Technological Transformations and Global Value Chains:

Strategic Challenges for Europe and its Territory[1]

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Abstract

Over the past decade, Europe faced multiple challenges that have already caused structural changes in the way regional growth patterns have been taking place. Among many, these challenges include a massive restructuring of Global Value Chains, with a reversal of the process of offshoring production towards the EU, and the pervasive diffusion of Industry 4.0 and digital service economy technological transformations. Both challenges exert effects that are ex ante expected to be intertwined with other driving forces, most notably related to the structural changes associated with the COVID-19 restrictions, and the presently ongoing Russia-Ukraine conflict. Thus, the well-entangled nature of these challenges makes it hard to separate out their net impacts at the local level.

The aim of this this paper is to simulate the net effects of technological transformations and global value chains, and isolate their local effects on GDP growth, thanks to a regional macro-econometric forecasting model, called *MAcroeconometric, Social, Sectoral, Territorial model* in its fifth version (*MASST5*). Results are presented against the backdrop of a reference scenario, modeling both the long-run trends characterizing the EU economy over the past decade, as well as the long-lasting consequences of both COVID-19 restrictions, and the presently ongoing Russia-Ukraine conflict.

Results hint at a remarkable spatial heterogeneity of the impacts of these challenges, both in absolute terms, as well as in terms of regional disparities.

Keywords: Macroeconometric regional growth models, Regional growth, Territorial disparities, Industry 4.0, Digital service economy, Global Value Chains.

JEL classification codes: R11, O18, O47, O52

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ἔσσεται ἦμαρ ὅτ᾽ ἄν ποτ᾽ ὀλώλῃ Ἴλιος ἰρὴ

καὶ Πρίαμος καὶ λαὸς ἐϋμμελίω Πριάμοιο.

(Iliad, book VI, 447-449)

1. Setting the scene

Over the past decade, Europe faced multiple challenges that have already caused structural changes in the way regional growth patterns have been taking place. Among many, these challenges include a massive restructuring of Global Value Chains (henceforth, GVCs), with a partial reversal of the process of offshoring production towards the EU and the pervasive diffusion of Industry 4.0 and digital service economy technological transformations. Both challenges exert effects that are ex ante expected to be intertwined with many driving forces, most notably related to the structural changes associated with the COVID-19 restrictions, and the presently ongoing Russia-Ukraine conflict. Thus, the well-entangled nature of these challenges makes it hard to separate out their net impacts at the local level.

The aim of this this paper is to simulate the net effects of technological transformations and global value chains, and isolate their local effects on GDP growth, thanks to a regional macro-econometric forecasting model, called *MAcroeconometric, Social, Sectoral, Territorial model*, in its fifth version (*MASST5*) (Capello et al., 2024). Results are presented against the backdrop of a reference scenario, modeling both the long-run trends characterizing the EU economy over the past decade, as well as the long-lasting consequences of both COVID-19 restrictions, and the presently ongoing Russia-Ukraine conflict.

To achieve this goal, we simulate the reference -scenario first presented in Capello and Caragliu (2023) with a full-fledged set of assumptions, aiming at capturing all relevant challenges. Next, we run alternative simulations whereby the assumptions related to GVCs and technological transformations are muted. Thus, we will be able to isolate the net impact of each of these two relevant challenges on future regional GDP growth rates. Results will in particular focus on (i.) the spatial distribution of GDP growth differences, and (ii.) the impact of these two simulation exercises on the future development of regional income inequalities. Results of these exercise document a remarkable spatial heterogeneity of the impacts of these challenges, both in absolute terms, as well as in terms of regional disparities.

The paper proceeds as follows. Section 2 briefly summarizes the recent geopolitical challenges whose role in driving regional growth patterns is empirically assessed in this paper. In particular we deal with the Russia-Ukraine conflict (Subsection 2.1); GVCs (Subsection 2.2); and Technological transformations (Subsection 2.3). Next, Section 3 briefly discusses the structure and the way to proceed of the MASST5 model. Section 4 presents the first set of empirical results, first briefly introducing the reference scenario, and then focusing on the spatial distribution of the regional impacts of technological transformations and Global Value Chains for the European case. Section 5 comments on the spatial disparities caused by these two challenges. Lastly, Section 6 concludes and sets out a future research agenda.

2. Geopolitical issues

2.1 The Russia-Ukraine conflict

As this paper is being written, the Russia-Ukraine conflict has been raging for more than a year. On February 24, 2022 Russian troops crossed the borders with Ukraine with the final goal to capture the

capital city of Kiyv and replace the government with figures closer to Russian preferences (Britannica, 2022). Early attempts at replacing the government were rebuffed, and in fact in the summer of 2022 the Ukrainian forces regained a substantial portion of the ground lost to the Russian inveders.

While the final outcome of the conflict still appears rather uncertain, one result that cannot be ignored is its effect on global geopolitical equilibria. Russia had hitherto thrived on its capacity to supply western Countries, mostly in Europe, with cheap energy sources feeding rapid economic development, at the expense of geopolitical uncertainty and indebtedness (Anderson, 2008). As a reaction to Russia's invasion of Ukraine, though, the European Union found new internal cohesion in the decision to levy (to date) ten different packages of sanctions.[4] The extent of the package and the enduring tension between Russia and its allies on the one hand, and the western bloc (including the European Union, the United States, the UK, and Japan and Korea) makes it highly unlikely that things will revert to the pre-conflict equilibrium any time soon (Chepeliev et al., 2022). For the sake of this paper, one aspect that deserves specific attention is related to how the uncertainty engendered by the conflict will eventually end.

In the absence of a clear foresight into how the conflict will eventually be solved, a reference scenario was built (Capello and Caragliu, 2022; Capello et al., 2024) which assumes that the short and medium run consequences of this conflict will remain, and, thus, international equilibria will likely suffer from a prolonged state of uncertainty and geopolitical polarization.

While this state will likely affect multiple economic outcomes, in this paper we will focus on the effects of such a prolonged state of uncertainty on GVCs and technological transformation processes, and, ultimately, on regional GDP growth.

2.2 Global Value Chains

GVCs are a relatively recent phenomenon made possible by the technological progress, allowing to control overstretched production stages with a central control function coordinating far away production sites. Chronologically, this phenomenon is tightly connected with the so called second wave of globalization. This process has been suggested to be affecting countless firms that "*now organize production on a global scale and choose to offshore parts, components, or services to producers in foreign and often distant countries*" (Antràs, 2020, p. 551).

While before the 2007/2008 financial crisis international trade linkages were mostly seen as a univocally positive phenomenon, the fast diffusion of the financial trigger to the crisis through international trade channels, coupled with growing concerns about the global dependence on China's productive plants, caused a partial reversal of the process of offshoring production towards the EU, the US, and, partially, India (Fan and Liu, 2021). This early process of GVCs upgrading was also motivated by an attempt to "move up the value chain", i.e. to gain segments of the production chain associated with higher profit rates (De Marchi and Alford, 2022).

Recently, the geopolitical tensions caused by the Russia-Ukraine conflict, triggered in the first place by Russia's attack on Ukraine, then further strengthened by Russia's retaliations for the western bloc's

[4] These include "*Freezing the assets of 207 entities (including key banks) and 1,473 individuals (primarily Russian officials and elites), to whom travel bans also apply. Imposing debt and equity restrictions on certain banks and companies. Restricting transactions with Russia's central bank and blocking access to its reserve holdings. Banning transactions with certain Russian state-owned military-industrial enterprises. Disconnecting 10 leading Russian financial institutions—including Sberbank, Russia's largest bank—from SWIFT (the world's dominant international financial messaging system). Broadening export controls on dual-use goods and technologies. Banning certain exports in the aviation, maritime, and technology sectors (e.g., semiconductors) and the export of drone engines and luxury goods to Russia*" (US Congress, 2023).

support of Ukraine's war effort (in the form of military supply and training, and financial relief), prompted a second wave of policies aiming at enhancing reshoring and near-shoring processes.

From a European perspective, sanctions implemented in the immediate aftermath of Russia's invasion of Ukraine were targeting several channels of international trade, and cause as much economic damage as possible, with the ultimate goal to nidge Russia into retreating. Among these measures, the ban of the Russian Federation from the SWIFT financial messaging system, and a plan to reduce the EU's dependence on Russian energy sources to zero in the medium to long run (Mellor, 2022; Estrada and Koutronas, 2022). However, any attempt at steering the composition of spatial extent of GVCs through policies may be jeopardized by the sheer complexity of such global structures (Gereffi et al., 2021).

For the aims of the present paper, how intense the effects of these policies is will likely depend on how intense participation in GVCs is, and which industries cause this dependence, in the European regions.

2.3 Technological transformations

A second conceptual bloc of interest for our simulations is related to the growing importance and the pervasive diffusion of technological transformation. This paper interprets as the latter as comprising the diffusion of the Industry 4.0 paradigm for manufacturing activities, and the digital service economy for tertiary ones. While for both these technological paradigm shifts this paper does not provide a novel interpretation, it is here worth briefly mentioning what is being meant.

The term "*Industry 4.0*" has been first used at the Hanover Fair in 2011, and has been subsequently adopted by policy documents by the German Federal Ministry of Education and Research and the German Federal Ministry of Economic Affairs and Energy (Drath and Horch, 2014). Industry 4.0 refers to a complex set of technologies comprising "*modular and efficient manufacturing systems and characterizes scenarios in which products control their own manufacturing process. This is supposed to realize the manufacturing of individual products in a batch size of one while maintaining the economic conditions of mass production*" (Lasi et al., 2014, p. 239).

The "Digital service economy" refers instead to a "*multifaceted phenomenon made of a sprawling range of businesses based on digital platforms and redesigning the boundaries of manufacturing towards services*" (Capello et al., 2023, p. 637). The evolution of the digital service economy is not disconnected by advanced manufacturing, in that by means of digital technologies firms are allowed to sell final products coupled with services with the aim of both better satisfying consumer preferences, while at the same time collecting real time data about their consumption behavior (Porter and Heppelmann 2014).

These two sets of technologies are at the basis of a profound transformation in the way people live, work, entertain themselves and do business. In fact, new business opportunities arise for those firms and activities able to grasp such a transformation. The way in which local actors will be able to take advantage from this technological transformation will shape the local competitiveness of regions.

Worryingly, at the regional level Europe presents a remarkable degree of heterogeneity in the diffusion of these two sets of technologies and the technological transformations they generate. In fact, their spatial diffusion presents rather orthogonal patterns, with Industry 4.0 technologies mostly concentrating in advanced manufacturing areas, while digital service economy industries tend to be more concentrated in major urban areas (Capello and Lenzi, 2021). This means that, once again, as in the case of GVCs, the spatial exposure to policies aiming at steering the diffusion and effectiveness of these industries will be inevitably linked to the initial diffusion of these industries, thereby allowing to identify space-specific impacts.

3. A methodology for assessing the role of technological transformations and Global Value Chains in European regional growth

As anticipated in Section 1, the effects of these mega-trends on regional growth patterns are difficult to isolate – each coming in a well-entangled bowl of feedbacks and loops. However, a macroeconometric regional growth model is exactly the type of tool allowing this exercise. To this aim, we employ the fifth and latest version of the MAcroeconometric, Social, Sectoral, Territorial model (MASST).

The MASST model is a macroeconometric regional growth model built to simulate regional growth in the medium and long-run. The acronym contains the different dimensions – Macroeconomic, Sectoral, Social and Territorial – on which the model is built. While the first version of the model is presented in detail in Capello (2007), the reader is referred to Capello and Caragliu (2021a) for a discussion of the historical evolutions of various versions of the MASST model; to Capello and et al. (2023) for a technical description of the latest version of the model; and, lastly, to Capello and Caragliu (2021b) for a recent application of the MASST model to ex-ante simulate the regional costs of COVID-19 closures.[5]

In the MASST model, regional growth is explained by a combination of national (macroeconomic) and regional (micro-territorial) factors. While the former capture, through a set of Keynesian quasi-identities, the main components of aggregate demand (Consumption, Investment, Public Expenditure, Exports, and Imports), the latter explain regional competitiveness, i.e. the supply side of the economy. In particular, the sectoral, social and territorial aspects taken into consideration to characterize the region are:

- quantified tangible and intangible elements: different assets of territorial capital, especially those with an intangible nature, linked to actors' perceptions, relational elements, and cooperation attitudes;
- territorial complexity: the set of context specificities and synergies that characterize regional growth.

Empirically, the model runs across two stages:

- in the estimation stage, structural relations between explanatory and dependent variables in various national and regional equations are estimated over a long run time span through a set of equations included in the model;
- in the simulation stage, estimated coefficients are employed for simulating likely future growth patterns (usually, over a 15-20 years' horizon), and given an internally coherent sets of assumptions forming regional growth scenarios.

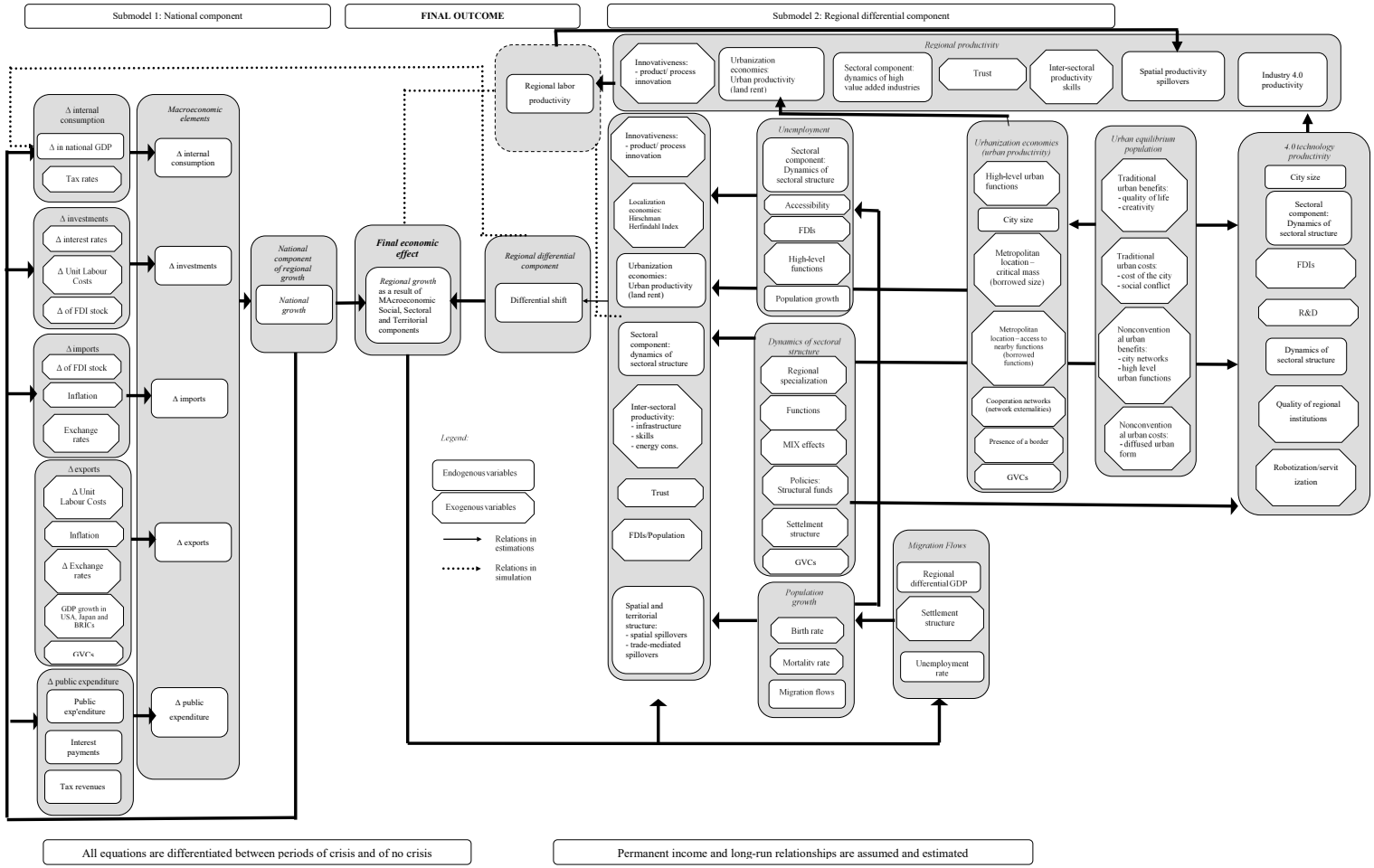
The model merges national and regional growth-enhancing factors by explaining regional growth (ΔY_r) as a decomposition between a national growth rate (ΔY_N) and a regional differential shift (s) (Capello, 2007) (Eq. 1):

$$\Delta Y_r = \Delta Y_N + s;\ r \in N \qquad (1.)$$

Figure 1 shows the logical structure of the model. In Figure 1, all grey-shaded figures represent an estimated equation. MASST5 is based on a panel data set covering the period 1995-2020 for the national sub-model (left-hand side of Figure 1), and a four periods panel data set for the periods 2004-2008;

[5] These simulations are also employed at NUTS3 level for simulating the costs of border closures due to COVID-19 restrictions in Capello et al. (2022).

Figure 1. Logical structure of the MASST5 model



Source: Capello et al. (2024)

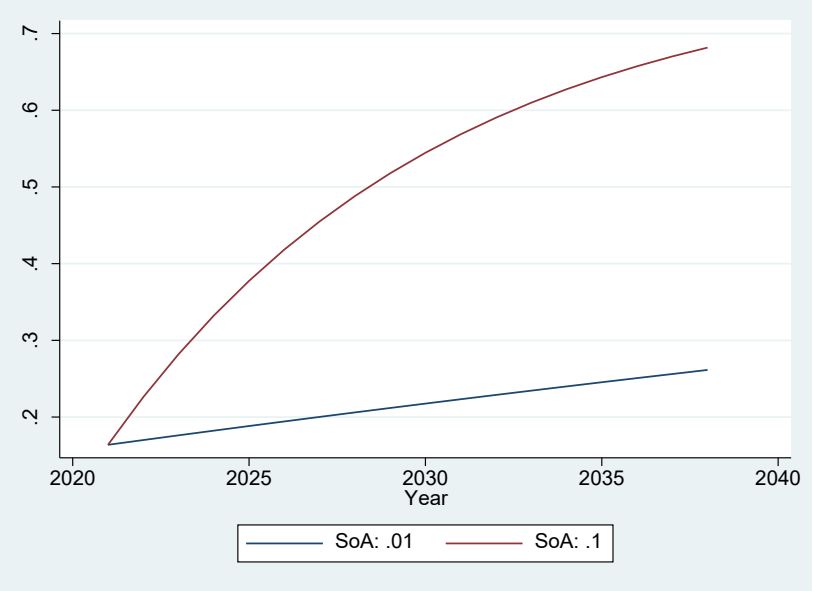
2008-2012; 2012-2016; 2016-2019 for the regional sub-model (right-hand side of Figure 1). Within each grey shape, two types of variables are indicated: rounded-angle shapes represent variables endogenous to the model, while octagon-shaded ones represent variables treated as exogenous. The latter are bound to approach, or reach, a given quantitative target, set by the modeler within an array of conditions that shape a scenario. Scenarios are defined as combinations of internally and logically coherent conditions that allow the modeler to depict a future combination of events, that are not necessarily more likely to take place; rather, they represent possible bifurcations that help identifying the effects of such extreme events.

Exogenous variables are thus treated as levers. Defining a generic target variable x, indexed t for the time period when it is calculated, Eq, (2) shows that a variable approaches its long-run target with a speed proportional to its distance from the target value itself:

$$x_t = x_{t-1} + s(T - x_{t-1}) \qquad (2.)$$

Graphically, Figure 2 shows an example of this mechanism for the Greek NUTS2 region of North Aegean, related to the regional trust vector. The initial value of this variable for the region is equal to 16.875%. The target for this variable for 2038 is set to 78%; the blue line is drawn by setting a speed of adjustment is equal to 1%, while the red line indicates a speed of adjustment equal to 10%.

Figure 2. Example of the target mechanism for the trust vector



Source: Authors' elaboration

In the next section, the MASST5 model is employed to empirically assess the relative impact of GVCs and technological transformations on regional growth rates. In MASST5, average annual real GDP growth is simulated for all NUTS2 regions in the EU27 plus the UK for the period 2021-2038. To achieve goal, we two simulations of the model, in each switching the targets of the modules modeling GVCS and technological transformations, respectively, off. This allows to isolate the *net* impact of each conceptual block of the model.

4. Regional impacts of technological transformations and Global Value Chains

4.1 The reference scenario

As mentioned in the introductory chapter, the aim of the paper is to see how the trends in two specific challenges, namely GVCs reorientation and technological transformations, play a role in a trend scenario where two other main challenges threaten the future of Europe, namely the COVID-19 pandemic and the Ukraine-Russia conflicts.

The aim is achieved in two steps. We first build a reference scenario, an exercise already presented in previous works (Capello and Caragliu, 2023; Capello et al., 2024) and only briefly summarized here, and then we impose that the trends of the two challenges of interest, technological change and GVCs, remain as in the past. The results of these two simulations, representing the originality of the present work, are presented in next two sub-sections.

The reference scenario presents a profoundly transformed Europe, suffering from new threats concerning borders for Europe generated by terroristic attacks, pandemic, war. Europe has to fix new goals for the European budget in health and security, even if it has gained more cohesion and trust among European countries that discovered the strength of solidarity among them in facing the pandemic. This leads to Common European policies, like common asylum systems for migration, the strengthening of the digital common market to overcome the strong digital divide among regions and countries in Europe, assuming therefore a more spatially widespread trend in technological transformations will occur than it is today the case. A reorganization of GVCs towards African countries, especially in the field of energy, after the Ukraine-Russia conflict that generated a drastic increase of energy prices, leading to high inflation. The geographical reorientation of GVCs is assumed to be accompanied by the capacity of Europe to upgrade its position in GVCs, as back-shoring processes in place. High interest rates reflect the uncertainty generated by the conflict on the financial markets.

The assumptions on the technological changes are therefore:

- an increase in the relative regional specialization in high-tech industries, capturing the technology producing sectors;
- an increase in the regional sectoral specialization in technology, carrier, and induced sectors, representing three types of adopting sectors;
- an increase in the intensity of regional robotization in manufacturing sectors, representing the adoption rate of automation;
- an increase in the intensity of regional online sales in service sectors, representing the digitalization of the regions.

For what concerns GVCs, we mainly assume in the reference scenario:

- a decreasing reliance on foreign final demand from extra-EU countries;
- a decreasing trend in backward participation, capturing the capacity of EU countries to position themselves in the GVCs.

These assumptions are included at both national and regional level, the last one with the possibility to select specific sectors (in particular: manufacturing industries; professional, scientific and administrative activities; financial and professional services; and the construction sector).

4.2 Impacts of technological transformations on regional growth in Europe

A first simulation shows the results of freezing the assumption on a more spatially widespread trend in technological transformations w.r.t. today. In operational terms, this means to keep the same trends of the past on the levers of the technological transformations. In particular, no changes are therefore assumed in:

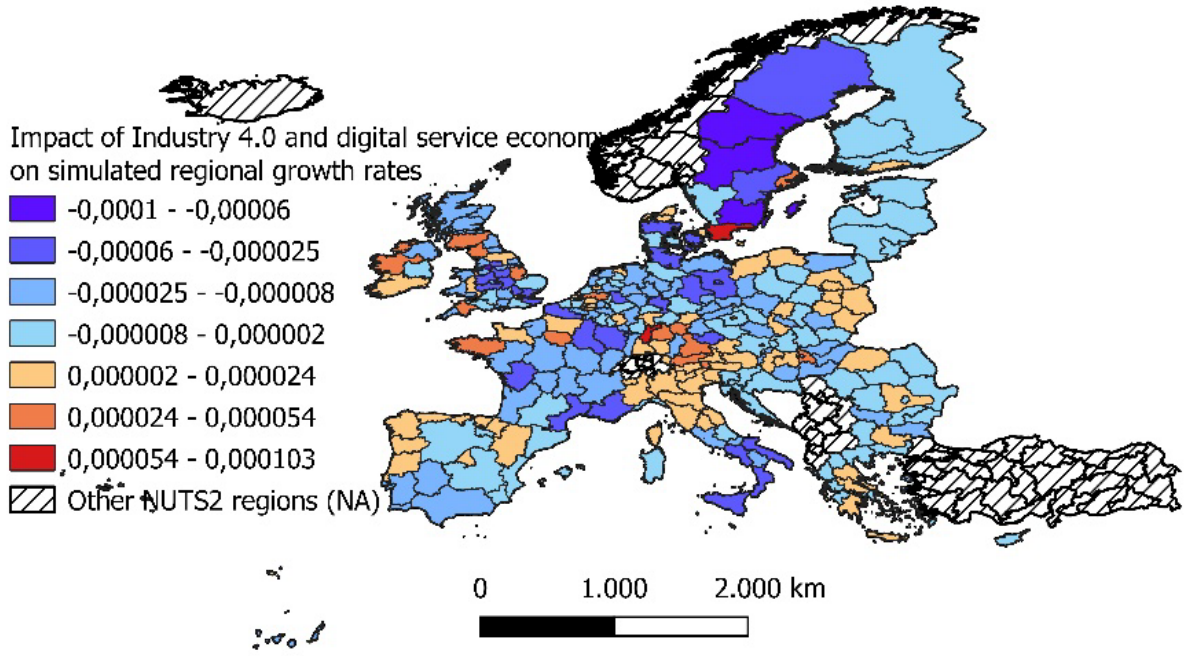
- the relative regional specialization in high-tech industries, capturing the technology producing sectors;
- the regional sectoral specialization in technology, carrier, and induced sectors, representing three types of adopting sectors;
- the intensity of regional robotization in manufacturing sectors, representing the adoption rate of automation;
- the intensity of regional online sales in service sectors, representing the digitalization of the regions.

Figure 3 shows the result of simulating the reference scenario without the above mentioned assumptions. In Figure 3, blue color pales indicate negative differences w.r.t. the standard reference scenario; for these regions, the lack of assumptions on a strengthening of the digital common market to overcome the strong digital divide among regions in Europe penalizes its GDP growth. Red colors indicate instead a situation where a digital common market penalizes the region in terms of GDP growth.

As Figure 3 documents, regions penalized by a widespread digitalization are typicailly high-income ones, which tend to gain from a strong position in the automation and digitalization technologies. These are mostly areas located in the North of Italy, the North of France, in Southern Germany and in Austria. Many urban areas would suffer from a widespread digitalization. This is the case of metro areas as Paris, Madrid, Milan, Munich, Stockholm, and Helsinki.

Regions penalized by not overcoming the digital divide among regions are several; mostly, they are located in remote areas, in both Western and Eastern countries. In other words, the decision not to develop a digital common market would penalize many remote regions in all European countries, both in the West and in the East of Europe. This result suggests the great relevance of a digital common market strategy for decreasing interregional disparities.

Figure 3. Impacts of technological transformation on regional growth rates

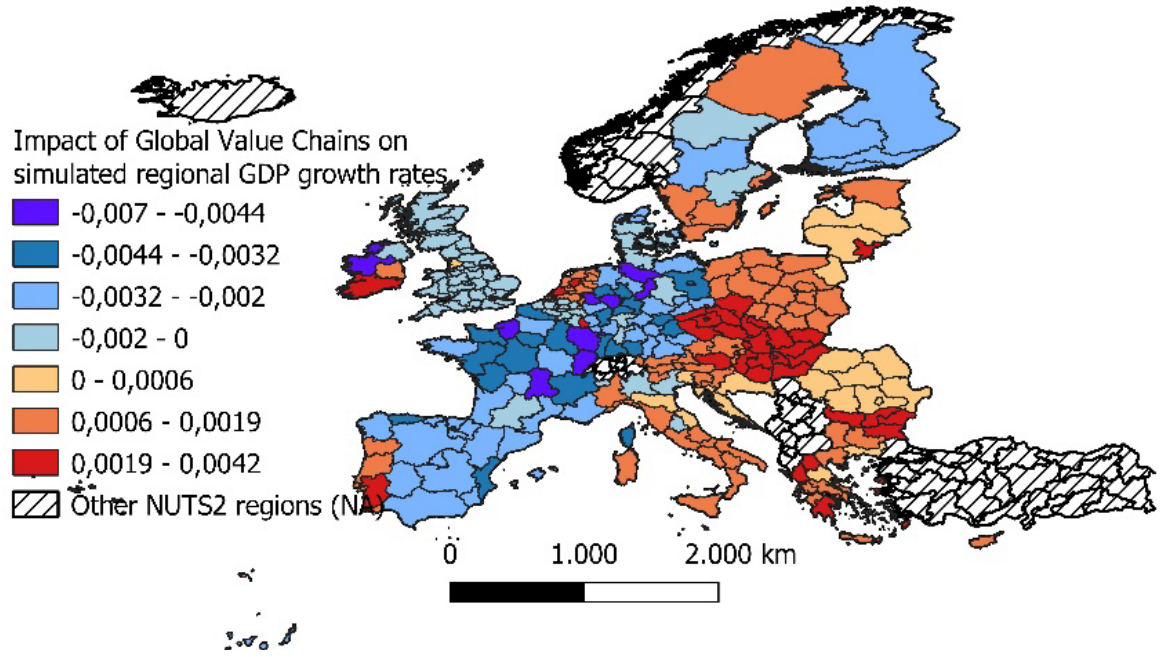


Source: Authors' elaborations

4.3 Impacts of Global Value Chains on regional growth in Europe

Figure 4 provides a conceptually similar picture for the simulation freezing the assumptions on the GVCs. For this specific case, the reorganization of GVCs to nearby countries and the capacity of Europe to upgrade its position in GVCs characterizing the reference scenario have been left as they are today.

Figure 4. Impacts of Global Value Chains on regional growth rates



Source: Authors' elaborations

As in the case of technological transformation, blue colors represent regions that are penalized by the freezing the assumption on decreasing GVCs participation and by the ensuing repositioning, while red regions are those gaining from the absence of these assumptions. Unsurprisingly, the latter are located in Central and Eastern European countries, as they would lose their manufacturing hotspot position of Europe; Ireland, and the Netherlands, that are characterized by a high concentration of financial services; and Swedish regions, where high-tech manufacturing is concentrated. Most Western regions (blue ones in the map) are those that would be penalized by the lack of assumptions on decreasing GVCs participation and by the repositioning. Most these areas are possible destination areas for back-shoring and nearshoring activities, because of their traditional manufacturing specialization, like German and Northern Italian regions (Lombardy and Veneto), and Spanish regions (Catalunia).

In both Figure 3 and Figure 4, a picture of spatial heterogeneity emerges. To address this point, Section 5 will present an additional analysis, by looking at the marginal impact of these two simulations on regional disparities.

5. Impacts of the two challenges on regional disparities

Figure 5 (Panels 1-c) show results of calculating the Theil index (Figure 5.1) and its decomposition into Between Countries (Figure 5.b) and Within Countries (Figure 5.c) Theil indices.

The Theil index can be interpreted as "*the expected information content of the indirect message which transforms the population shares as prior probabilities into the income shares as posterior probabilities*" (Theil, 1967, pp. 125-126).

Empirically, the Theil index is calculated as (Eq. 3):

$$Theil = \frac{1}{N}\sum_{i=1}^{N}\frac{y_i}{\bar{y}}\,ln\left(\frac{y_i}{\bar{y}}\right) \tag{3.}$$

where N is the number of spatial units (NUTS2 regions in our case), y_i is the variable of interest in the i^{th} region (in this case, regional GDP) and $\bar{y}$ is the average regional GDP calculated for all 281 regions in our sample. The index is also amenable to an interesting decomposition, breaking it down into its between Countries component and the within Countries one.

Interestingly, Figure 5.a shows that the two simulations discussed in Section 4 present two rather opposite effects. On the one hand, the absence of a decreasing participation and upgrading position of regions in GVCs leads to a decrease in regional disparities. In fact, the lack of such assumptions are in favor of poorer countries, typically, the manufacturing belt of Europe, and at detriment of rich countries, that gain from back-shoring and functional upgrading of GVCs. This is reflected in the fact that without the assumptions on GVCs the between country disparities increase (Figure 5.b). Instead, as functional upgrading is led by high-productivity metro areas, within country disparities decrease (Figure 5.c).

Figure 5. Total, Between Countries, and Within Countries Theil indices switching GVCs and Industry 4.0 and Digital service economy equations in MASST5

Figure 5.a Total Theil indices

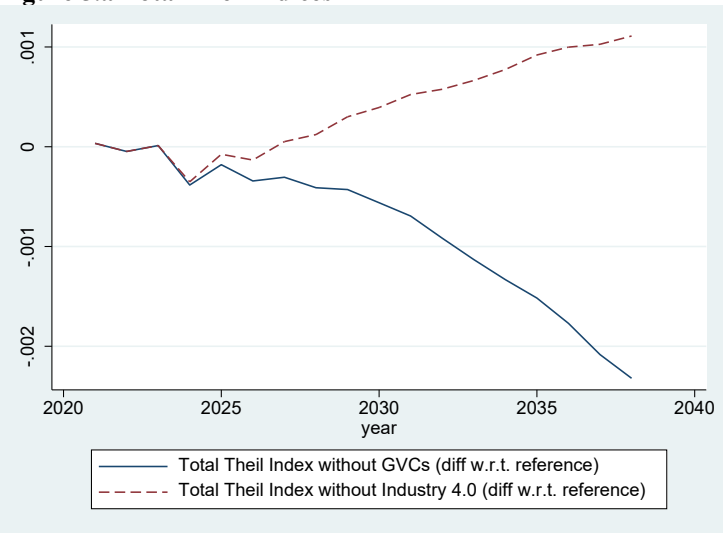


Figure 5.b Between countries Theil indices

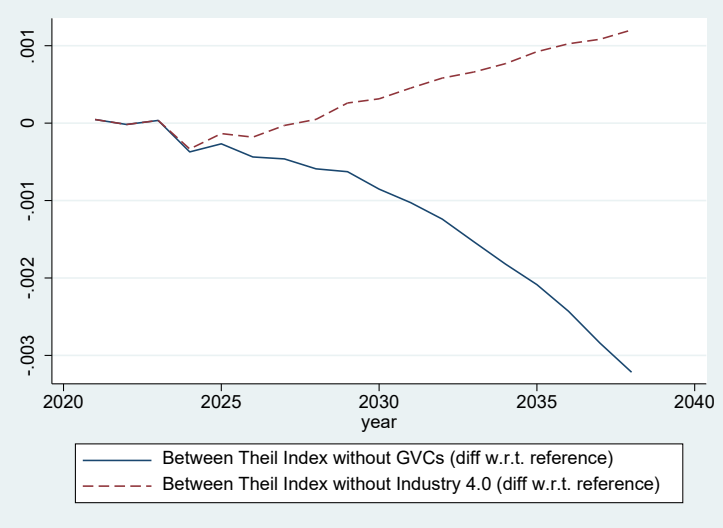
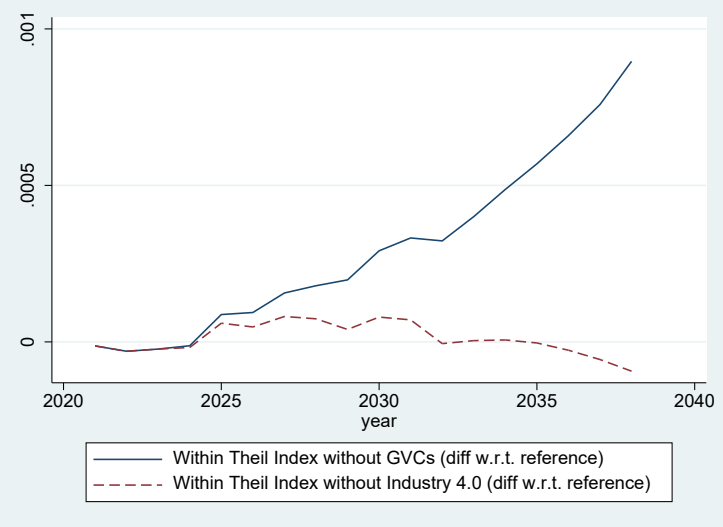


Figure 5.c Within countries Theil indices



Source: Authors' elaborations on the basis of MASST5 model simulations

A completely different story is presented for the case of the technological transformation. In this case, the lack of policies assuring the widespread diffusion of digitalization and automation generates an increase in total regional disparities (Figure 5.a), as it goes at detriment of poor countries. Between country disparities increase (Figure 5.b), while a less clear pattern emerges for within country disparities (Figure 5.c), that tend over the long period to decrease since regions that tend to be penalized by a widespread digitalization are the strong ones, i.e. those that at present gain from being the pioneers of technological transformations.

6. Conclusions and ways forward

This paper employed the MAcroeconometric, Social, Sectoral, Territorial model 5 (MASST5) model to isolate the effects two of the main challenges that Europe is facing and will likely be forced to tackle over the future decades, viz the restructuring of GVCs and the pervasive diffusion of technological transformations (in the form of Industry 4.0 and digital service economy). Results have been obtained by running two alternative simulations against the backdrop of a reference scenario modeling both the long-run trends characterizing the EU economy over the past decade, as well as the long-lasting consequences of both COVID-19 restrictions, and the presently ongoing Russia-Ukraine conflict.

The novelty of this exercise lies in allowing isolating the net impact of the effects of these two challenges that would otherwise be entangled in a complex net of feedbacks and loops that would make it hard to assess their final effect. Doing so provides useful food for thought for drafting educated guesses on the likely consequences of changes in the extent and spatial distribution of these two mechanisms in case the presently ongoing Russia-Ukraine conflict remains unsolved in the medium run.

Policy implications are numerous; here, a couple of them are worth mentioning.

On the front of GVCs, the presently ongoing conflict between Russia and Ukraine, along with the growing trade tensions between two major global players such as USA and China, has already triggered policies aiming at rerouting trade flows towards politically closer trade partners (e.g. Algeria for gas; Matalucci, 2022). While the complexity of GVCs makes it hard to assess the net effect of rerouting trade flows (Gereffi et al., 2021), MASST5 simulations make it possible to look at the aggregate impacts on regional GDP growth, highlighting substantial spatial heterogeneity in their impacts.

On the front of technological transformations, a major effort is needed to assess the spatial distribution of policies aiming at governing the diffusion of digital technologies that are expected to change the world of work for good (Acemoglu and Restrepo, 2020) For instance, recently ChatGPT, the popular chatbot coded by OpenAI broke all previous records in terms of the speed of diffusion and the growth of its users base (Hu, 2023). Anecdotal evidence suggests that a growing number of academic papers and essays are being prepared with more or less intense use of chatbots (Marche, 2022). How this will impact the future of work, and whether the spatial distribution of these impacts will also be affected, will in its turn require sound empirical assessments.

As a future line of research, MASST5 could also be employed to quantify the regional impacts of alternative scenarios, to be compared to the benchmark assumptions modeled for producing the reference scenario, but capturing the overall impacts of multiple assumptions simultaneously taking placing in the European economies. If anything, the past decade taught us that history is proceeding at an accelerated pace, and tools offering results to feed evidence-based policies may help in steering the discussion, and addressing complex challenges in a less blind manner.

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