth rate	Average productivity growth rate	Average total employment growth rate
EU28	1.60	0.34	0.27
EU27 without UK	1.61	0.35	0.28
United Kingdom	1.49	0.02	0.35
Old15	1.59	0.17	0.24
CEECs	1.72	0.75	0.38

The following tendencies emerge:

- from a macroeconomic point of view, the Reference Scenario is characterized by a stable relaunch after the crisis, with an average yearly growth rate of 1.6% for EU 28. This rate would be slightly higher (1.61%) were the United Kingdom taken off the list, due to its lower performance determined by potential negative Brexit effects (+1.40%);
- CEECs countries show still an average growth rate higher than Old 15 Countries (1.72% against 1.59%) but the difference has remarkably abated;
- Old15 are characterized by a slow increase in overall productivity, in line with the warnings laid down in the official OECD document “The future of productivity” (OECD, 2015);
- the difference between Old15 and New13 is more consistent in terms of productivity than in terms of employment growth. CEECs countries are likely to experience a second transition, although a less problematic one with respect to the first one, towards a more equilibrated, endogenous pattern of development. Old15 countries instead are entering a stage of re-launch thanks to an advanced and pervasive use of new technologies and the benefits of what is commonly known as ‘Industry 4.0’.

Table 7.2 reports the results of GDP growth rates at Country level.

Table 7.2: 2018–2035 average yearly GDP growth rate by country and for the EU

Country	Average GDP growth rate
Austria	1.54
Belgium	1.34
Bulgaria	1.97
Croatia	1.35

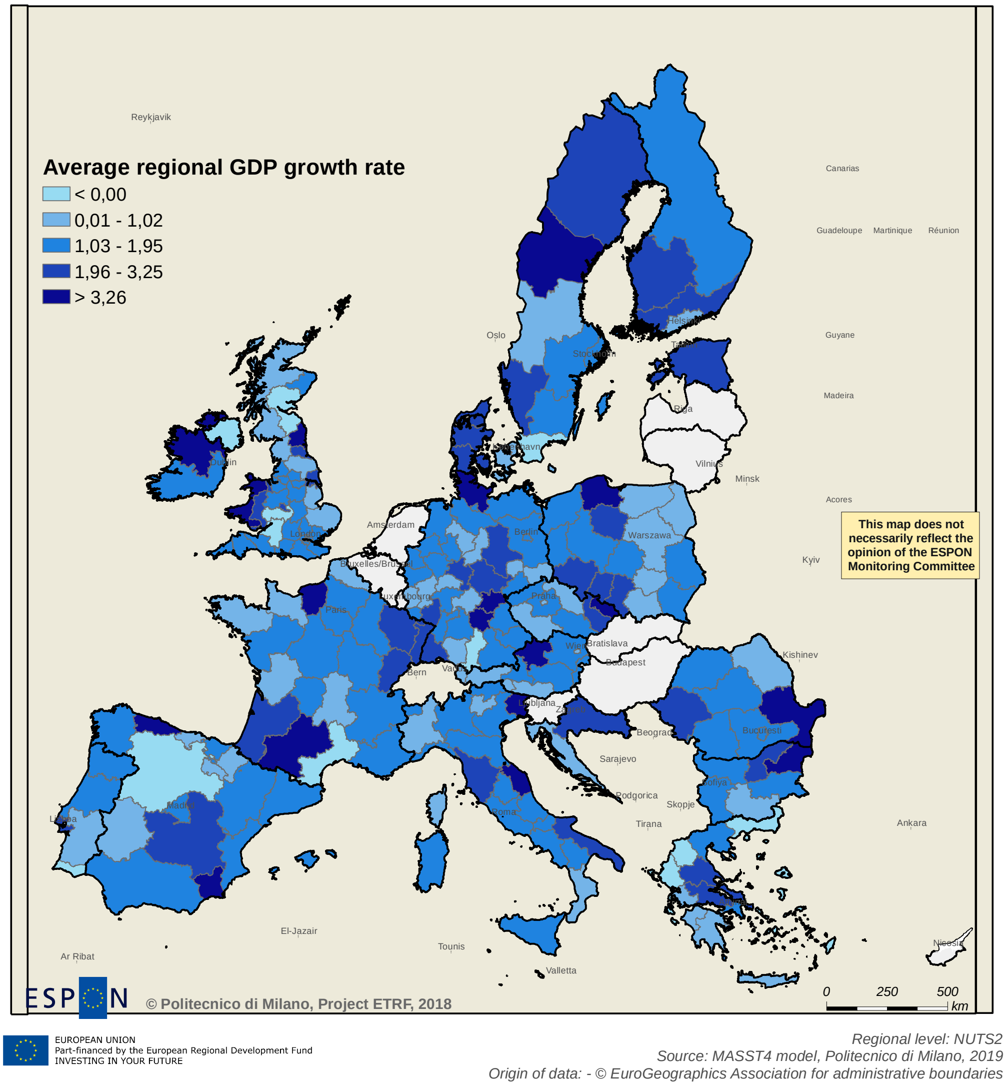
Cyprus	1.74
Czech Republic	1.46
Denmark	1.79
Estonia	2.04
Finland	1.19
France	1.60
Germany	1.72
Greece	1.38
Hungary	1.79
Ireland	1.74
Italy	1.60
Latvia	1.81
Lithuania	1.67
Luxembourg	1.60
Malta	1.92
Netherlands	1.45
Poland	1.74
Portugal	1.58
Romania	1.70
Slovakia	2.02
Slovenia	1.44
Spain	1.37
Sweden	1.50
United Kingdom	1.49

Among Old15 countries, top performers (in terms of GDP) include Germany and Denmark; among CEECs, Estonia, Slovakia, Bulgaria, and Hungary stand up. Two countries of the group that were relatively slow in the recovery from the crisis, namely Italy and Cyprus, are showing better performances, narrowing the gap with respect to the mean EU growth rate, while Finland and Greece are still facing difficulties. Some western countries that were performing very well before the crisis, namely Ireland and then were severely touched by the crisis (with Portugal) are now performing a little less than the EU average.

8 Regional results

Map 8.1 presents annual average GDP growth rates between 2018 and 2035 in EU NUTS2 regions. The map does not highlight any longer the macro-regional patterns that were present in the recent past (namely the celebrated East-West divide and the North-South differentials that emerged in the early stages of the crisis). Regional growth rates are now converging around the averages and diverging behaviours involve some single regions (like Castilla Leon, Algarve, Languedoc-Roussillon, Croatia, North-Western regions in Greece and the Aegean islands, and southern Sweden).

Map 8.1: Annual average GDP growth rate – 2018-2035



Source: Author's elaboration

Some dualism is still left in terms of regional GDP growth rates within single countries, and even more so in terms of per capita GDP levels. The major and more evident cases refer to:

- the Eastern part of Poland with respect to the more dynamic western (and particularly South-Western) part of the country and to the capital region of Warsaw;
- the Eastern and Southern part of Greece, with respect to the core, central area;
- the Mediterranean axis in France, less dynamic than the rest,
- some (not all) regions in the Italian Mezzogiorno, like Abruzzo, Calabria and Sicily;

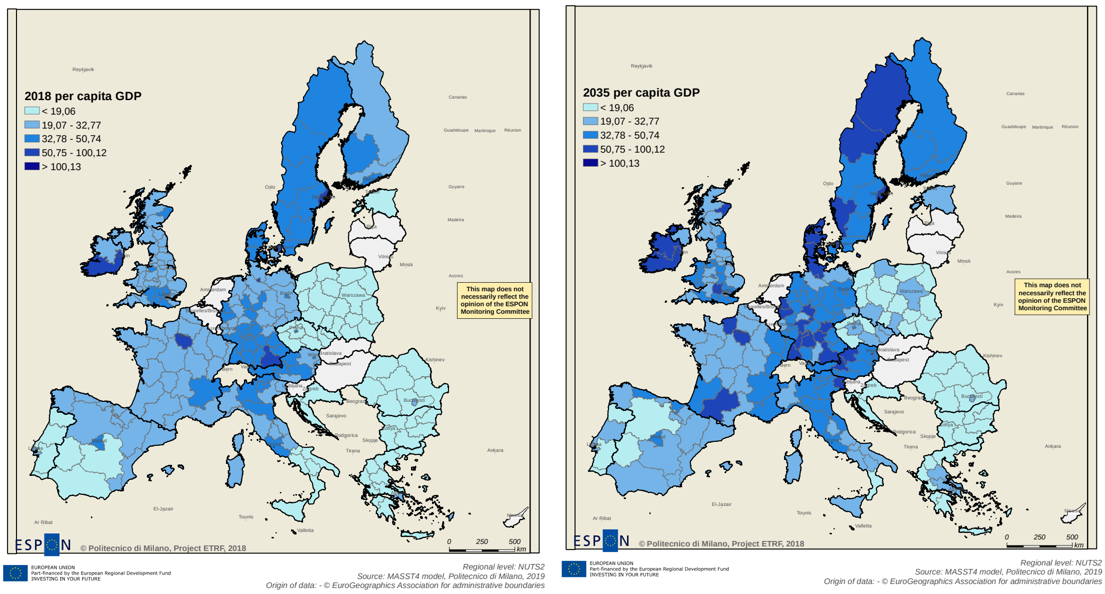
- the Eastern part of Denmark, including Copenhagen, less dynamic than the rest of the country;
- some scattered regions in UK.

In general, main large cities and their regions, although in good shape, are not necessarily the most dynamic in their countries as could be expected. Major diffusion processes of new technologies and best organizational breakthrough will be apparently at work in the direction of solid, mid-income regions and medium-size cities.

Regional GDP growth rates depicted in Map 8.1 lead to GDP per capita levels presented in Map 8.2. When comparing the future situation of per capita GDP in 2035 with the present situation (2018), a major increase in per capita GDP is found:

- in large cities of CEECs;
- in industrial areas of Southern countries, like the central part of Italy, the South-East part of Greece, South of France;
- in the Eastern part of Germany;
- in Ireland;
- in the Southern part of Germany and in Austria;
- in the Benelux area;
- in Scandinavian countries, especially in capital cities, but also in regions of the North.

Map 8.2: Per capita GDP in 2018 and 2035



Source: Author's elaboration

9 The integration scenario: assumptions and results

A second quali-quantitative exercise has implied the creation of what has been labelled an "*integrated scenario*". In particular, given the economic nature of the MASST model, the qualitative visions suggested in the ETRF project were not replicable. What we propose here is a scenario in which economic integration among European member countries reinforces, despite Brexit.

Several qualitative assumptions characterise the integrated scenario. These assumptions have been added to the ones of reference scenario, so that the difference in the results obtained between the integrated and the reference scenario is due only to the additional assumptions that characterize the integrated scenario, namely:

- an increase in the global value chain among EU countries ("production integration effect");
- an elimination of non-tariffs barriers among European countries ("market integration effect");
- an increase in trust within and among countries ("social effect");
- higher quality of government ("institutional effect");
- stronger cooperation networks among cities ("cooperation effect").

Qualitative assumptions are translated into the following quantitative ones (Table 9.1).

Importantly, Brexit is assumed to exert its effects from 2020, as in the reference scenario. Table 9.2 provides the results on the difference between the annual GDP growth rate between 2018 and 2035 in the integrated with respect to the reference scenario.

Table 9.1: Qualitative assumptions, model levers and quantitative assumptions in the reference scenario

Qualitative assumptions	**Model levers**	**Quantitative assumptions (targets in 2035)**
higher trade flows among EU countries ("production integration effect");	Trade matrix	Doubling of interregional trade flows intensity
higher decrease in non-tariffs barriers ("proximity to larger markets effect");	Border effects (interaction between border region dummy and FDI effects on regional DIF)	Elimination of the border effect
higher trust within and among countries ("social effect");	Trust	Increase in trust (everywhere, stronger in Old15 Countries and in metro areas)
higher quality of government ("institutional effect");	Quality of Government	Spatially-neutral increase in Quality of Government
stronger cooperation networks among cities ("cooperation effect";	Diffusion and thickness of inter-urban scientific cooperation networks (FP projects co-participation)	Spatially-neutral increase in inter-urban networks
higher exports ("market integration effect")	Constant in national export equation	Increase in the constant in national export equation

Source: Author's elaboration

Results of running the integration scenario simulation are presented in Tables 9.2 and 9.3. Table 9.2 shows annual average GDP growth for the simulation period (2018-2035) in the integration scenario as a difference with respect to the reference scenario. Results show that while on average all macro areas gain from a more integrated scenario. Such gains are larger for CEECs than for Old15 Countries. Without UK, the European Union registers a slightly positive sign, witnessing that Brexit does not constitute a loss for the EU.

Table 9.2: Annual average GDP growth 2018-2035 Integration scenario w.r.t. the reference scenario

	Average GDP growth rate
EU28	0.24
EU27 without UK	0.25
United Kingdom	0.11
Old15	0.23
CEECs	0.29

Source: Author's elaboration

Table 9.3 shows instead Country-specific results, again as a percentage difference with respect to the reference scenario. In general, all countries benefit from an integration process, as broadly argued by international economics theories emphasizing the advantages of scale and scope economies obtained through a larger market. UK gains much less than the average, registering a damage from leaving the Single Market. Within Old 15, Luxembourg, Belgium, The Netherlands, located in the core of Europe, gain the most, as expected. However, some exceptions are worth discussing; especially Ireland, a geographically peripheral country, and to some extent Austria, gain more than the average from the economic integration process. Ireland is also an open country, based on multinationals and their embeddedness in international input-output relationships and Global Value Chains. All CEECs benefit from an integration scenario, with the exceptions of Croatia and Poland which gain relatively less with respect to other CEECs.

Map 9.1 presents the results of the difference in GDP growth rates between the integration and reference scenario at regional level. A rather diverse picture emerges, with some regions even losing with respect to the reference, probably because of their lower ability to grasp the advantages of a sudden integration. Instead of benefitting from a larger market, their non-competitive peripheral local markets suffer from being closer to the core, becoming easier areas to conquer by strong, competitive and centrally located firms.

In general, most regions gain. However, the reasons are different, and specific advantages emerge in some areas. In particular:

- southern regions in Italy, the Mediterrenean regions of Spain and in the Bulgarian areas take advantage from the «production integration effect» and the «proximity to a larger market effect», which combine their impact;
- the southern part of Spain, Ireland, The Northern Scandinavian countries gain thanks to a «proximity to a larger market effect»;
- the core of Europe, all the Benelux regions and the Northern regions of Germany strongly gain to be in the centre of a larger market.

It is interesting to see that there are regions that gain less in the integration scenario with respect to the reference scenario. Even if this result may sound counterintuitive, since integration is expected to be a positive push for economic systems, there are some few cases where this is not the case: integration means fiercer competition which calls for a certain degree of competitiveness in an economic system. Some regions in Scotland, in Eastern countries and in the Iberian peninsula, still have better growth trajectories under reference scenario asusmptions with respect to the integration assumptions, demonstrating a limited capacity of their economic system to deal with higher competition. This situation is in line with what happened after the enlargement processes of the EU, when lagging regions strongly suffered from higher integration, something that pushed the Italian politicians to ask (and to obtain) for the double of Cohesion funds for the country in preparation of single market integration (Camagni, 1992)[12].

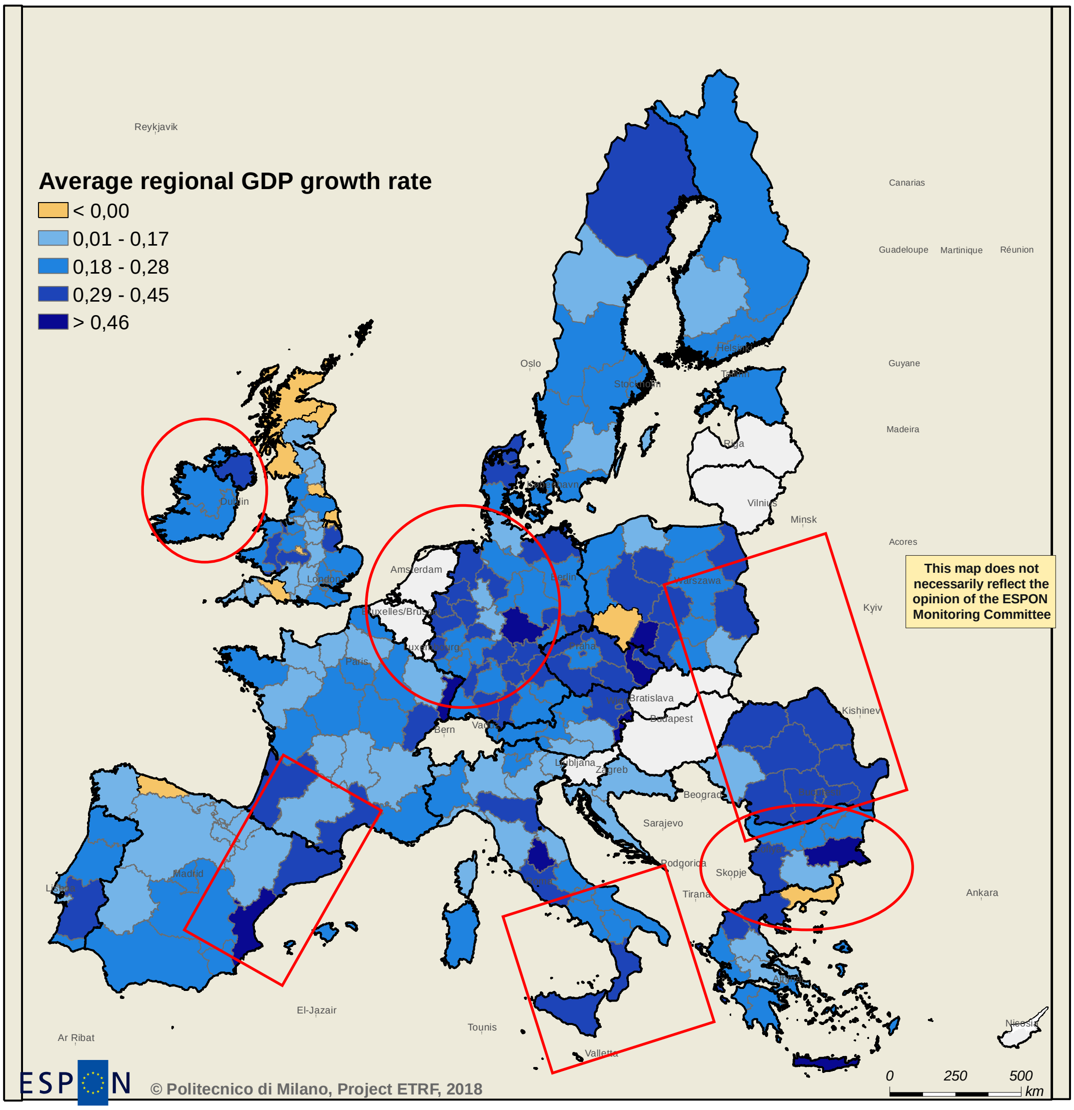
Table 9.3: Annual average GDP growth 2018-2035 Integration scenario w.r.t. the reference scenario by country

country	GDP growth w.r.t. reference scenario
Austria	0.21
Belgium	0.37
Bulgaria	0.19
Croatia	0.14
Cyprus	0.20
Czech Republic	0.28
Denmark	0.18
Estonia	0.20
Finland	0.16
France	0.13
Germany	0.17
Greece	0.13
Hungary	0.25
Ireland	0.26
Italy	0.12
Latvia	0.20
Lithuania	0.24
Luxembourg	0.48
Malta	0.39
Netherlands	0.28
Poland	0.17
Portugal	0.12
Romania	0.19
Slovakia	0.27
Slovenia	0.24
Spain	0.14
Sweden	0.18
United Kingdom	0.11

Source: Author's elaboration

[12] Camagni R. (1992), "Scienze regionali e Mezzogiorno: concetti, principi e riflessioni normative", in Camagni R., Hoffmann A., Latella F. (eds.) (1992), *Mezzogiorno e scienze regionali: l'analisi e la programmazione*, Milano: Franco Angeli, vol. 17, 23-45

Map 9.1: Regional annual average GDP growth 2018-2035 Integration scenario w.r.t. the reference scenario



EUROPEAN UNION
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Regional level: NUTS2
Source: Politecnico di Milano, 2018
Origin of data: - © EuroGeographics Association for administrative boundaries

Legend:

: «proximity to larger market effect»

: areas where a comination of «production integration effect» and «proximity to larger market effect» takes place

Source: Author's elaboration

10 Regional disparities

An interesting result concerns the evolution of regional disparities under different assumptions for the two scenarios. Disparities in the two cases are calculated by means of the Theil Index, which decomposes total disparities into inter-regional (within-Country) and between-Countries disparities.

The Theil index for a set of Countries and regions can be written as (OECD, 2016)

$$Theil = \frac{1}{N}\sum_{i=1}^{N}\frac{y_i}{\bar{y}}\,ln\left(\frac{y_i}{\bar{y}}\right) \tag{1}$$

where *y* is th variable for which the Index is calculated (in what follows, per capita GDP), N is the number of regions observed, and $\bar{y}$ is the mean value of the variable of interest across the observed sample.

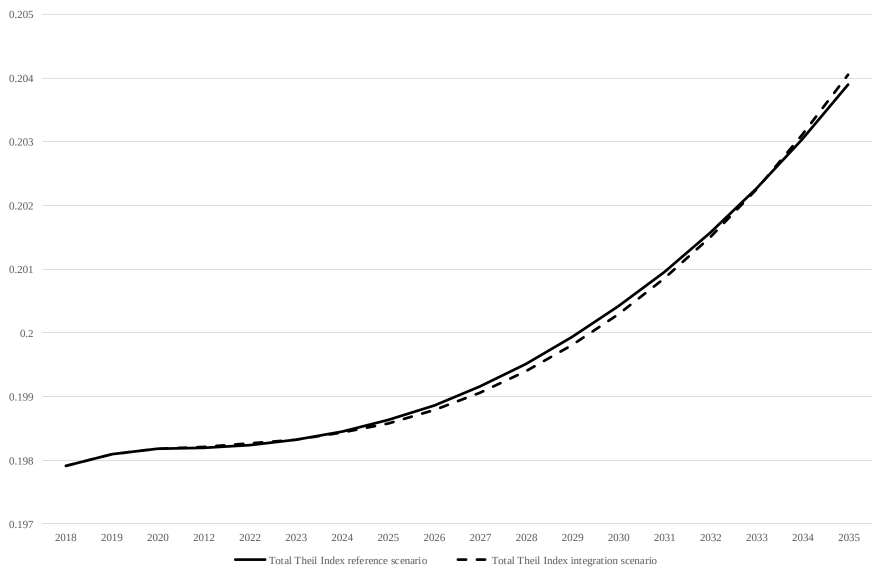
Eq. (1.) can be rewritten as

$$Theil = \frac{1}{N}\sum_{i=1}^{N}s_j\frac{y_{ij}}{\bar{y}_j}\,ln\left(\frac{y_i}{\bar{y}}\right) + \frac{1}{M}\sum_{i=1}^{M}s_j ln\left(\frac{y_i}{\bar{y}}\right) \tag{2}$$

In Eq. (2.), the first part of the index measures disparities within subgroups of regions belonging to a Country, while the second sub-index captures disparities between subgroups of Countries.

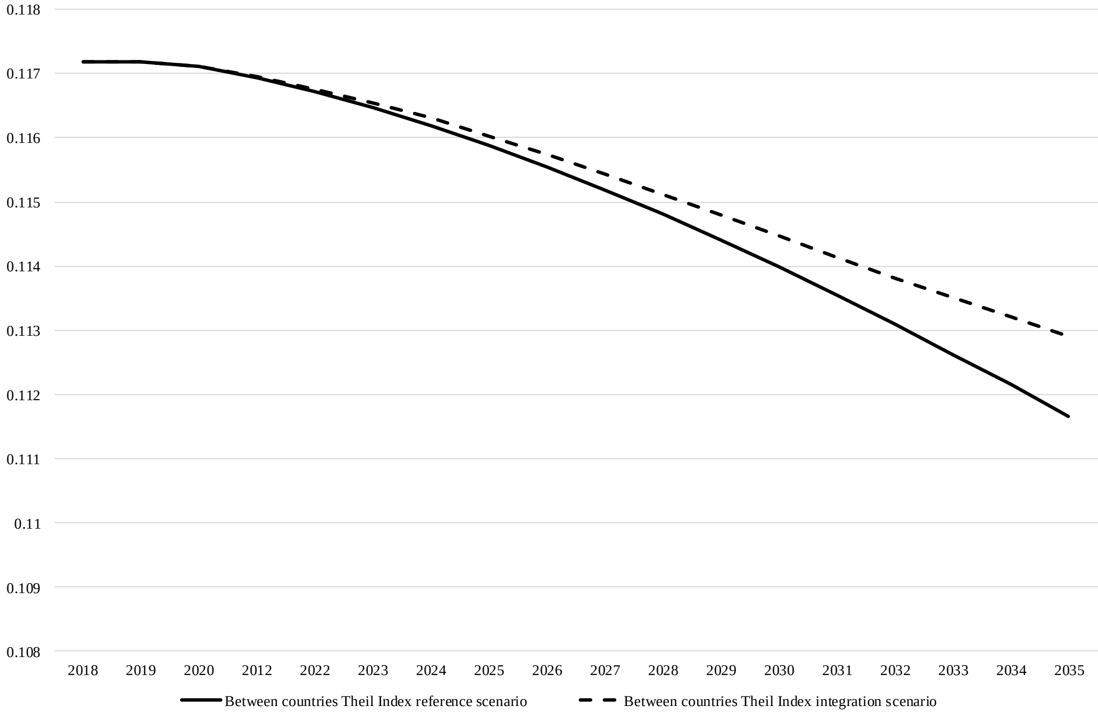
Figure 10.1 displays a comparison of total Theil indices for the reference (continuous line) and integration (dashed line) scenarios. Results suggest that, in the long run integration, is achieved through an increase in regional disparities, as a result of a lower decrease in between country disparities (Figure 10.2) not compensated by a sufficient lower increase in within country disparities (Figure 10.3).

Figure 10.1: Total Theil Index, reference vs. integration scenario



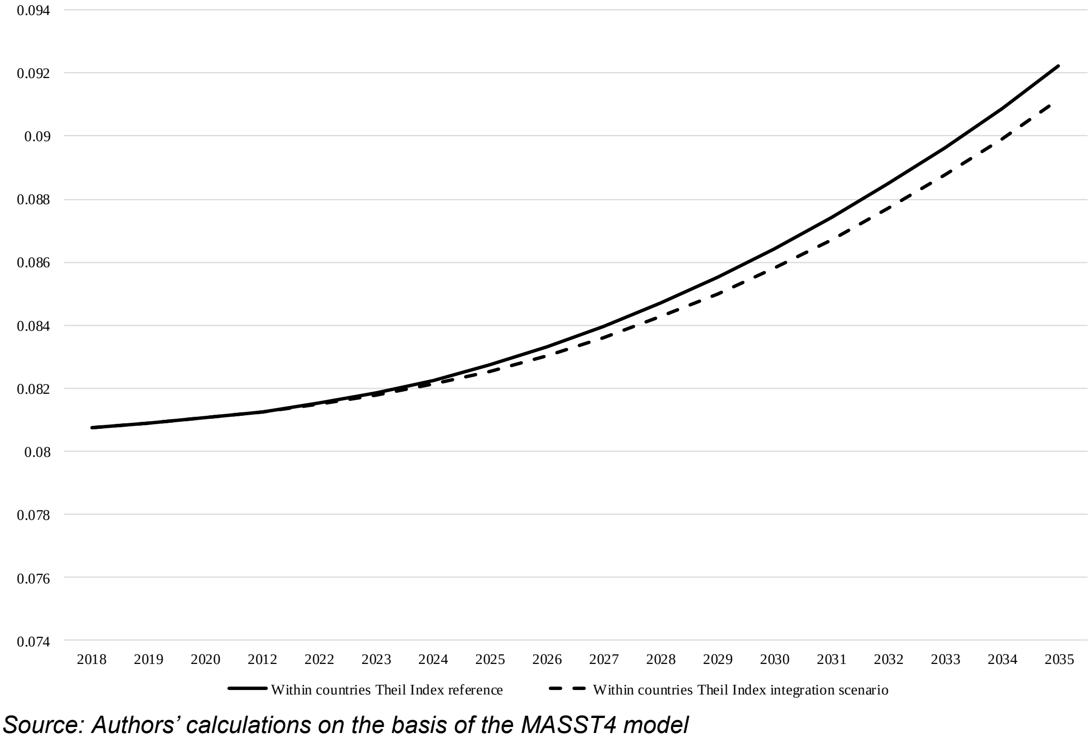
Source: Authors' calculations on the basis of the MASST4 model

Figure 10.2: Between Countries Theil Index, reference vs. integration scenario



Source: Authors' calculations on the basis of the MASST4 model

Figure 10.3: Within Countries Theil Index, reference vs. integration scenario



Source: Authors' calculations on the basis of the MASST4 model

These results call for an explanation. During the different European institutional and economic integration processes – sources of growth opportunities for strong areas of the countries and not for lagging ones – within country disparities have increased. For this reason, it was reasonable to expect that in the integration scenario an increase in disparities within countries would have been the result. The analysis shows instead that this is not the case (Figure 10.2). The interpretation of such result lies in two facts. The first one is that the integration scenario is assumed to take place among countries that *have already entered* the EU since quite some time; lagging regions adjusted to the market competition that a higher integration imposes, with the result that they are now able to grasp the advantages of a deeper integration. The second one is that the EU integration has produced a diffused growth, increasing the development level in most lagging regions, able to grasp the opportunities offered by an economic integration; only a few areas remained poor, with an increasing level of poverty, that makes them be unable to grasp such growth opportunities.

For what concerns between country disparities, in an integration scenario they are expected to decrease quicker, since integration produces growth opportunities to all countries. This is not the case, at least from what our results tell us. Between country disparities decrease at lower pace than in the reference scenario. The explanation lies in this fact that the crisis has produced “new poor”, i.e. countries in Western Europe, that grow at very low rates (e.g. Italy, Greece, UK, and to a certain extent France); an increase in integration, calling for higher competitiveness to keep pace with fiercer competition, is difficult to be coped with for such economies, slowing down the convergence process among countries more than in a reference scenario (Figure 10.3). Moreover, an integration scenario increases the relative costs of Brexit for the UK, which registers an even lower GDP growth than in the reference scenario, with a negative effect on the convergence process.

11 Conclusions of Part B

The two scenarios here presented provide a rich set of results whose importance is not to be evaluated against the likelihood that they will eventually materialize, but rather as an evidence-based ‘what if’ exercise that allows sound policymaking to counteract potential unpleasant outcomes.

In particular, we have highlighted the following main outcomes:

- integration leads to a more expansionary economy, although these effects are not homogeneously distributed across space. In other words, not all regions gain with the same intensity from a more integrated framework;
- a higher integration process also increases the relative costs of Brexit for the UK. In fact, UK is among the countries gaining the least from an integration scenario. This can be justified in the light of the less intense trade and geographical spillovers that channel the positive effects of integration;
- a quicker integration process leads to an economic loss in some regions. Areas that are less sheletered towards international competition, as well as some regions located in the UK are potential (partial) victims of an integration process, in that their gains would be less intense than in the rest of the EU;
- an integration scenario is in the long run a less cohesive scenario. Total regional disparities grow less than in the reference scenario, but this only happens until the very last two years of the simulation stage, when a partial reversal of this trend takes place.

About the reason for an integration scenario to be less cohesive, much has been said in the report. What became clear is that the within country disparities, that have always suffered from integration phases, in this case grow less than in the reference scenario as the result of a much higher integration level that each region has after years of Single market. The capacity to cope with fiercer competition seems to be more equaly distributed among EU regions. On the other side, between country disparities generate a slowdown of the convergence process, as the result of countries coming out from the crisis with weaker economies unable to grasp competition as they should.

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List of Annexes

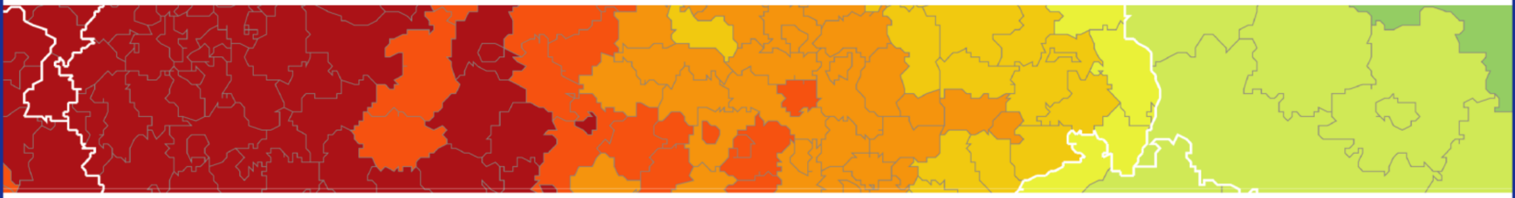
Annex 1: Technical Appendix of Part A

A1. Breakdown of endogenous and exogenous variables in the MASST4 model according to the national, regional, and urban sub-models

Table 11.1: Endogenous and exogenous variables in the MASST4 model

	National submodel	Regional submodel	Urban submodel
Number of equations	6	9	2
Endogenous variables	GDP growth	Regional differential shift	Urbanization economies (urban land rent)
	Consumption growth	Manufacturing employment growth	Equilibrium urban population
	Investment growth	Service employment growth	
	Import growth	Regional innovation	
	Export growth	Evolution in regional innovation patterns	
	Public expenditure growth	GDP spatial spillovers	
	Potential GDP	Unemployment growth	
		Population growth	
		Migration growth	
Exogenous variables	Tax rates	Human capital	Urban quality of life
	Private interest rates	R&D expenditure	Urban crime rates
	Interest on oublic debt	Regional specialization	City networks
	Unit Labour Costs	Functions performed	High-level urban functions
	Growth of FDI stock	MIX effects	Borrowed size
	Inflation rate	Structural Funds expenditure	Borrowed functions
	Trade-weighted exchange rates	Territorial settlement structure	Spatial lags of functions
	GDP growth of United States and Japan	Birth rates	
	GDP growth of BRIC countries	Death rates	
		Net migratory flows	
		Regional Quality of Governance	
		Multimodal accessibility	
		Regional FDI stock	
		Trade-based spillovers	

Source: Authors' elaboration



ESPON 2020 – More information

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