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Digital transition in a turbulent world: European regional growth opportunities in 17 years' time

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ABSTRACT

Recently, the digital transition has been highlighted as a strategy fostering economic competitiveness. How the advantages from the digital transition will distribute over time and space is still unclear. This paper builds scenarios comparing the effects of a digital transition. Technological assumptions are consistently related to the assumptions on other structural changes. The internal coherence among assumptions is guaranteed by a larger overarching framework based on how the geopolitical context will evolve. A deeper within-EU integration and global cooperation, or a fragmented Europe torn in a world polarized in two blocs, enhance the digital transition and the main structural changes in different ways.

Qualitative assumptions, validated through a Delphi analysis, are translated into quantitative ones and included in our MAcroeconometric, Social, Sectoral, Territorial 5 (MASST5) model, a regional macro-econometric forecasting model, through which simulations of GDP growth rates at regional (NUTS2) level are simulated for the period 2021–2038. Results show that if the digital investment plans stimulate growth, they only partially reverse regional growth divergence trends caused by advantages stemming from an integrated market, even if distributed with the aim of closing the digital gap among European countries.

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1. Introduction

The technological transformations triggered by the digital transition are a pervasive feature of advanced economies. The vast innovations in wide-ranging technological fields, such as artificial intelligence, robotics, internet of things, autonomous vehicles, 3D printing, sensors, nano-technologies, biotechnology, energy storage, just to name a few of them (Brynjolfsson and McAfee 2014; Schwab 2017), transform the ways in which people work and communicate, express, inform and entertain themselves, and, finally, do business. The economy and the society go through profound structural reorganizations, summarized in the literature as Industry 4.0 and the digital service economy (Capello and Lenzi 2021). The former refers to the process of digital automation and robotization in the manufacturing sector, strengthened through the creation of digital value chains to enable inputs from suppliers and customers, and easy exchanges between business partners (Lasi et al. 2014), leading to the development of the so called 'Smart Factory', or 'Manufacturing 4.0', or 'Industry 4.0' (Ciffolilli and Muscio 2018; Müller, Kiel, and Voigt 2018; Santos, Charrua-Santos, and

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Lima 2018; Ślusarczyk 2018). The digital service economy relates to the idea that the full-scale digitalization trend characterizing modern economies and society is redesigning the boundaries between product and services, with the latter not only complementing and/or enriching the former (a phenomenon termed *servitization*) but also, and increasingly so, substituting them. The dematerialization of the product (e.g. a CD) into its own content (e.g. music) allows the last one to be sold online in the form of a digital service (e.g. a subscription to Spotify), destroying the market of the original product in favor of the service (Capello, Lenzi, and Panzera 2023).

The radical transformations inevitably create positive expectations about the outcomes of these changes, coupled with a simultaneous fear of disruption. Greater efficiency and competitiveness are expected to be easily achieved thanks to both technological transformations. The new managerial and organizational styles, and the new business models in which efficiency gains rest on *mass customized* products and in extreme cases of individual products (*batch size one,* as defined by Lasi et al. 2014), and on the integration and orchestration of distant machines along the value chain (Bailey and De Propris 2019) developed through the Industry 4.0 transformation are expected to enhance efficiency. In the same vein, new business opportunities are created by digital markets. By easing the matching of buyers' and sellers' needs, by selling their own services, products and contents competing with those offered by the providers hosted on the platform itself, digital market platforms can generate value added. Along the same lines, producers of the service, goods or contents offered can be manufacturing firms, as well as an owner of a resource with idle capacity, or of spare time, obtaining value from the existence of new digital markets (Capello, Lenzi, and Panzera 2023).

Positive expected outcomes are also accompanied by worries of disruption. Fears about the role of technological change as a factor preventing the creation of new jobs replacing those becoming outdated due to the automation of specific functions and professions are not new (Autor 2015).[1] Examples of workers revolting against job automation include the famed Luddite movement, comprising workers of the textile industry systematically destroying the steam-powered machines displacing their jobs (Curley 2009). In fact, jobless growth prompted Keynes' famous prediction that many would lose their jobs because of technological change '*due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour*' (Keynes 1933, 360).

Disruptive visions of a civilization brought close to a *near workless-world* go hand in hand with the digital transition, this time with worries about the future not only of manual but also of cognitive jobs that can be substituted by artificial intelligence (Brynjolfsson and McAfee 2014; Rifkin 1995 Schwab 2017;), when both (manual and cognitive jobs) are characterized by routinary tasks (Acemoglu and Autor 2011; Autor, 2022).

The final outcome will be the sum of both positive as well as negative effects that emerge from the digital transition and its related technological transformations. Whether this will be positive or negative is difficult to tell in advance. The scientific debate has recently analyzed the spatial breakdown of where technological transformations occur, along with their impact (Capello and Lenzi 2021).[2] However, future outcomes are hard to foresee, although their importance cannot be overestimated, especially with the goal to enact policies offsetting the negative effects that the technological transformations can engender.

With the aim to increase knowledge of the spatio-temporal effects of the recent digital transition on European regional growth, the paper builds scenarios testing the role of digital transition in a turbulent world and comparing the effects of a digital transition happening jointly with other challenges, namely globalization, increased migration, and climate change. This will allow us to assess whether the digital transition effects will be strong enough to counterbalance the effects of other challenges.

For this purpose, we do not focus on one-dimensional scenarios driven only by technological trajectories. Instead, *integrated* scenarios are built, based on different assumptions on the way the different challenges will develop. Within each scenario, technological assumptions have to be consistently related to other structural challenges, like globalization, migration flows and climate change. The internal coherence among assumptions is guaranteed in our scenarios by a larger overarching framework based on the general expectation on how the geopolitical context will evolve.

The first scenario assumes that Europe will develop in harmony, with a deep sense of belonging to a common community, reaching cohesive goals among and within member states, in an integrated world economy. In this case, agreements recently being signed concerning the digital transition will be enacted. These include the *Digital Markets Act* (European Parliament 2022) and the *Digital Services Act* in the EU, following, among many, the US' *Digital Government Strategy* which set for the US government the target to increase the quality of digital services provided by the government to US citizens also by *Streamlining Service Delivery and Improving Customer Service*, and by *Delivering an Efficient, Effective, and Accountable Government*. Along the same lines, in this scenario the *Digital Compass* for the digital transition adopted by the EU in March 2021 will be able to achieve its targets, namely: (i.) 75 per cent of firms using Cloud, Artificial Intelligence and Big Data; (ii.) Grow scale-ups and finance to double EU unicorns; (iii.) More than 90% of Small and Medium Enterprises reaching at least a basic level of digital intensity. The same is assumed for the updated *Industrial Strategy* suggested by the EU in May 2021, that develops three main areas of intervention: (i.) the strengthening of the Digital Market; (ii.) the fostering of EU's open strategic autonomy, to overcome technological and industrial dependency from other countries; (iii.) the acceleration of the twin transition.

The second scenario assumes instead a situation of a fragmented Europe, where national attitudes will prevail in a world polarized in two blocs. In this case, the above mentioned agreements in the field of digital transition will be carried out with a different attitude and different scopes, at the advantage of single countries, and of strong areas within each country, distributing differently growth opportunities and costs of the digital transition.

Our aim is not to identify desirable, positive, ideological or most likely scenarios; rather, quantitative foresights aim at combining in a logical way the alternative trajectories of the digital transition accompanied by other important structural changes in the economies resulting from the bifurcation in the way in which geopolitical conflicts might end. In fact, a crucial precondition for the credibility of quantitative foresights is that assumptions are not endogenous to results.

Qualitative assumptions for the two scenarios, validated through a Delphi analysis, presented in Section 3 are translated into quantitative ones and included in our MAcroeconometric, Social, Sectoral, Territorial model in its fifth version (MASST5), a regional macro-econometric forecasting model, through which simulations of GDP growth rates at regional (NUTS2) level are obtained for the period 2021–2038. Regional inequalities will also be obtained in the case of the two scenarios. These scenarios will be compared to a Reference scenario (Section 2).

2. The reference scenario

Generally, results of alternative scenarios are compared to a trend scenario. Given the recent turbulent economic periods, an extrapolation of recent trends is not useful, since it would simply capture the contingent capacity of European Countries to restore the situation to a pre-COVID condition. Moreover, a trend scenario would not take into consideration the numerous factors that the pandemic has changed, and that will never go back to the pre COVID-19 situation.

Therefore, we build a reference scenario, taking into account the structural changes generated by the COVID-19 pandemic, and that are going to remain in the future. These are documented in Table 1.

First of all, COVID-19 structurally acted on the diffusion and use of digital technologies. Full-fledged stay-at-home measures and the need for social distancing imposed the reorganization of daily activities, accelerating the development and uptake of digital services at an unprecedented pace (DeFilippis et al. 2020; Martin, Hauret, and Fuhrer 2022). The practices of smart working, distant teaching, and online sales have permanently risen, which called for further investment in digitalization. Digital technologies become an integral part of the society, and fundamental for firms' survival (EIB 2022). A vast literature exists on the effects of the diffusion of digital technologies on the choices of consumers and firms to relocate outside the city (Tranos and Ioannides 2020),

Table 1. Qualitative assumptions of the three scenarios.

Scenario assumptions	Reference scenario A profoundly transformed Europe	Scenario 1: An integrated Europe in a cooperation world	Scenario 2: A fragmented Europe in a bipolar world
Geopolitical conditions	New threats for Europe leading to structural changes New threats concerning borders for Europe generated by terroristic attacks, pandemic, war New goals for the European budget: health and security	A restored political equilibrium with Russia US, China and Europe as the main world players in an integrated economy An increase in the world demand relaunching the world economy Decisive implementation of the twin transition in Europe (green and digital policies) European policies in search of efficiency Cohesion as part of the EU goals, not the main one Reintroduction of the Schengen agreement	Formation of two international blocs: formation of political alliances between Russia China and India on the one hand and US and Europe on the other Suspension of the comprehensive agreement on investment between China and EU (signed in March 2020) Limited increase in world real GDP growth due to a division of the global market European safety as the main EU goal Schengen agreement removed
	A more cohesive Europe than in the pre-covid period Higher trust among European countries Common European policies: e.g. common asylum systems for migration	A reinforced cohesive Europe thanks to a new sovereign countries' attitude Stability within the EU leading to common European Union policies on migration and technological development	Uncertainty within the European Union due to different EU countries' attitudes towards the two blocs that affects cohesion and stability within European Union Difficulties in implementing common EU policies in the fields of migration and cohesion
Globalisation	Shorter GVC, especially in technological sectors: higher upstream position of Europe	European geographical re-direction of GVCs towards: • Africa, not only controlled by China but also by European investments; • Near-shoring in Europe: Ukraine, Moldova and Croatia	GVC's reinforcement within the two blocs of countries
Digitalisation	Higher digitalisation with a strong divide among regions and countries in Europe	A digital market in Europe leading to • the overcome of digital divide and of skill gaps; • the achievement of a proactive society to digital technologies: • support to European technologies; • higher European investments in digital technologies • a demand able to exploit such technologies. Implementation of the recommendations of the European digital compass	Europe investing in military digital technologies with the consequence of: • a slow the adoption of 4.0 technologies • a role of follower in 4.0 invention Two specialised areas for the invention and production of 4.0 technologies: China vs. US Digital market postponed Infrastructural and technological skill gaps among European countries due to national digital plans
Migration	Increasing migration from poor countries (Africa), due to worsening of life conditions Increase of migrants distributed in all European countries	A containment of migration flows within and from outside Europe as a result of the 'Implementation of the comprehensive strategy for Africa' and the reconstruction of Ukraine	An increase in migration flows within and from outside Europe as a result of the failure of the 'Implementation of the comprehensive strategy for Africa'
Energy supply	A reorganised energy supply:	Decisive steps towards the Green Deal through renewable technologies. Development of the twin transition	A reorganised energy supply: • from Russia to African countries;

(*Continued*)

Table 1. Continued.

Scenario assumptions	Reference scenario A profoundly transformed Europe	Scenario 1: An integrated Europe in a cooperation world	Scenario 2: A fragmented Europe in a bipolar world
	• from Russia to African countries; • a push of renewable technologies		• a push of renewable technologies
	Green Deal postponed Decisive increase in energy price	Energy price kept under control in all Europe	Energy price increase differentiated among European countries according to their dependence on traditional energy sources
Macroeconomic conditions	High inflation rate due to supply shortage and energy prices High interest rates	Low inflation rate Low interest rates	Low inflation rate: US acting as the main international market for Europe Medium interest rates

ranging from futuristic views on the end of cities and of the role of agglomeration economies (Castells 1991) to conservative views suggesting the strengthening of the role of the city thanks to the possibility of irreplaceable face-to-face contacts (Büchel and Ehrlich 2020). In our reference scenario, these effects are left to the model to be predicted, through its results on growth rates in European regions. In this scenario, investment in digital technologies become a must for the future, and expands in two directions. On the one hand, investment will focus on enabling technologies, i.e. digital infrastructure, at the basis of transformative applications, and to a set of applied technologies allowing the development of new business value creation modes. On the other hand, investment will trigger an increase in digital technology adoption rates both for business and consumers. Technological skills will be reinforced to make individuals and firms capable of reaping the benefits generated by these technologies. However, the present infrastructure and skill gaps among countries, regions, sectors, firms and individuals will persist, partially jeopardizing the advantages that digital technologies will generate. Investment will be mainly devoted to the strengthening of the current situation.

Changes in the rhythm of digitalization trends took place within a framework of deep structural changes affected by COVID-19 (Balduzzi and Faralla 2024), and by the recent international geopolitical disequilibria that need to be taken into account when building a reference scenario based on the combinations of structural changes.

COVID-19 exploded in Europe after a difficult period in which the recovery from the 2008 crisis displayed remarkable contradictions among European countries. Europe entered the COVID-19 pandemic in a fragmented economic situation, due to heterogeneous reactions to the 2008 crisis by European countries: Southern European countries, burdened by low growth rates (Sapir 2020) and by their fragility stemming from high levels of public debt, low productivity growth, and an inability to pursue institutional reforms, a group of Eastern countries catching up with the Western bloc, but at decreasing rates (Grodzicki and Możdżeń 2021), and a relatively fast growing bloc of Countries in the EU's core and Northern part (Storm and Naastepad 2015).

Recurrent shocks, from the 2007/2008 global contraction to the COVID-19 pandemic, caused a number of cracks in the wall of European integration. The rise of populism in some countries, generalized political unrest causing frugal countries urging the adoption of restrictive rules on public debt and a reduction in European budget, against Visegrad countries, in favor of a lesser control on European budget, and cohesion-friendly countries, open to cooperation and integration, were overcome in favor of a common strategy.

This more proactive integration strategy has different roots.[3] For starters, it emerged as a reaction to the rising levels of geopolitical risk. Next, the COVID-19 pandemic also strengthened the feeling

that scattered political action cannot replace the power of joint policymaking. A shared European policy for the acquisition and distribution of vaccines and of rules to contain the pandemic, the launch of the rich and unprecedented (in terms of quality and size) *Next Generation EU* Plan for the recovery, a common management policy of migration flows through a joint asylum system, have filled out the common political agenda of EU27 countries, showing an unprecedented capacity to find political agreement within the EU, with common efforts in strategic areas as health, security, migration and social cohesion. *Next Generation EU* acknowledges the asymmetric nature of the COVID-19 pandemic, which translates into a distribution favoring the hardest-hit countries. Thus, the pandemic and the ensuing economic contraction reinforced a cohesive Europe, following Jean Monnet's statement that '*L'Europe se fera dans les crises et elle sera la somme des solutions apportées à ces crises*' (Monnet 1976, 488).

The increase in trust among European countries found a further source of reinforcement in the 2022 Russia-Ukraine conflict. Europeans were surprised, and enacted a range of measures to protect democratic values and the ability of the 27 member states, in coordination with international partners,[4] to apply unprecedented financial, trade and individual sanctions in favor of Ukraine (Fabry 2022).[5]

At international level, rising China–US tensions emerging during the Trump Administration, through tariffs on imports from China and other main trade partners, including the EU (Lake and Nie 2023), has not changed during Biden's administration. Growing tariffs have consequences for international trade and GVCs (e.g. Cappariello et al. 2020). Within this tense landscape, COVID-19 further highlighted the fragility and vulnerability of the international organization of production. Severe supply security issues emerged. As various key production centres entered lockdown, the shortage of supplies of intermediate and final products highlighted GVC vulnerabilities. This was especially evident in the health industry, with bottlenecks in the provision of personal protection equipment and mechanical ventilators (Gereffi 2020). Supply chain disruptions resulting from COVID-19 had major impacts on national and regional economies, leading to calls for the reshoring of international production structures in order to make GVCs more resilient (Jankowska et al. 2021). Many urged caution, arguing that access to global production was a key factor in enabling governments to cope with the rapidly changing demand linked to the pandemic. However, the argument suggesting that GVCs expose economies to excessive risks in times of crisis, thereby calling for shorter value chains, is still alive (OECD 2021).

3. Alternative scenarios

3.1. Advantages of integrated scenarios

Building scenarios only on the assumptions on the way digital investments would be handled would lead to simplistic results. Building general, integrated scenarios means moving beyond a one-dimensional logic (in our case, the technological rationale), and thinking about a number of plausible assumptions that, summed together, produce a picture of what the future could look like.

The difficulty in building integrated scenarios consists in maintaining an internal logic in their construction. This means that the technological assumptions have to be consistently related to other structural challenges, like globalization, migration flows and climate change. As mentioned in the introductory section, the internal coherence among assumptions is guaranteed in our scenarios by a larger overarching framework based on the general expectation on how the geopolitical context will evolve.

The advantage of integrated scenarios is that we move away from simple technologically driven scenarios. This means that we do not only test the effects of the simple technological trajectories on the future of Europe, but we compare the effects of a digital transition with other sources of changes, thereby identifying whether the former are strong enough to counterbalance the latter. This exercise provides a qualitative measure of the relative importance of the technological phenomenon.

The first scenario we build is called '*An integrated Europe in a cooperation world*'. It assumes that the conflict finds a satisfactory political solution, with both Russia and Ukraine agreeing on a new status quo. The present tensions among the Russia–China–India bloc on the one hand, and the US-Europe on the other hand solved by a world agreement stressing global integration and international cooperation as main pillars. Alternatively, we built a '*A fragmented Europe in a bipolar world*' scenario, based on an incomplete and tense ending to the Russia-Ukraine conflict, with a post-war world split into two main blocs of countries polarizing around their political differences, a situation that politically hinders also the EU.

Within these scenarios, specific assumptions are made on the digital transition. In the case of an increased European integration, it is plausible to expect cohesion to be the main goal of the Union. Within this assumption, funds would be distributed with the aim to overcome the digital gap between countries and regions in Europe. If instead Europe moves towards a fragmentation in its political and social union, funds will be distributed according to national plans, with a bonus for strong regions within each country. Moreover, if Europe acts in a more cooperative world, where trade can exploit scale economies, investment in the digital transition will be higher, since digitalization will become a necessary tool to face global competition. Instead, if Europe is in a situation of a global fragmentation, with two blocs of countries as trade partners, investment in the digital transition will be more limited. Security will be the main goal for the European Union, leaving technological development as a second-tier goal.

The qualitative scenario assumptions are presented in Subsections 3.2 and 3.3, and summarized in Table 1.

3.2. An integrated Europe in a cooperation world

Our first alternative scenario is based on the assumption that a more cooperative attitude in terms of international trade and geopolitical conflicts, including the war between Russia and Ukraine, allows a full return to the pre-crisis political period, reinforced in terms of trust and integration currently threatened by the perceived feeling of a global conflict possibly triggered by local ones. For instance, an agreement between Russia and Ukraine may happen through a Korea-like arrangement with new borders reflecting the outcome of the conflict on mutually accepted grounds. While at the time being this seems unlikely to happen, also in the light of the mutually inflicted wounds (Bell and Wolf 2022), this would pave the way for a renewed climate of easing tension across the global arena.

A more integrated global economy implies that the EU would pay more attention to efficiency goals, also as a result of increased competition (Haufler and Wooton 2010). At the same time, the EU would also focus on cohesion as a relevant goal, if not on top of the agenda. In an integration perspective, the Schengen treaty reverts to full operability, overcoming the present temporary border controls reintroduced because of the Russia-Ukraine conflict (European Commission 2023a).

This scenario is based on a restored political equilibrium with Russia, fostering economic integration, with the US, China and Europe as the main global players, with an increase in world demand (Baldwin and Venables 1995). Prior threats triggered by the Russia-Ukraine conflict also promote cooperation among EU Countries. This would translate into more stability within the EU, allowing joint EU policies, especially in the field of digital transition.

For what concerns the digital market, a cooperative attitude among EU Countries as well as among the main trade partners of the EU allows definitive steps forward in the direction of creating a digital market in Europe, and a technologically integrated Europe. In this scenario, the Digital Common Market would be fully implemented and that the financial resources dedicated for the digital transition will increase. At the same time, the resources will be distributed with the aim to overcome the digital divide and the skill gaps presently characterizing EU territories (Caragliu and Del Bo 2023); stimulating the uptake of digital technologies in the EU society; supporting the production of EU digital technologies, with more robust EU investment; and stimulating internal demand for technological transformation. All this translates into a higher capacity of the EU

economy as a whole to offset the potential negative concentration of digital potentialities, through a more spatially equitable distribution of resources across the whole continent, more intense investment in Europe, and a more proactive attitude on the demand side allowing to overcome the divide in the use of such technologies.

Representing the digital backstone of GVCs, the reinforcement of digitalization in Europe supports the restructuring of GVCs expected to take place in two directions. One is towards reorienting trade towards African partners, and a second one through a process of near-shoring of EU manufacturing towards Ukraine, Moldova and the Balkans.

A more cooperative attitude means also that the EU enacts commonly agreed policies for handling migration flows within and from outside Europe as a result of implementing the '*Comprehensive strategy for Africa*' (EC 2020) and the reconstruction of Ukraine. In the energy field, the full resolution of the Russia-Ukraine conflict allows to keep energy prices at moderate levels, halting the upward trend taking place over the past couple of years. Lastly, from a macroeconomic perspective, the general stability produced by integration and cooperation allows to enjoy low inflation and interest rates, with easier access to risk capital for all EU firms.

3.3. A fragmented Europe in a bipolar world

The Russia-Ukraine conflict may also be solved with the formation of two international blocs, one with closer institutional and diplomatic arrangements with Russia, China, and India, the other characterized by strong ties among the US, the EU, the UK, Japan, and Korea. This solution implies a permanent suspension of the comprehensive agreement on investment between China and EU (signed in March 2020).

In Europe, a new political separation into two main blocs calls for security strongly on the agenda of the EU, which invests in it. This leaves cohesion as a second order policy target. Within this context, the Schengen treaty, currently partially and temporarily suspended in several EU Countries, is abandoned.

The tense political situation imposes investing in military and digital technologies, with two main consequences: (i.) a slowdown in the adoption of 4.0 technologies all over the continent, and (ii.) the confinement of the EU to the role of follower in 4.0 technology invention. This causes the further strengthening of two main global competitors in the activity of inventing and producing 4.0 technologies, i.e. China and the US. In this scenario, the digital market would also be postponed (European Commission 2023b), leaving room for national digital plans, and for a fragmented Europe in a bipolar world. Therefore, this scenario formalizes a less effective reaction to digitalization, as the failure to adopt a common digital agenda leaves individual EU Countries deal with exogenous technological change in a scattered manner, without reaching the scale economies linked to the full exploitation of the common market, and with insufficient funding to generate more unicorns as mandated by the Digital Compass.

This scenario is characterized by higher levels of uncertainty. In Europe, differences in the attitudes of EU countries towards the two blocs affect the internal cohesion and stability of the EU. Generalized lack of trust and nationalistic attitudes make it more difficult to implement common EU policies in the fields of migration and cohesion and enact structural reforms.

From an international trade perspective, the consequence of fragmentation is polarization of GVCs within the two blocs of countries. For the EU, this means a polarization within the continent, with a weakening of extra-EU ties across all industries, and in particular a strengthening of the ties between the EU and the US for electronics and health w.r.t. China and a weakening of the ties in terms of energy imports w.r.t. Russia, partially replaced by African partners.

A less cooperative global context is associated with less stable macroeconomic conditions. On the one hand, interest rates resume their pre-COVID trend towards moderate levels, due to the role played by the US as the main international market for EU products. On the other hand, interest rates are not as low as in the case of the reference scenario, due to the persistent feeling of relative

lack of cooperation between the main global players, and the consequent imperfect recovery of global FDIs.

Incomplete global cooperation translates into increased migration within and from outside Europe. Within the EU, the lack of cooperation causes the failed implementation of the '*Comprehensive strategy with Africa*' (European Commission 2020), recently set up to handle and optimize the massive flows of migrants induced by conflicts in the South-Saharan and Middle East regions (European Commission 2020). Along similar lines, a polarized world with two global superpowers implies a substantial reorganization of the structure of energy supply. For the EU, this means a shift from imports of energy from Russia to African partners, while at the same time pushing forward the transition to renewables. In practical terms, impacts are the same for all Countries in the continent. In fact, energy price increases are arguably differentiated among EU countries according to their dependence on traditional energy sources.

4. Results at aggregate and country level

The qualitative assumptions have been validated by experts through a Delphi analysis (see Appendix A.5), translated into quantitative ones (Appendix A.4) and included as levers in our macro-econometric regional growth model (MASST), which provides an annual average real GDP growth rate for the three scenarios for the period 2021–2038. In interpreting these results, it is important to stress that MASST does not provide forecasts.[6] Rather, MASST depicts the tendencies and relative behavioral paths of real GDP growth at the regional level under specific conditions, i.e. possible states of the world characterized by an exogenously assumed context. In this sense, MASST5 does not produce precise estimates of future GDP levels, but rather their main tendencies, based on the assumptions about the driving forces (Capello et al., 2008). The outcome of the MASST model has been termed '*Quantitative foresight*' (Camagni and Capello 2012).

Table 2 shows aggregate results for both the reference scenario as well as for the two alternative scenarios, for the following variables: (i.) annual average real GDP growth rates; (ii.) annual average employment growth rates; (iii.) annual average manufacturing employment growth rates; (iv.) annual average service employment growth rates. Results for the two alternative scenarios are presented as a difference w.r.t. reference scenario.

In the reference scenario, a first significant result suggests a substantial medium and long-run rebound from the COVID-19 induced contraction for the whole Europe. The digital investments, together with the other structural changes characterizing our reference scenario, lead to an

Table 2. Results at EU level for the three scenarios.

Scenario	Annual average real GDP growth rate	Annual average employment growth rate	Annual average manufacturing employment growth rate	Annual average service employment growth rate	Regional aggregate with geographical areas	CEECs w.r.t. Old15
Reference	2.78	−2.24	−6.65	−1.14	EU 28	0.23
	2.92	−2.28	−6.43	−1.19	EU 27 (w/o UK)	
	2.76	−1.95	−7.32	−0.86	Old15	
	2.99	−4.42	−4.39	−3.92	CEECs	
Integrated	0.68	−0.39	−0.67	−0.31	EU 28	0.14
Europe in a	0.65	−0.54	−0.68	−0.47	EU 27 (w/o UK)	
cooperation	0.67	−0.30	−0.71	−0.22	Old15	
world	0.81	−1.33	−0.58	−1.56	CEECs	
A fragmented	0.03	−2.40	−1.57	−2.43	EU 28	0.23
Europe in a	0.01	−2.51	−1.53	−2.58	EU 27 (w/o UK)	
bipolar world	0.01	−2.36	−1.63	−2.37	Old15	
	0.24	−2.79	−1.42	−3.27	CEECs	

Source: Authors' elaboration on the basis of MASST5 simulations.

Note: *the annual average growth is between 2021 and 2038. 'Integrated Europe in a cooperation world' and 'Fragmented Europe in a bipolar world' scenarios shown as percentage point difference w.r.t. reference scenario.*

expansionary trend (around 2.7 per cent) in real GDP growth rates, for the EU27 plus UK in the seventeen years period. Excluding the UK from this result, growth rates are slightly higher for the EU27 (2.9 per cent), suggesting that the model foresees a slight underperformance of this Country with respect to the rest of Europe.

A second important finding for the reference scenario is associated with the slowdown of the convergence process. In fact, while CEECs keep a faster pace w.r.t. Old15 Countries, the difference (equal to 0.23 per cent) is much smaller than over the two decades around the two largest accession waves (2004 and 2007). The growth rate of Old15 Countries is in fact basically equal to the EU27, suggesting that the absolute relevance of Western economies remains unabated over the simulation period. Among other reasons, holding the relative gap in the digital transition constant, as assumed in this scenario, among countries does not support convergence between Western Europe and CEECs.

A third relevant point is related to the strengthening of the current productivity growth, at the expense of a decrease in aggregate employment, mostly driven by a substantial contraction of manufacturing employment. Among other reasons, this result depends on the technological transformations occurring in this scenario. Industry 4.0 acts on manufacturing employment by inducing job cuts, while the digital service economy is not as negatively affected in terms of job losses. Both results are in line with the results of the EU Reference Scenario 2020, currently used by the EU as baseline simulations for assessing a different filed, i.e. the policy initiatives in the *European Green Deal* package launched by the European Commission in July 2021.

Moving to the two alternative scenarios, we obtain rather different results. On the one hand, '*An integrated Europe in a cooperation world*' is the most expansionary scenario. Higher investment in the digital transition triggered by stronger competition in an integrated world, jointly with more integrated global value chains and by scale economies associated with global integration, exert their positive effects. Both traditional blocs of the EU economy grow faster in this scenario. However, CEECs gain more, thereby leading to an increase in the wedge between EU14 and CEECs (+0.14 per cent w.r.t the reference scenario). This result suggests that large investment in digital transition distributed everywhere, with the aim to overcome the existing gaps in the use of these technologies, are not enough to offset the growth advantages accruing to strong areas and countries, which causes the diverging behavior we observe.

A '*Fragmented Europe in a bipolar* world' scenario is, unexpectedly, moderately more expansive w.r.t. the reference scenario, providing a first general important message that an imperfect solution to a geopolitical conflict is conducive to better outcomes than one where uncertainty prevails. Real GDP growth rates are in fact higher. The digital investment, assumed to be higher than in the reference scenario, is distributed mainly to strong regions. Divergence trends are more contained, suggesting that digital investment is not sufficient to offset other centripetal market forces.

Much like in the reference scenario, displacement effects are particularly strong in the manufacturing sector, due to an increase in labor productivity. In fact, in both scenarios, growth is mostly productivity-driven. Population ageing will likely cause a shrinking in the size of the EU workforce, thus making it impossible to achieve aggregate productivity growth without a substantial contribution of technological change.

Table 3 documents the results for the average annual real GDP growth rates in the reference, and in the two alternative scenarios at country level. A mosaic of interesting results emerges. In the reference scenario, growth is driven mostly by the economic performance of France and Germany among EU's largest economies, with quite some smaller countries also benefitting from a substantial rebound from the COVID-19 contraction (Cyprus, Estonia, Ireland, Malta, and Slovakia). In France and Germany the digital transition is already developed, and the additional digital investments add towards the direction of robust growth of the two countries.

Against this backdrop, the '*Integrated Europe in a cooperation world*' scenario presents a rather different picture, in that in a more integrated framework both high- and low-income countries would benefit. This result can also be due to the distribution of digital investment aiming at closing the digital gap among countries and regions. Within this scenario, some countries gain

Table 3. Annual average real GDP growth in the Reference, 'Integrated Europe in a cooperation world', and 'Fragmented Europe in a bipolar world' scenarios at Country level.

Countries	Annual average real GDP growth in the reference scenario	Annual average real GDP growth in the 'Integrated Europe in a cooperation world' scenario	Annual average real GDP growth in the 'Fragmented Europe in a bipolar world' scenario
Austria	1.02%	1.00%	0.24%
Belgium	1.64%	0.58%	−0.08%
Bulgaria	2.41%	0.97%	0.19%
Cyprus	3.72%	0.99%	0.22%
Czech Republic	2.53%	0.87%	0.32%
Germany	3.55%	0.60%	−0.16%
Denmark	1.92%	0.59%	−0.06%
Estonia	3.62%	0.83%	0.29%
Greece	1.84%	0.96%	0.30%
Spain	2.31%	0.59%	−0.09%
Finland	1.45%	0.59%	−0.06%
France	3.56%	0.56%	−0.17%
Croatia	2.91%	1.01%	0.24%
Hungary	3.10%	0.90%	0.26%
Ireland	3.90%	0.89%	0.21%
Italy	1.52%	1.03%	0.24%
Lithuania	3.26%	0.96%	0.18%
Luxembourg	2.39%	0.55%	−0.10%
Latvia	3.03%	0.97%	0.19%
Malta	4.53%	0.89%	0.27%
Netherlands	1.60%	0.98%	0.19%
Poland	3.55%	0.93%	0.28%
Portugal	2.49%	0.94%	0.27%
Romania	1.01%	0.94%	0.30%
Sweden	0.71%	1.02%	0.26%
Slovenia	2.90%	0.99%	0.22%
Slovakia	3.81%	0.96%	0.17%
UK	1.64%	1.01%	0.19%

Source*: Authors' elaboration on the basis of MASST5 simulations.*
Note*: 'Integrated Europe in a cooperation world' and 'Fragmented Europe in a bipolar world' scenarios shown as percentage point difference w.r.t. reference scenar*io.

more substantially, especially those located in the manufacturing hotspots of Europe (*Factory Europe*; Behar and Freund 2011), while those same countries are mostly affected by a '*Fragmented Europe in a bipolar world*' scenario.

Despite European average growth rates being slightly higher in the '*Fragmented Europe in a bipolar world*' scenario w.r.t. the reference one, some countries are actually expected to achieve slower growth rates (Belgium, Germany, Denmark, Spain, Finland, France, and Luxembourg). This suggests that only by fully solving with a mutually satisfying solution the complex set of geopolitical issues that are causing a wedge among global growth poles, EU27 growth will eventually take off.

5. Results at regional level

Results at regional level for the average annual real GDP growth rate for the simulation period are illustrated with maps in Figures 1–3. Across all maps, positive growth rates (in absolute terms for the reference scenario, in relative terms in the alternative scenarios) are shown with increasingly darker red colors; negative (or less positive) growth rates are represented with increasingly darker blue colors.

Figure 1 shows that in the reference scenario a new geography of economic growth in Europe would take place, with a strong concentration of economic performance in the central belt of Europe, cutting across France and Germany in the EU14, and reaching to Poland, the Baltic states, and Croatia in the CEECs area. This means that the structural changes caused by COVID-19 pandemic

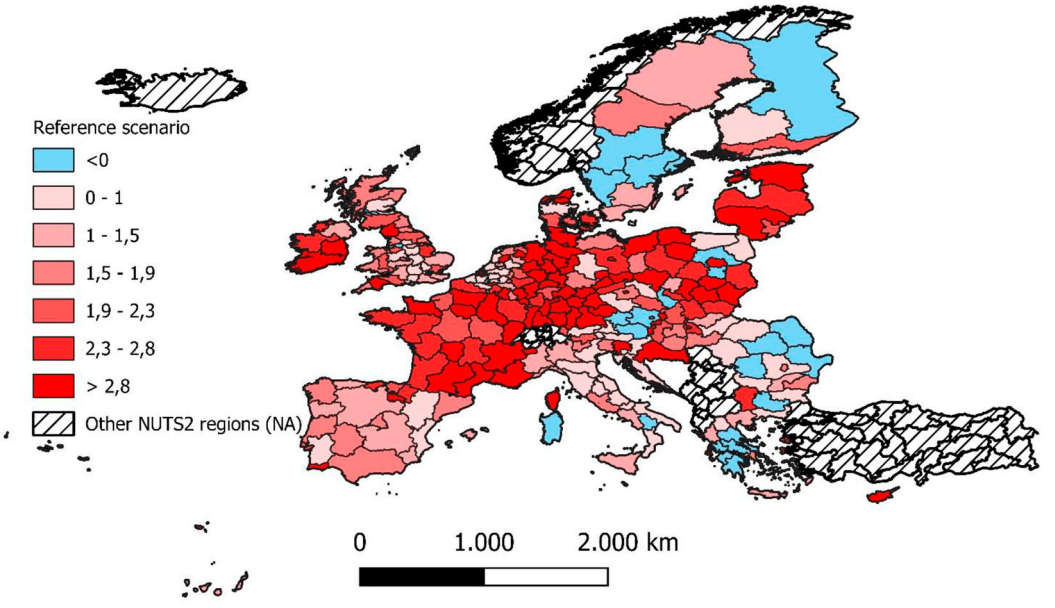


Figure 1. Annual average real GDP growth in the Reference scenario. *Source: Authors' elaboration on the basis of MASST5 simulations*.

generate a rather substantial reversal of the usual East–West wedge, at the expense of regions located in the geographical periphery of Europe (Countries in the South and North of the EU). As in the case of the country level, the assumption on the digital investments distributed keeping the same digital gap leads to an expansionary trend especially in the richest regions. These reap in fact more advantages from the technological upgrading.

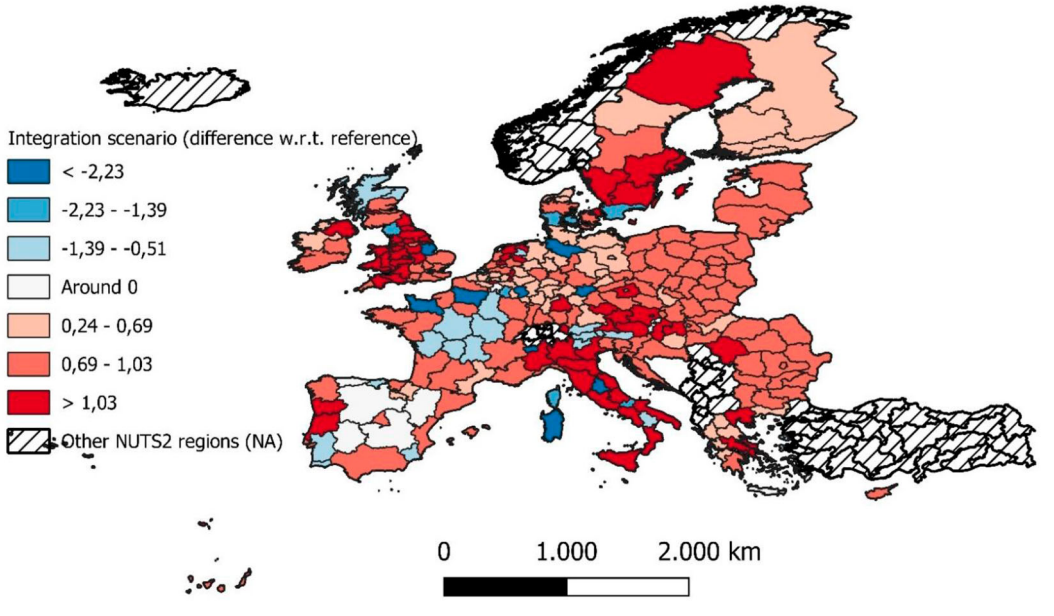


Figure 2. Annual average real GDP growth in the 'Integrated Europe in a cooperation world' scenario. *Source: Authors' elaboration on the basis of MASST5 simulations. Note: % difference w.r.t. reference scena*rio.

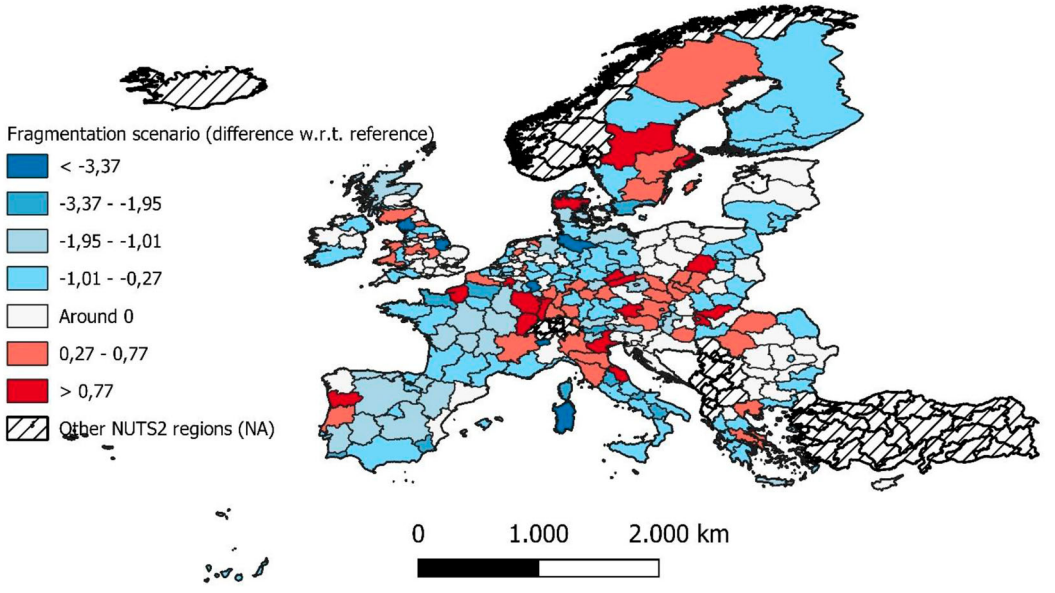


Figure 3. Annual average real GDP growth in the 'Fragmented Europe in a bipolar world' scenario. *Source: Authors' elaboration on the basis of MASST5 simulations. Note: % difference w.r.t. reference scenario.*

In a '*Integrated Europe in a cooperation world*' (Figure 2), a relevant role in the rather expansionary and spatially diffused positive real GDP growth rates is played by both digitalization processes and the restructuring of GVCs. As for the former, a widespread diffusion of robotization and digital service processes will trigger faster regional productivity growth. As for the latter, higher global integration also means a structurally stronger network of trade across global superpowers. In this scenario, developing regions grow more than in the reference, too, as found in Capello and Dellisanti (2024). This positive trend is also the outcome of the distribution of financial resources for the digital transition, favoring the decrease in the geographical digital gap characterizing Europe.

In a *'A fragmented Europe in a bipolar world'*, Figure 3 shows that only some strong areas in Germany (manufacturing) and Italy (Po plane), along with some more peripheral regions, would gain w.r.t. the reference scenario. The prevailing color is blue: most regions would grow less than in the reference scenario. Some high-income areas would actually register lower growth because of the more limited size of the market w.r.t. the reference scenario, but most of the fast-.growing areas in this scenario are high-income ones, also benefitting from digital investment, which, in this scenario, would be higher and distributed centripetally (i.e. favoring national champions). Europe will in any case gain by being linked through trade networks to the Western bloc (including the US, Japan, and South Korea, all expected to experience faster growth rates than in the reference scenario). The geography of growth in '*A fragmented Europe in a bipolar world*' scenario shows that peripheral areas in Spain and Italy actually grow substantially less. On the other hand, Scandinavian Countries actually gain more than in the reference, as the result of being the European market for primary resources (natural gas and oil).

The distributive effects of the digital investments are particularly embedded in the last set of results regarding the regional inequalities that are formed between European countries, and within them among their regions. They are calculated with the Theil index,[7] and results of this exercise are shown in Figure 4. Figure 4.a shows that in the reference scenario an increase of total disparities is generated in the aftermath of the COVID-19 restrictions, driven mostly by within-Country disparities, but with a flattening of overall disparities in the medium and long run (Capello and Caragliu 2021).

Some counterintuitive results emerge. Despite the social cohesion goal of the '*Integrated Europe in a cooperation world*' scenario, this scenario is characterized by higher regional inequalities than the reference. The general high cohesion among EU countries, leading to a slower increase of between country disparities (Figure 4.b), is not enough to compensate for the increase in within-Country disparities (Figure 4.c). Large investment in digital transition distributed to overcome the existing gaps in the use of these technologies does not suffice to offset growth opportunities created by an integrated world market, thereby strengthening regional divergence trends.

Contrary to expectations, '*A fragmented Europe in a bipolar world*' scenario shows a lower regional disparity level than in the reference scenario. This positive trend towards higher cohesion is the result of both between and within country disparities. While the between country disparities' less steep growth persists over time (Figure 4.b), a lower increase of within-country disparities tend to attenuate over time, probably as the result of concentration on national champions as a result of a nationalistic attitude.

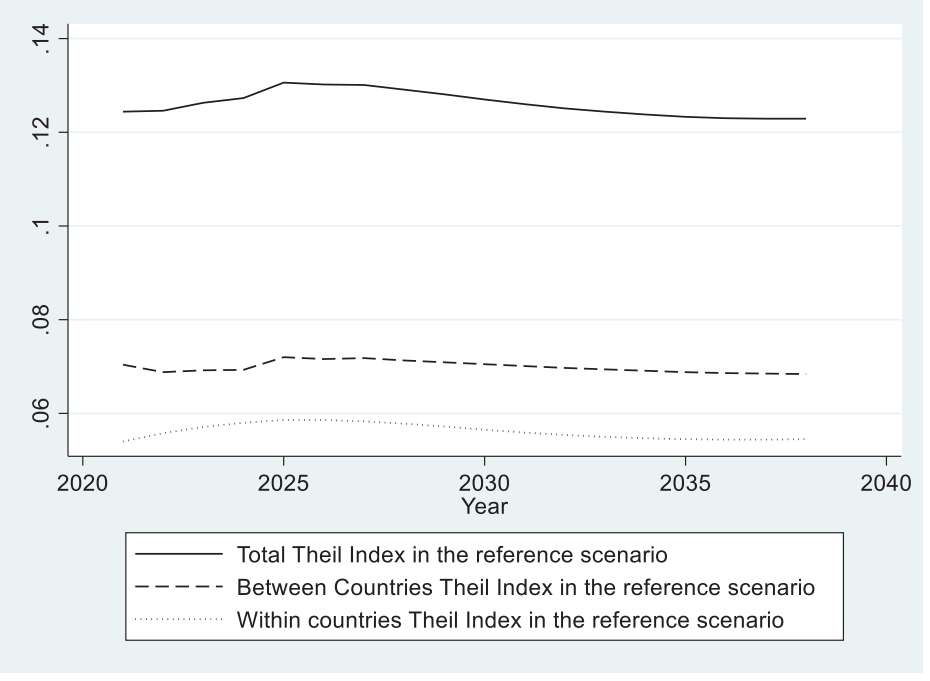
6. Conclusions and policy implications

Europe is at the verge of major bifurcations in the way digital transformations will be implemented and its positive and negative effects will be managed. While individual, market-specific assessments of the likely impacts of these bifurcations are slowly emerging, the literature is missing an integrated assessment exercise that measures the effects of the digital transformation together with other simultaneous structural changes. At the same time, the evidence collected on individual shocks so far has been mostly focusing on ex-post appraisals, while the changing nature of technological transformations calls for ex-ante assessments of the likely territorial impacts of the ways these trends will evolve in the medium run.

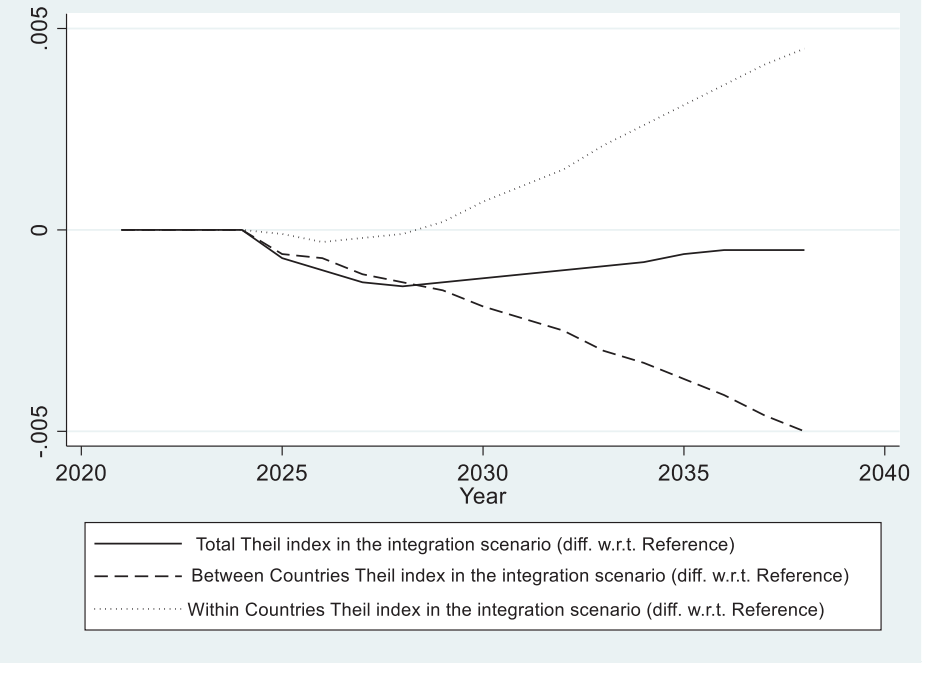
This paper fills these gaps and simulates the consequences of alternative ways in which digital investments would be handled linking the technological assumptions to a larger overarching framework whose internal consistency and logic is given by the general assumptions on how the geopolitical context will evolve. An integrated Europe in a global world, or a fragmented Europe torn in a world polarized in two blocs, can support the digital transition and its geographical distribution differently. The qualitative assumptions, validated through a Delphi analysis, are translated into quantitative ones and included in our MAcroeconometric, Social, Sectoral, Territorial model in its fifth version (MASST5).

Our results suggest that a reference scenario, characterized by an imperfect solution to present geopolitical conflicts, is substantially less expansionary that any other solution. But what is especially relevant in our results is that if the digital investment plans come out as a lever of growth, they only partially reverse divergence trends caused by advantages stemming from an integrated market. In fact, in the scenario of an integrated Europe, economic growth is still relatively more intense than the reference scenario, also thanks to large digital investments. However, even if these funds are distributed to take into consideration the overcoming of the digital gap, economic growth is achieved with a lower increase in regional disparities with respect to the reference scenario. Market forces characterizing an integrated world economy are so strong that they cannot be offset by financial support to technological change provided with a spatially even pattern.

From a policy perspective, our results suggest that the bifurcations in the development patterns modeled by our scenarios call for policy measures aiming to handle the substantial unequal effects caused by the ways out of the currently ongoing conflicts. Either solution would in fact come with a cost. In the case of an integrated Europe, this scenario would be generally more expansionary, even if some economically weaker regions would actually be negatively affected by furthering economic cooperation. In the case of the '*Fragmented Europe in a bipolar world*' scenario, the costs would be rather more spatially dispersed, and many more areas would face the negative impact of an imperfect solution to geopolitical issues.

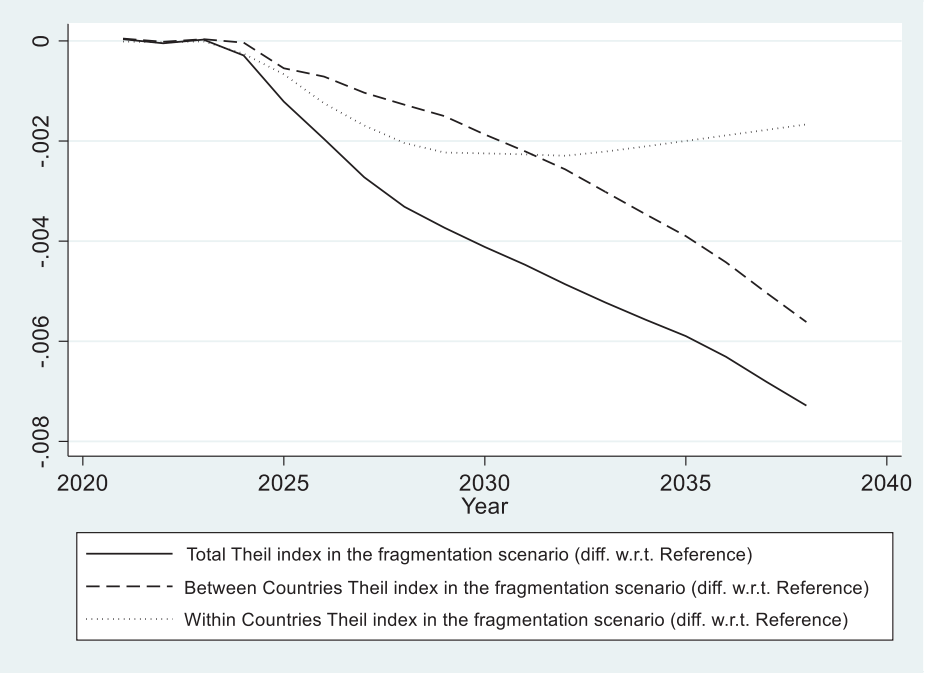


a. Between Countries, Within Countries, and total Theil indices for the reference scenario



b. Between Countries, Within Countries, and total Theil indices for the "Integrated Europe in a cooperation world" scenario as % difference w.r.t. reference scenario

Figure 4. Theil indices for the reference scenario (a). Theil indices for the 'Integrated Europe in a cooperative world' (b), and the 'Fragmented Europe in a bipolar world' (c) scenarios as a percentage difference w.r.t. the reference scenario.



c. Between Countries, Within Countries, and total Theil indices for the "Fragmented Europe in a bipolar world" scenario as % difference w.r.t. reference scenario

Figure 4 *Continued*

The digitalization transition generates growth opportunities. This means that policies to make regions climb the digital ladder have to be enacted by the EU. However, policies must be designed taking into consideration a more general framework, which highlights the relevance of various levers and mega-trends characterizing the way the world is going to evolve over the next couple of decades.

Notes

1. Before the First Industrial Revolution, peasants would be happy when each year's harvest would match the previous year's (Braudel 1953); in fact, Angus Maddison's project's long-run backcasts of aggregate productivity growth (Bolt and van Zanden 2020) for France, Italy, and United Kingdom (the three Countries with the longest time coverage) suggest that labor productivity growth was basically flat until the late Middle Age. In fact, only with the First Industrial Revolution did Europe enter a period of faster technological change. See Technical Appendix A1 for a more extensive discussion of Maddison-style estimates for this sample.
2. Empirical evidence about the extent of job losses induced by technological transformation and job automation is mostly microeconomic. For instance, Dinlersoz and Wolf (2024) show that more automated establishments are characterized by a shift from the labor share towards the capital share. At the same time, they also show that less workers active in production receive higher wages. Along the same lines, Cette, Nevoux, and Py (2022), using a different perimeter for the definition of technological change taking place in firms, document that using big data causes a loss in the labor share of about 2.5 per cent.
3. The Reference scenario shares with the alternative ones a common assumption about Brexit and the impact of populism. As MASST5 simulations start from 2021, the decision of the UK to give up EU membership, effective Feb. 1, 2020, is incorporated in the MASST5 simulations, and, hence, has no differential effects on the alternative scenarios. However, we do find that the decision of the UK to leave the EU is expected to engender negative effects for UK regions, as discussed in Section 5. We decide not to simulate further similar decisions in alternative simulations, but we do take into account populist attitudes in the '*A fragmented Europe in a bipolar world*', through the levers described in this and the next section.

4. A recent special issue on *Regional Science, Policy & Practice* (Pascariu, Holovko-Havrysheva, and Krayevska 2023) collects some of the earliest findings from a regional perspective. For the sake of our own simulations, the work by Haddad et al. (2023) proves to be particularly relevant, because the Input-Output exercise presented is methodologically closest to a full-fledged macroeconometric simulation. Their results suggest that simulating the potential removal of some Ukrainian territories from the within-Country trade system may have negative effects that span beyond the region itself, precisely through the Input-Output relations. While offering convincing evidence about the losses due to the conflict, this work does not extend the simulation beyond Ukrainian borders.
5. At the micro level, evidence on the partial success of sanctions on Russian imports is provided in Kohl, van den Berg, and Franssen (2024). In their work, 2014 sanctions are found to have a negative impact on the intensive margin of exports for the universe of Dutch firms analyzed. All in all, the evidence on the effect of sanctions appears blurred, and specific only to some of the products and industries affected, as evidenced in the review presented in Korhonen, Simola, and Solanko (2018), based again on the 2014 sanctions wave.
6. On this point, and for a discussion of the structure of the MASST5 model, see Capello, Caragliu, and Dellisanti (2024), and the synthetic presentation in Technical Appendix A.2.
7. The Theil index is calculated with the following formula:

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

where N is the number of regions, 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 regis. Interestingly, this index can be decomposed into the international (between Countries) and the interregional (within Countries) component, which allows to source the determinants of EU-wide disparities.

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