

Complexity and FDI in market-dependent economies: The hidden effect of industrial offshoring

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ABSTRACT

This study examines the complexity in the Eastern European economies, with a focus on the role of foreign direct investment (FDI). Despite transitioning to market economies, these countries remain economically fragile and dependent. Their lower technological complexity and reliance on foreign capacity make them vulnerable. However, some countries like Austria and Poland demonstrate successful integration of production and innovation. The analysis shows FDI has a limited impact on developing complex knowledge but contributes positively to economic complexity. Results also indicate that in the long-term, economic and technological complexity does not lead to accelerated total factor productivity growth, contrary to complexity literature. Combining labour with innovation, safeguarding local industries, and prioritizing education and research are more effective approaches. The study clearly shows how Hungary is stuck in an “assembler trap.” It also finds that the gap between economic and technological complexity negatively affects liberal democracies.

KEYWORDS

economic complexity, foreign direct investment, knowledge, dependent economies, productivity, Eastern Europe

JEL CLASSIFICATION INDICES

L20, F36, F43, L16

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1. INTRODUCTION

Over the past 30 years, the Eastern European countries have attempted transition from a socialist economy to a market economy (capitalism). Under capitalism, countries were motivated by the opportunities for innovation, entrepreneurial dynamism, and growth that a market economy could provide (Kornai 2013). Marketization and privatization were seen as the main methods of transition to a developed market economy (Ncanywa et al. 2021). However, the intense marketization of the economy in countries without established market institutions has led to a dependent market economy type characterized by dispersed shareholders or different forms of finance (Nölke – Vliegenthart 2009). This issue may also explain the patterns of innovation in the Eastern European countries. László Palkovics (2022), then the Hungarian Minister of Technology and Industry, stated that the country ranked among the top 10 in terms of production complexity and high-tech exports. Previous research also showed that while Hungary ranked higher in the Economic Complexity Index (ECI) than the United States and the V4 (Visegrad) countries;¹ and Slovenia is in the top 20 in the ranking, it performs poorly in terms of global competitiveness (Ivanova – Cepel 2018). This raises questions about the specific products and underlying capabilities of these countries (Hausmann et al. 2013). Therefore, in this paper we investigate whether the economic complexity paradigm fits well in the Central Eastern European (CEE) context.

The complexity and diversity of a country's exports is an accurate indicator of the level of knowledge and expertise available in the economy. Regardless of the level of growth, complexity was also found to have a negative effect on inequality (Hartmann et al. 2017; Lee – Vu 2020) and a positive effect on CO₂ emissions (Can – Gozgor 2017). The discrepancy between a country's economic complexity and its global competitiveness, innovation and technological capacity for some Eastern European countries indicates that the output of these economies is not being transformed and distributed into benefits, wealth, and shared gains for the entire population of these countries. It is likely that this points to a problem of resource allocation. While we are in the process of understanding these symptoms, countries may be shifting from liberal democracies to autocracies, desperately trying to reduce the gap between wealthy, exploitative corporations and ordinary people, or increasing wage inequality (Diamond 2008; Ibarra-Olivo – Rodríguez-Pose 2022). As market economies drive countries mostly toward profitable industries and places, they leave behind many places, groups of people and potential undiscovered opportunities (Rodríguez-Pose 2018). This suggests a failure of markets in Eastern Europe and a shift of certain countries from liberal democracies to conservative governments. Moreover, slow economic growth, the rise of populist movements expressing dissatisfaction with economic development in these countries, and the inability to compete with domestic know-how in Industry 4.0, lead us to focus on these countries through the prism of the complexity paradigm.

The recent development of economic nationalism and national industrial policies has been observed in some countries (Juhász et al. 2023). The importance of national industrial capabilities is now greater than ever. The reliance on foreign direct investment (FDI) and foreign knowledge places countries at a disadvantage, particularly if they lack robust national industrial capabilities or serve as offshore hubs. Our research critiques the *knowledge spillover theory of*

¹Czech Republic, Hungary, Poland and Slovakia



FDI, integrating it with complexity theories to create a framework that highlights risks for countries lagging in economic evolution. We challenge the universally positive view of globalization, noting its adverse effects on dependent, outsourcing and labour-exporting nations. This study provides a detailed analysis of the interaction between economic and knowledge complexities, innovation, FDI and growth, moving beyond simple advocacy for privatization and marketization.

Mealy and Teytelboym (2022) suggested that nations with a high ECI have export baskets that are similar to those of other nations in similar circumstances and both export technologically advanced products. However, is it possible that countries with a high ECI do not necessarily have the necessary technological capabilities? Existing theory suggests that this should not be possible. Because innovation is carried out by multinational corporations through their hierarchical coordination mechanisms and financing methods (Nölke – Vliegenthart 2009).

The novelty of this study lies in its exclusive focus on the Central Eastern European (CEE) countries. It departs from conventional perspectives that prematurely labelled these countries as having completed their transition to market economies. The study argues that, contrary to conventional wisdom, these countries, with the exception of Austria and Poland, continue to struggle with economic fragility and dependency. It calls for critical reflection on the sustainability of their economic growth and challenges common assumptions about the alignment of economic and technological capabilities. Pioneering the concept of the “assembler trap,” the study underscores the dangers of *over-reliance on foreign capital and technology*.

We examine the export structure and innovation capabilities of the CEE countries and their neighbours and assess whether economically complex countries do indeed possess higher levels of technological capabilities (technological complexity) for the period between 1995 and 2019, and how this complexity gap may lead to a decline in liberal democracy in these countries. The long-term perspective provides a clear picture of post-socialist dynamics and recent complexity dynamics in these countries. Throughout the study, we focused primarily on the Eastern European countries of the Czech Republic, Romania, Croatia, Slovenia, Hungary, Slovakia, Poland and Bulgaria, while Austria served as a comparator, because Austria is perceived by many as a country that moved away from its state-influenced market economy towards a market-oriented economy.

2. LITERATURE REVIEW

2.1. The transition to the market economy and the weakening of local capabilities

The accession of the CEE countries to the EU was intended to facilitate their transition to market economies and promote income convergence with Western Europe. Despite the warnings of Krugman (1991) that convergence in development levels between the periphery and the core rarely occurs, attempts to artificially create cohesion have only led to further asymmetries in development and disparities within countries (Geppert – Stephan 2008).

The term Dependent Market Economy (DME) characterizes the “successful” capitalist model in the Central European Countries (Hungary, Poland, Czech Republic and Slovak Republic). The interplay of complementarities of institutions (e.g. quality cheap labour and FDI) leads to comparative advantages in the production of complex goods such as automobiles and electronics (Nölke – Vliegenthart 2009). However, the sustainability and consistency of DME’s success



varied. It was contingent upon the political context of these nations, as dramatized by the economic polarization in Hungary (Scheiring 2021). In addition, it increased the dependence on FDI and multinational corporations (MNCs), which can limit the development of local knowledge capabilities (Piech – Radosevic 2006; Vlčková – Sass 2019). This is due to the free flow of capital, where international capital was looking for opportunities, not research in CEE (Gal – Lux 2022). While these foreign companies provided many well-paying jobs, they often crowded out local firms thus contributing to deindustrialization in the host country (Rodrik 2016). The main method of financing business in these CEE countries became FDI, which favoured and supported the foreign companies rather than the local ones. Even the major banks in Hungary, for example, were, for a while, predominantly foreign (not any more).

Related to Krugman's (1991) core-periphery assumptions, labour moved to the regions with higher wages. All these weakened local manufacturing and deindustrialized the CEE countries even in the industries they had previously mastered. However, a country's success depends on how well its domestic industries perform in international trade, sometimes at the expense of other countries. It is therefore in the interest of developed countries to keep the emerging countries and industries at a certain level of growth (Gomory – Baumol 2000).

Although many developing countries have a high share of employment in manufacturing, including high-tech manufacturing, their dependence on FDI has reduced their knowledge and industrial capacity, resulting in deindustrialization (Rodrik 2016). This translated into modest growth rates, with GDP growth in the V4 averaging 2.8% over the past 30 years, with Hungary having the lowest (2%), while the share of FDI in GDP increased dramatically (Gal – Schmidt 2017). The dynamics of market integration benefited the advanced western regions more than the less developed CEE members (Kallioras – Petrakos 2010). Sustainable growth requires a balance between FDI and strategic development of local knowledge capabilities, rather than specialization in the MNC-dominated industries. It can be concluded that Eastern European countries rely mostly on foreign knowledge while production is done by MNCs, therefore there will be a significant difference between the scores of the Technological Complexity Index (TCI) and the Economic Complexity Index (ECI) in these countries. At the moment, they are most in need of local knowledge for the absorption of specialized, complex technologies (Cohen – Levinthal 1990).

Some multinational enterprises (MNEs) maintain low operational costs through cheap labour and outdated machinery, inhibiting technological advancement and effective production methods (Pagés 2010). This model is evident in the Visegrad Group, where foreign investments primarily boost export sectors (Bohle – Greskovits 2012). Additionally, the separation between intellectual activities (R&D) and physical work (manufacturing) hinders growth. However, integrating education with production and leveraging new machinery can drive industrial development and diversification, as evidenced in the strategies recommended by Colquhoun (2005) and further supported by Foray (2014).

Éltető et al. (2022) observed a duality of the FDI-dependent CEE countries, where domestic firms barely develop technological capabilities, including the use of Industry 4.0, while MNCs are far ahead in the development and adoption of superior capabilities, casting doubt on knowledge spillover claims. While providing employment, MNCs in the CEE countries often used foreign knowledge to crowd out domestic firms and value chains. This dependence constrained entrepreneurial discovery, a key process for innovation. EU policies also promoted specialized industries, contradicting the principles of economic complexity that value the



diversification of relevant knowledge (Foray 2014). The EU's smart specialization (S3) strategy aims to identify niche areas for growth based on existing capabilities. However, its effectiveness depends on governance, entrepreneurship and industrial diversity (Morgan 2015).

Hypothesis 1: In the Eastern European countries there is a significant discrepancy between the scores of economic complexity and technological complexity (production capabilities and innovation capabilities).

2.2. Economic complexity

The diversity and sophistication of a country's exports are indicators of its potential future production capabilities. Hidalgo and Hausmann (2009) noted that the interaction among increasing numbers of economic activities is associated with national wealth and development. In the developed nations, widespread knowledge diffusion contributes to significant accumulations of creative knowledge. Economic complexity is generally linked to lower income inequality, as a greater variety of complex products can enhance income growth across populations (Hartmann et al. 2017; Ncanywa et al. 2021). However, this relationship can vary based on the factors like governance quality and contextual variables (Bandeira et al. 2021), and it may also exacerbate disparities among the labour groups.

Globalization greatly affects the way production activities are carried out, especially in developing countries. Due to increasing interconnectivity and growth of MNCs, many of the production activities are now overseen by MNCs or their subsidiaries. In most cases, the production activities are carried out through the FDI model (Wilhelms – Witter 1998). It can be observed that the so-called “exploiting” or “assembling” countries, as they are called, export high-level manufacturing that is not accompanied by local technological capabilities. In comparison, the developed countries have the largest share of technological capabilities (Schteingart 2015). Recently, it has been observed that FDI positively influences the complexity of the export basket, which later influences the diversification of services exports and economic growth (Gnangnon 2022; Osinubi – Ajide 2022). However, some studies claim that FDI can also be a double-edged sword, i.e., it can help to enter new markets, but it can also only use the resources of existing markets and focus only on existing products and not on advancing science (Tian et al. 2015). While Szalavetz and Sass (2023) pointed out that the good performance of innovative peripheral regions lies in the capabilities of local firms, domestically owned highly innovative firms, and cooperation with universities, this situation is not the case in Hungary, for example, where firms are dependent on foreign technology, capital and governance. Although regional GDP growth in Hungary is driven by manufacturing, there's no synergy between FDI and the innovation system (Lengyel – Leydesdorff 2015). Moreover, other studies claim that the effect of FDI on productivity is not necessarily significant, suggesting that the spillover effects of FDI claimed in the literature may not exist (Fan et al. 2022).

Hypothesis 2a: FDI has a positive and significant effect on economic complexity.

Hypothesis 2b: FDI has an insignificant effect on the level of technological complexity.



2.3. Technological complexity

One way to determine whether a country has the knowledge to produce certain products is to examine its invention activity in the form of patents. A common misconception is that research measures knowledge in terms of inputs rather than outputs, and that what matters is the quality of the knowledge created. Balland and Rigby (2017) propose a framework for measuring knowledge complexity based on the number of patents a country produces in different categories. A complex system consists of many interdependent elements that interact in complex ways (Frenken 2006). Information for innovation arises from the recombination of existing ideas and from local discovery. However, knowledge subsets created in one region tend to be difficult to replicate elsewhere (Schumpeter 1934; Balland – Rigby 2017). Tacit knowledge plays a critical role in the emergence and evolution of technologies, especially those that are more unique and complex, and this points to the importance of knowledge location, as this type of knowledge is often sticky to space. Competitiveness is determined by the extent to which firms can expand their knowledge domains and use more knowledge components, but this has not been measured by existing frameworks (Balland et al. 2019). Similar to economic complexity, excessive specialization in complex technologies can lead to lock-in and monopolistic rents for existing firms, as it makes it more difficult for other firms to acquire the ability to dominate these technologies. Another disadvantage of complex knowledge is that there is little spillover of such knowledge, and the type of knowledge that is often diffused among local actors is that derived from moderately complex technologies (Sorenson et al. 2006). The production of complex products requires vast amounts of knowledge that can only be accumulated through large networks of experts.

Hypothesis 3a: Technological complexity has a positive significant effect on total factor productivity (technological efficiency).

Hypothesis 3b: Economic complexity has a negative significant effect on total factor productivity (technological efficiency).

2.4. Entrepreneurial ecosystems and complexity

Specialization in certain complex technologies can lead to unhealthy market dominance of one product over another, resulting in inefficient market dynamics based on increasing returns and lock-in, market choices, and their equilibrium effects, while increasing returns create conditions in which a single firm or a small group of firms can dominate a market (Durlauf 1998). Countries with high levels of technological complexity tend to have higher numbers of high-growth and large firms. This is attributed to decreasing cost of production with higher level of output and the presence of non-competitive market conditions that favour the establishment of high-capacity production entities.

The complexity thesis is similar to the ecosystem concept in entrepreneurship (Consoli – Patrucco 2011). Observing the interactions between actors is also an important aspect of the evolution of the system. The improvement of the entrepreneurial climate should serve as a background or an ex-ante condition for the choice of industries for growth and development paths. To understand the characteristics of the entrepreneurship ecosystems (EE), researchers tend to focus on a specific case, location or cluster. What is needed is a multilevel and multiscale



research approach that looks at the linkages between factors in an EE from a spatial dimension (Alvedalen – Boschma 2017).

The Entrepreneurial Discovery Process, a concept from entrepreneurship research, is expected to bring new business and economic opportunities. This can be strengthened by relationships between research centres, universities, government, firms and regional institutions (Mariussen et al. 2020). The EE measures the impact of these actors and reintegrates the entrepreneur into knowledge and innovation systems and networks, making them essential for a country's growth. The quality of EEs can bring a new innovation policy approach by increasing scale and openness to create a critical mass of entrepreneurship and innovation capabilities. Collaboration with ecosystem actors can add new capabilities and knowledge enabling lean transformation and innovation to solve complex, integrated problems beyond simple production (Meyer – Williamson 2020).

We can see, for example, in Figure 1 in the Annex that Poland is leading in the indicators of product innovation and start-up skills, while Hungary has one of the weakest ecosystems compared to the other countries in the V4. Even though Hungary overtakes Poland in terms of internationalization, this is only due to the export and globalization aspect of its economy. Moreover, we can observe that Poland has higher than all the human capital indicators. We can argue that Poland is the best using its human capital, while not being extremely connected to the globalized economy and much of the effort remains within the country, resulting in a much more embedded economy. But such embeddedness is not easy to implement and MNCs see it more as an obligation to be embedded. Moreover, because the foreign capital has a short exploitation span in the host country, then looking for other places it has no motivation and opportunity to be embedded, therefore it cannot contribute to sustainable growth (Lee et al. 2009).

3. METHODOLOGY OF OUR RESEARCH

3.1. Economic and technological complexity

We seek to measure both the economic complexity and the technological complexity of each country under study in order to gain an understanding of the activities and capabilities. Economic complexity index (ECI) is measured using the United Nations Statistical Division's COMTRADE database, calculated on the export pattern of a country. A detailed classification of goods has been made according to the Harmonized System (known as HS 1992). When analysing the exports, not only the volume of exports is evaluated, but also the complexity of the products. A country's Revealed Comparative Advantage (RCA) is calculated by comparing its share of global exports for a given product to its global share. An increase in the share shows that a country has a comparative advantage in that product. A high RCA indicates that a country exports a variety of complex products, which presents a more complex economy. This is because more sophisticated goods often require advanced technological and industrial capabilities to produce and export. This element of the analysis consists of a matrix in which the first dimension corresponds to the countries and the second dimension corresponds to the value of the exported products. Country product networks are operationalized using a $n \times m$ affiliation matrix $M = (M_{c,i})$, where $M_{c,i}$ indicates whether the country c has RCA in the export of certain class of products i ($c = 1, \dots, n; i = 1, \dots, m$) and $RCA_{c,i}^t = 1$, if:



$$\frac{\text{products}_{c,i}^t / \sum_i \text{products}_{c,i}^t}{\sum_c \text{products}_{c,i} / \sum_c \sum_i \text{products}_{c,i}^t} \geq 1$$

We calculate the technological complexity based on the data provided by “OECD.Stat”. In this case, we do not have product classes exported, but rather specific patent classes. The time period of the analysis is 1995–2019. In the same way as RCA calculation, a country c will have RTA (Revealed Technological Advantage) in technology “ i ” if the share of technology in its technological portfolio exceeds the share of technology i in the entire patent portfolio of the world. In this case RTA is based on patent and $A_{c,i}^t = 1$, if:

$$\frac{\text{patents}_{c,i}^t / \sum_i \text{patents}_{c,i}^t}{\sum_c \text{patents}_{c,i} / \sum_c \sum_i \text{patents}_{c,i}^t} \geq 1$$

In a similar manner to Balland et al. (2019), the TCI sequentially combines two variables: the diversity of countries and the ubiquity of technological classes (in the case of technological complexity) or products (in the case of economic complexity). According to these two variables, both groups of nodes in a country’s technological network have a two-mode degree of centrality. A country’s degree of centrality ($T_{c,0}$) can be measured by the number of technological classes in which it has RTA (diversity):

$$\text{DIVERSITY} = T_{c,0} = \sum_i M_{c,i}$$

where $M_{c,i}$ was previously discussed. Similarly, to the country degree of centrality, the degree centrality of a technological class ($T_{i,0}$) can be determined by counting the number of countries that exhibit RTA in that particular class (ubiquity):

$$\text{UBIQUITY} = T_{i,0} = \sum_c M_{c,i}$$

Using these measures of diversity and ubiquity sequentially, we can determine measures of both technological complexity and economic complexity for countries over a series of n iterations, where (P) is the product group:

$$TCI_{\text{countries}} = T_{c,n} = \frac{1}{T_{c,0}} \sum_i M_{c,i} T_{i,n-1}$$

$$ECI_{\text{countries}} = P_{i,n} = \frac{1}{P_{i,0}} \sum_i M_{c,i} P_{c,n-1}$$

3.2. The entrepreneurial ecosystem

To measure the evolution of the entrepreneurial ecosystem we employ the previously discussed penalty for the bottleneck function. The data between 2006–2019 was extracted from the Global Entrepreneurship and Development Institute (The GEDI Institute). The Global



Entrepreneurship Index (GEI) is a widely recognized measurement of how well a country supports the entrepreneurship processes. The index is composed of 14 pillars that are also composed of smaller indicators regarding people's attitudes, skills and ambitions for entrepreneurship, and indicators related to the local environment for entrepreneurship. The index calculation methodology is the Penalty for Bottleneck (PFB) methodology created by [Acs et al. \(2011\)](#). This methodology is distinct from the others in that it makes the premise that the system's operation is contingent on the system's weakest component or variable.

3.3. Total factor productivity

Total factor productivity (TFP) growth, or raw TFP is based on growth rates of capital stocks and labour inputs in terms of hours worked, these are provided over the period of 1996–2019 by the EU KLEMS, an industry level, growth and productivity research project. To calculate TFP they considered only growth of capital stocks (K) and hours worked (H) as the decomposition that is given in:

$$\Delta \ln Y = \Delta \ln TFP_0 + s^-_C \Delta \ln K + s^-_L \Delta \ln H$$

where the growth rate of TFP is calculated as a residual ([Stehrer – Sabouniha 2023](#)). The TFP data was extracted for the period between 1996 and 2019, in sync of the complexity indicators also calculated for the same period. However, that is not the case for the GEI measurement, which covers the time interval of 2006–2019, resulting in a disparity in the number of observations between the models. However, this disparity is not expected to affect the results of the analysis. The TFP data is provided for 23 countries in Europe.²

3.4. Descriptive statistics and model specification

We used an unbalanced fixed effects model to account for unobserved heterogeneity at the country level, which is important in panel data analysis. We applied min-max normalization between 1 and 100 for the TCI, ECI and GEI variables to ensure they were on a comparable scale. Logarithmic transformations were applied to the FDI, GDP and population variables to deal with skewed distributions and stabilize the variance. The model specification includes country and year fixed effects to increase robustness to the omitted variable bias by capturing unobservable factors constant across countries or over time.

All the models analysed have a specific form of fixed effects model, similar to the one below, with slight modifications in the independent variables and control variables:

$$TFP_{it} = \beta_0 + \beta_1 TCI_{it} + \alpha_i + \gamma_t + \varepsilon_{it}$$

where:

- i denotes the country,
- t denotes the time period,
- TFP_{it} is the Total Factor Productivity for country i at time t ,

²The sample countries for the TFP model are: Austria, Denmark, Ireland, Portugal, Belgium, Spain, Italy, France, Netherlands, Sweden, Germany, Romania, Bulgaria, Estonia, Lithuania, Slovakia, Cyprus, Finland, Latvia, Slovenia, Czechia, Hungary and Poland.



- TCI_{it} is the normalized TCI for country i at time t ,
- α_i represents country fixed effects,
- γ_t represents time fixed effects, and
- ε_{it} is the error term.

4. RESULTS

The purpose of this study is to assess the level of economic and technological complexity in the Eastern European countries and to examine the impact of FDI on economic complexity and its subsequent effect on TFP. The results of the study were as expected, particularly the fact that there has been little effort to improve the technological capabilities of the Eastern European nations.

The study paid special attention to the Hungarian economic model. Figure 1 illustrates that the CEE countries have experienced significant growth in their normalized economic complexity

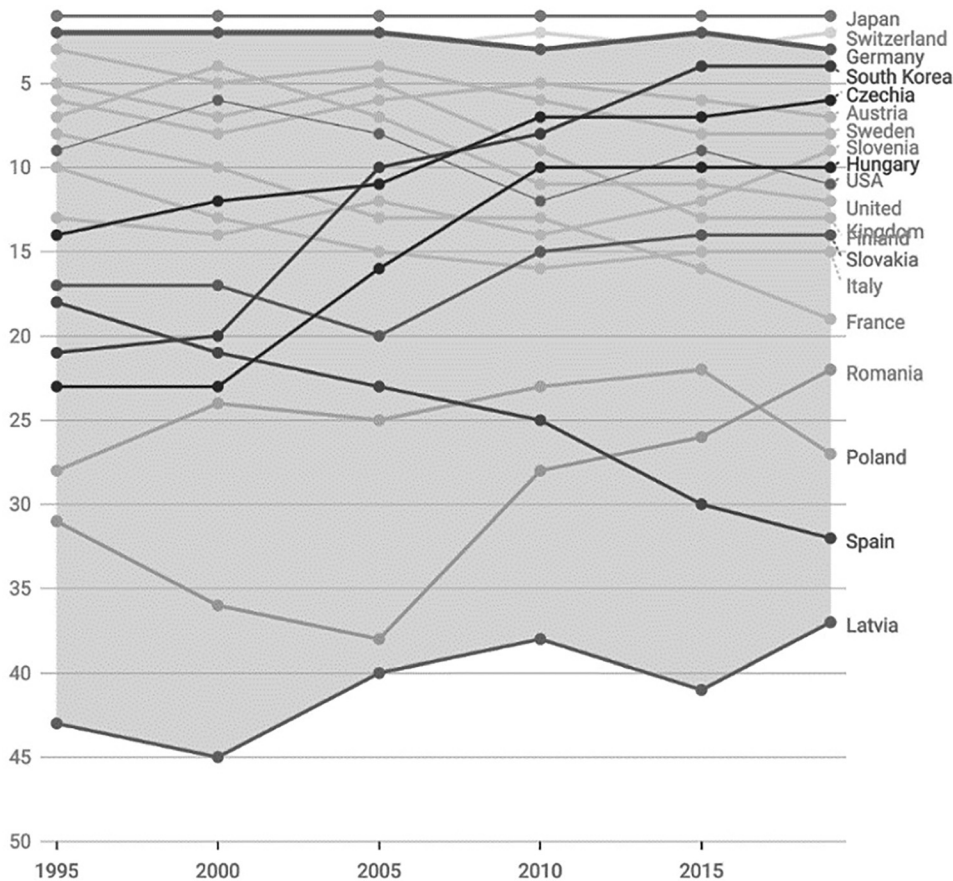


Fig. 1. Evolution of the Economic Complexity Index in Eastern European countries



scores. This suggests that these countries have successfully leveraged their knowledge, industries and market economies to achieve high levels of growth. However, a nearly linear trend in Figure 2 would indicate that a country also has the ability to create, absorb and transform new knowledge and technologies into economic output. However, this is not the case for several CEE countries, including the Czech Republic, Slovenia, Romania, and especially Hungary, which show a significant decrease in the discrepancy between economic and technological complexity. This abrupt decline may indicate that the necessary technological competencies to drive economic growth are not currently present in the local economy. Compared to the developed countries, such as Germany, France or Sweden, which are true examples of complex economies, there is a clear balance between the production of knowledge (TCI) and the use of knowledge (ECI). This leads us to conclude that the knowledge used in the Eastern European economies is not produced by them, which leads us to accept Hypothesis 1, that there's a discrepancy between economic and technological complexity.

Figures 3 and 4 show the evolution of the scores for economic and technological complexity. While Austria's scores have increased in a similar manner to other countries, this is not the case

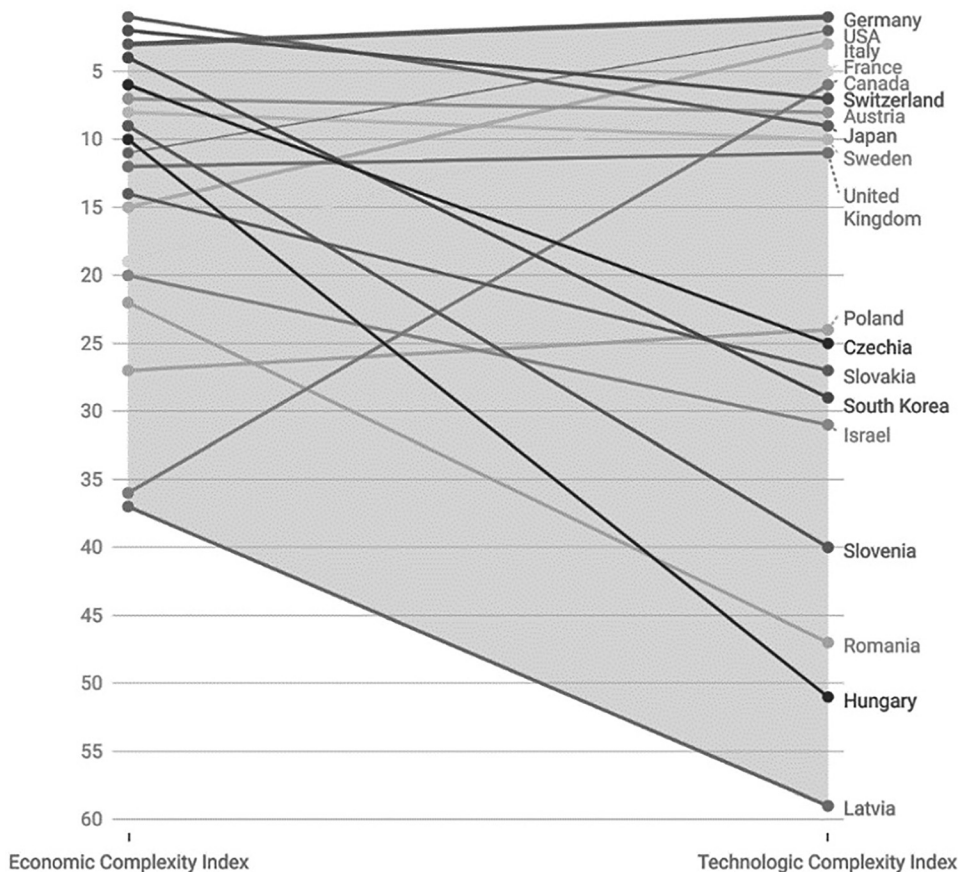


Fig. 2. Comparison between the Economic Complexity Index and Technological Complexity



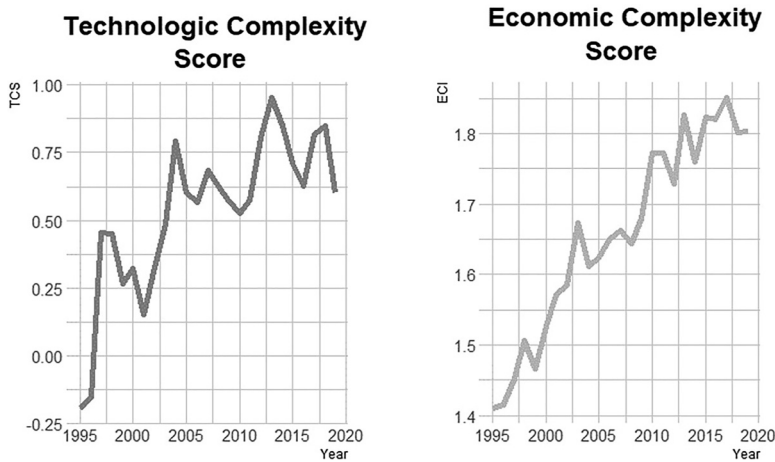


Fig. 3. Economic Complexity Index and Technological Complexity in Austria

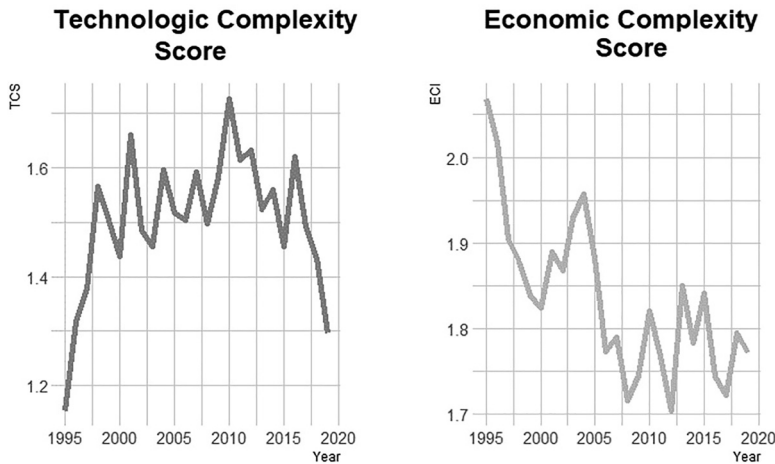


Fig. 4. Economic Complexity Index and Technological Complexity in Czech Republic

for the Czech Republic, where the score has decreased relative to other countries, meaning that its economy has actually become less complex. Focusing entirely on manufacturing, the decline of the Slovak demand as a driver of innovation, and the growth of the Chinese economy could be just some of the reasons why the Czech Republic is losing its position in the region (Svejnar 2013). We cannot exclude here also the challenges required by the accession of the Czech Republic to the EU after the hard waves of privatization and transition to the market economy.

The situation was not much different for other Eastern European countries, such as Hungary (Figure 5). Using participation in the global value chain (GVC) of the automotive industry, Szalavetz and Sass (2023) argue for the effect of the early mover advantage on location (core-periphery) and agglomeration economics. The authors contrast Austria's high FDI-domestic



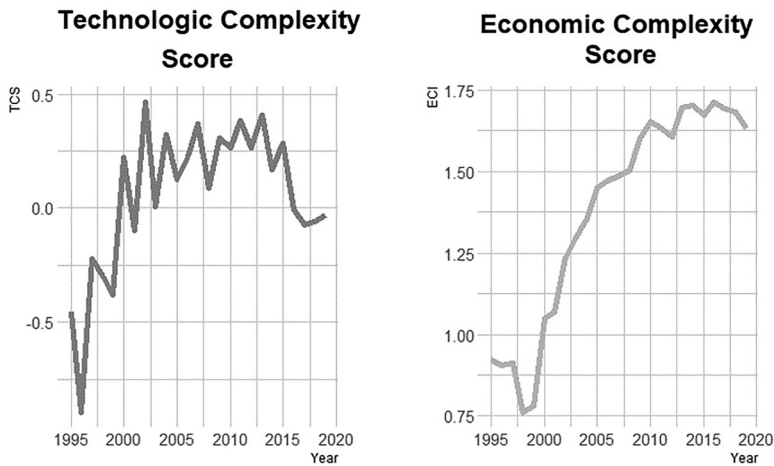


Fig. 5. Economic Complexity Index and Technological Complexity in Hungary

Source: Own elaboration

industry multiplier effect, where associated knowledge spillovers, high skills and wages, specialization, and Industry 4.0 adoption are abundant, with Hungary's dependent market economy with limited knowledge spillovers and domestic industry linkages. In addition, the CEE economies are negatively affected by brain drain, huge unhealthy FDI flows driven by low wages, and the 2008 crisis (Gal – Schmidt 2017). Poland, on the other hand (Figure 6), has had a much easier time. It has managed to harmonize economic production with its research efforts, which is why its ECI and TCI scores are more or less the same. This is also shown by the

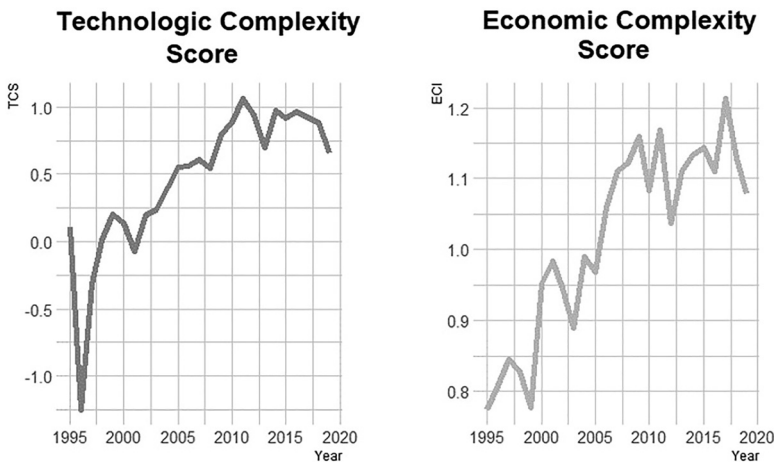


Fig. 6. Economic Complexity Index and Technological Complexity in Poland

Source: Own elaboration



Ecosystem Radar Chart in the appendices, where Poland is far ahead of other V4 countries in many pillars, especially in indicators such as human capacity and start-up skills. For countries in a situation like Hungary, the entry into the knowledge economy may be more difficult (Piech – Radosevic 2006), where the government should clearly implement such public policies. However, in countries like Hungary, knowledge about production processes and innovation is mainly concentrated in a handful of firms, with little spillover to local firms due to limited automotive R&D capacity (Pavlinek et al. 2017). This can only be changed by improving the quality of human capital. This can be modelled on Ireland, which has invested most of the money it received from the European aid in education rather than infrastructure. Cutthroat competition in the automotive industry forces large multinationals to find cost-cutting strategies, such as positioning their production close to the Western markets and looking for countries willing to provide relatively highly skilled human capital at low cost (Pavlinek 2017). They recognised the opportunities offered by some Eastern European countries.

While the automotive industry is one of the most important sources of FDI, Pavlinek (2017) mentioned that improving production capacity is attributed to the most important suppliers and the assembly unit, while employment in R&D is mainly limited to a small group of large foreign subsidiaries. The main research activities have been carried out in the home country of the multinational enterprise. This is how several countries in Eastern Europe, such as Hungary, Romania and also the Czech Republic, fell into the assembler trap. This can be seen in Figure 7, where the normalised ECI score is plotted together with the TCI score. Similar results were obtained by Braun et al. (2021) where the implications are quite clear for a country like Hungary with a moderately efficient trade structure and a low Finn Cycling Index (indicating low self-organization). A structure with a moderate degree of efficiency implies that the country has a

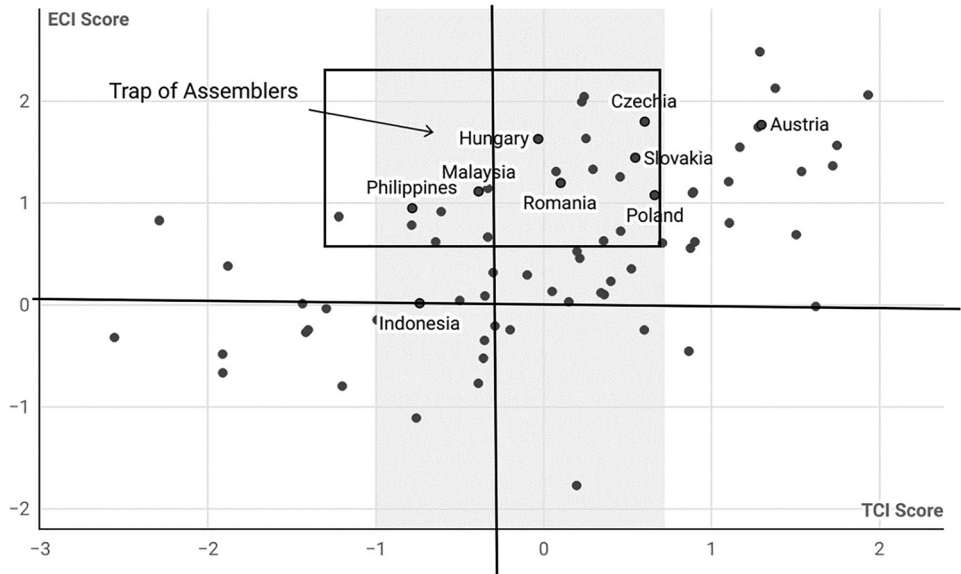


Fig. 7. The trap of assemblers



moderate degree of integration in global production networks and in international trade. This exposes the country to external economic shocks and disturbances, although it may lead to some efficiency gains. On the other hand, the low level of self-organization suggests that domestic sectoral linkages and feedback within the country are limited. Considering these factors in combination, it is clear that such a nation is heavily dependent on foreign supply chains. Moreover, in the event of disruptions in these chains, its limited capacity for self-organization suggests that it would struggle to produce essential goods domestically. Escape from such a situation may be possible by specialising in related industries with high investment in advanced research and education. Being in a position of an assembler or having a high gap between economic complexity and technological complexity, may lead in Eastern Europe to a decrease in liberal democracy, a more detailed observation can be seen in Figure 2 and Table 4 in the Annexes.

The disparity between Austria and other countries illustrated in Figure 8 stems from differences in RCA in exports and Relative Technological Advantage (RTA) in patents. For instance, Hungary shows a technological edge in certain patent categories, which does not align with its comparative advantages in product categories (RCA) seen in exports, such as high-tech products. This misalignment between production specialization and knowledge specialization can lead to dependency on foreign technology for competitive production and exports. Conversely, a high RTA does not guarantee production specialization in the relevant industries, potentially limiting the benefits of technological strengths. Therefore, aligning production capabilities with technological knowledge is crucial for sustainable economic growth, as demonstrated by Austria's consistency in production and technology related to steel and railroad maintenance in Figure 9, which contrasts with Hungary's unrelated specialization in office machines and patents in beer fermentation and edible fats.

Countries must often decide which new industries to enter based on existing skills and capabilities, a challenge highlighted by Balland et al. (2019). In a Schumpeterian sense, where firms continually seek new opportunities and knowledge (Schumpeter 1934), the diversity of a country's patent classes can indicate the ease with which entrepreneurs might identify these opportunities. This diversity not only reflects the available knowledge but also the expertise of the human capital involved in such specialized research. A diverse patent portfolio increases the likelihood that other entities like startups, academia and civil society engage in the entrepreneurial discovery process, which is crucial for economic growth. Our research³ shows that economically successful countries often have a diverse RTA compared to those primarily focused on manufacturing. However, there's a need for balance; spreading efforts across too many research areas might prevent achieving competitive advantages and developing a critical mass of expertise and entrepreneurs in the most promising sectors.

Our model analysing the drivers of economic and technological complexity for 83 countries offers significant insights (Table 1). It finds that the normalized ECI is positively correlated with the TCI, with a significant coefficient of 0.207 ($P < 0.05$), indicating that countries with higher economic complexity tend to have higher technological complexity. However, FDI's impact on TCI is not statistically significant, suggesting that FDI does not influence economic or technological complexity in this model.

³The plot regarding the evolution of RTA in most developed countries can be requested from the authors.



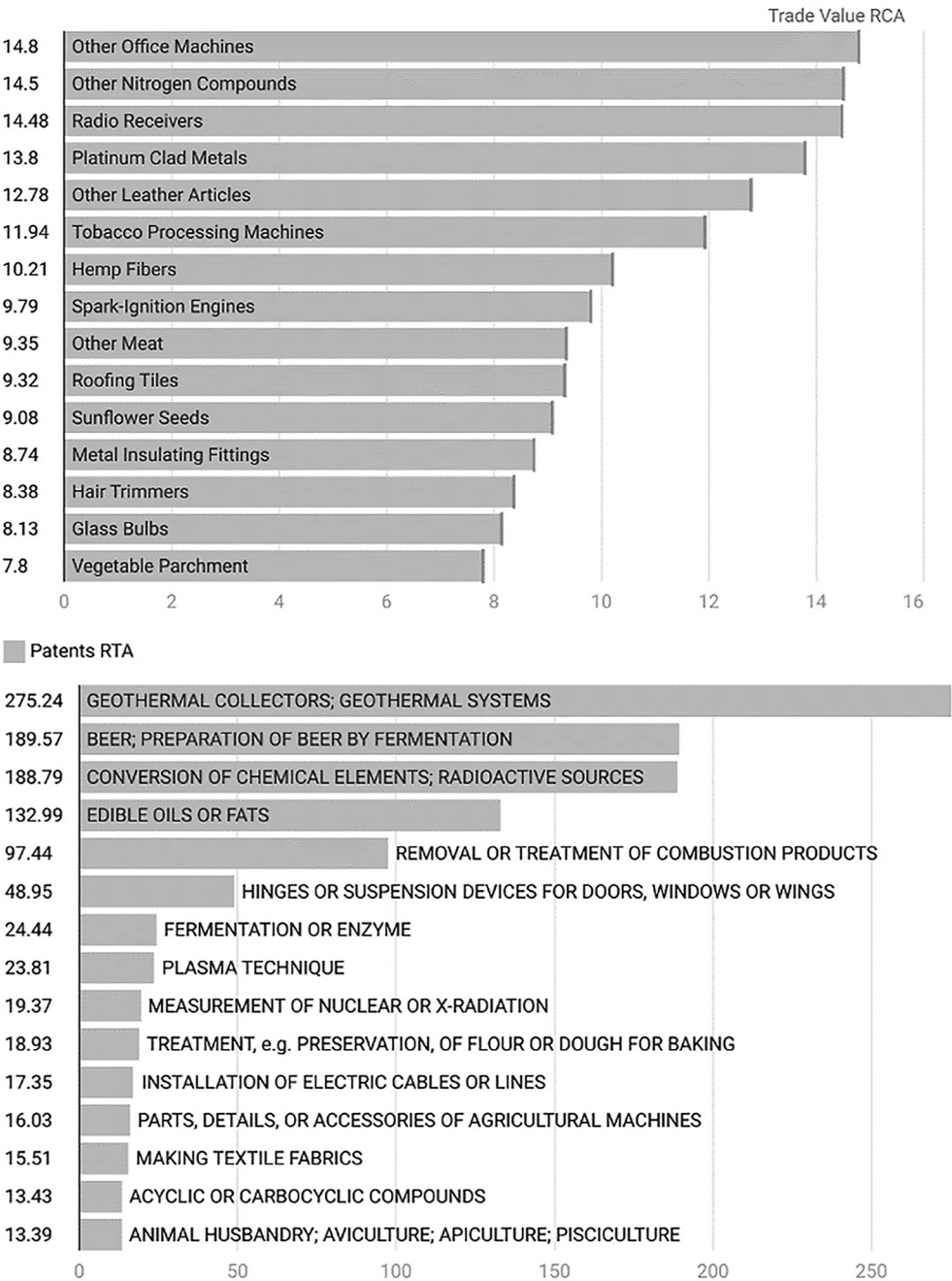


Fig. 8. Relative comparative advantage and relative technological advantage in Hungary



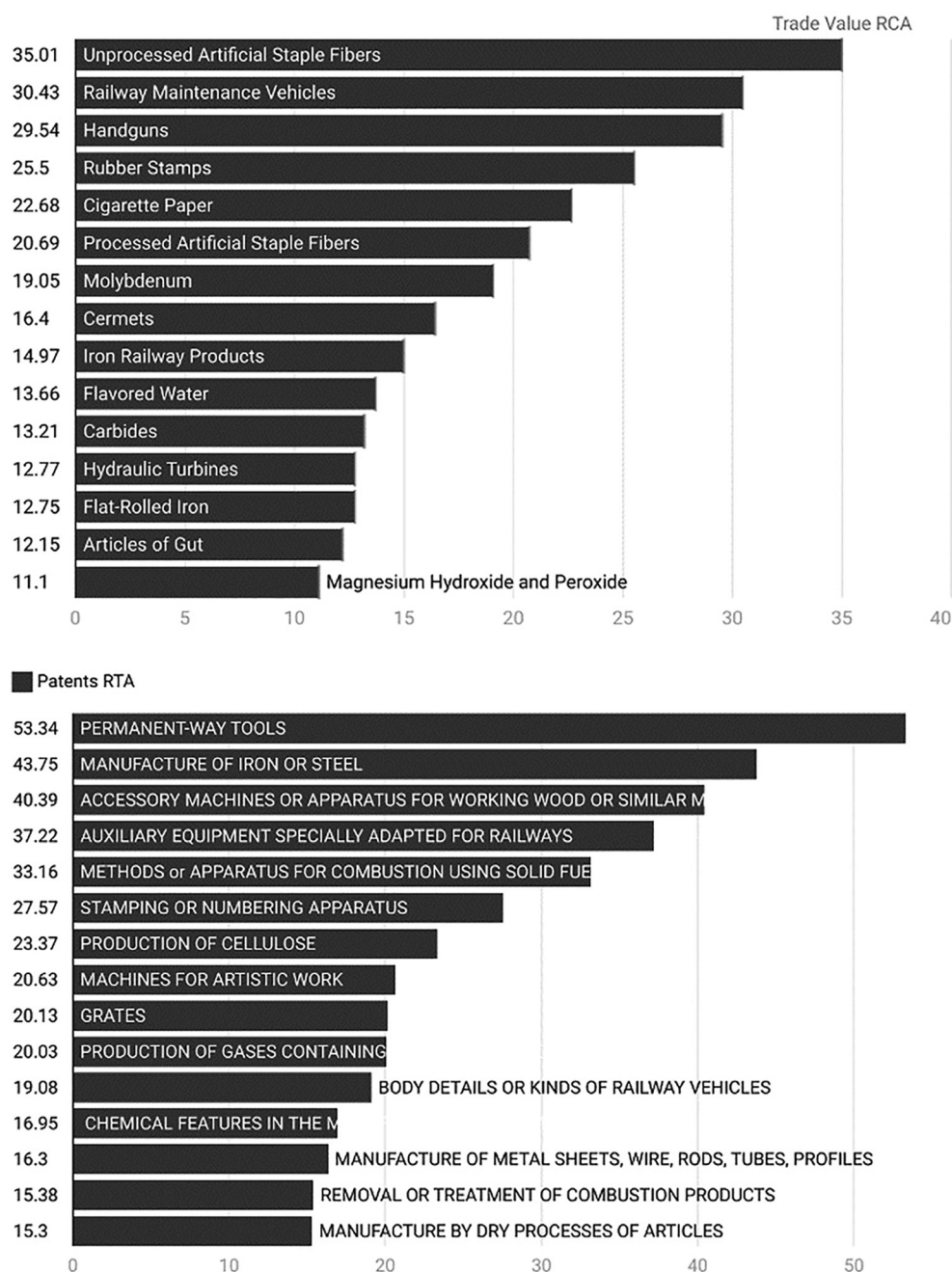


Fig. 9. Relative comparative advantage and relative technological advantage in Austria



Table 1. Descriptive statistics of the main variables

Statistic	N	Mean	St. Dev.	Min	Max
TFP	543	1.6	2.9	−12.3	16.4
Diversity	1,947	88.2	92	1	395
TCI (normalized)	1,947	58.6	22.2	0	100
Population	1,947	0.068 bn	0.19 bn	0.00085 bn	1,4 bn
FDI net flow	1,917	18 bn	50 bn	−345 bn	734 bn
GDP	1,940	689 bn	1931 bn	1,6 bn	21400 bn
ECI (normalized)	1,947	52.8	21.7	0	100
GEI (normalized)	811	42.1	27.2	0	100

Note: The number of observations depends on the data availability and time dimension.

In a second analysis, FDI shows a strong positive correlation with ECI, with a coefficient of 3.317 ($P < 0.01$), reflecting that higher FDI levels are associated with greater economic complexity (Table 2). This relationship is supported by Antonietti and Franco (2021), although reverse causality is not observed. Additionally, a significant relationship between the normalized TCI and ECI (coefficient of 0.092, $P < 0.1$) suggests that higher technological complexity correlates with increased economic complexity, underscoring the interplay between technology

Table 2. Contributors to economic and technological complexity for 83 countries

	Dependent variable		
	TCI (1)	ECI (2)	Tech diversity (3)
Foreign Direct Investment (log)	0.911 (0.552)	3.317*** (0.886)	–
Global Entrepreneurship Index (norm)	–	–	−0.012 (0.009)
Economic Complexity Index (norm)	0.207** (0.098)	–	−0.002 (0.007)
Technological Complexity Index (norm)	–	0.092* (0.047)	0.009** (0.003)
Country fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Observations	1,830	1,830	767
R^2	0.690	0.853	0.928
Adjusted R^2	0.675	0.846	0.919
Residual Std. Error	12.510 (df = 1,745)	8.360 (df = 1,745)	0.384 (df = 687)

Note: * $P < 0.1$; ** $P < 0.05$; *** $P < 0.01$.



and economic development. However, this pattern does not hold for the sample of Eastern countries. The inclusion of country and time fixed effects controls for specific factors over time and across countries. The model's R^2 value of 0.853 indicates it explains about 85.3% of the variation in ECI, with an adjusted R^2 of 0.846 accounting for the variables and sample size. These findings suggest that both FDI and technological complexity significantly contribute to economic complexity as measured by the ECI. In the third model, it is evident that technological complexity influences the diversity of industrial paths countries may pursue.

The relationship between economic and technological complexity takes on a different dynamic in the specific case of the investigated countries. It appears that high levels of economic complexity, represented by a variety of industries, do not necessarily translate into equally high levels of technological complexity. This implies that while these countries may have a complex basket of economic activities, their ability to transform this knowledge into sophisticated innovation pathways is limited, and this is another argument to accept Hypothesis 1. However, the analysis shows that FDI is a crucial determinant of economic complexity in the Eastern European countries. The positive and significant effect of FDI on economic complexity (with a P -value of less than 0.1) suggests that FDI may be responsible for the complex economic activities of these countries. This implies that foreign investment contributes to the development of complex industries and the expansion of the economic capabilities of the Eastern European countries, leading us to accept Hypothesis 2a, which states that FDI will have a significant and positive effect on ECI. In both Tables 2 and 3, we can observe that FDI is insignificant when it comes to technological complexity, therefore we accept Hypothesis 2b, which argues about the insignificance of FDI on TCI. A similar study was conducted by Ning et al. (2023), who found that FDI affects the technological complexity of local firms in a U-shaped curve pattern.

Table 3. Contributors to economic and technological complexity for CEE countries

	Dependent variable		
	TCI (1)	ECI (2)	Tech. diversity (3)
Foreign Direct Investment (log)	−1.847 (2.038)	6.299 [*] (2.685)	–
Global Entrepreneurship Index (norm)	–	–	−0.003 (0.002)
Economic Complexity Index (norm)	0.099 (0.098)	–	−0.004 (0.006)
Technological Complexity Index (norm)	–	0.062 (0.046)	0.003 (0.004)
Country fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Observations	113	113	58
R^2	0.740	0.918	0.859
Adjusted R^2	0.722	0.912	0.836
Residual Std. Error	12.314 (df = 105)	9.734 (df = 105)	0.230 (df = 49)

Note: ^{*} $P < 0.1$; ^{**} $P < 0.05$; ^{***} $P < 0.01$.



However, their use of MNEs’ R&D investment as a proxy for FDI is an exploratory type of FDI, while we are concerned about exploitative FDI, such as that prevalent in Eastern Europe.

We anticipated, as observed in the literature, that technological complexity would positively impact TFP change. However, as seen in Table 4, the data did not support this hypothesis, leading us to reject Hypothesis 3a, which posited that complexity enhances a country’s technological efficiency. One reason could be the advanced knowledge and skill sets required to effectively utilize and benefit from technological complexity. Many countries in the study may lack the necessary human capital or infrastructure to leverage their technological complexity to boost TFP. Nevertheless, when we accounted for country-clustered standard errors, we observed a significant positive effect of technological complexity on TFP, while the impact of economic complexity remained negative. This suggests that technological complexity can enhance TFP under certain analytical conditions. Additionally, a negative correlation between GDP and TFP was noted, indicating that countries with lower GDP might experience

Table 4. Contribution of complexity to technological efficiency for the 23 European countries

	Dependent variable: TFP change				
	Model 1	Model 2	Model 3	Model 4	Model 5
Tech. complexity	−0.034 (0.035)	0.022 (0.021)	0.025 (0.022)	–	–
GDP	–	−2.456*** (0.614)	−2.485*** (0.599)	−5.434* (2.895)	–
Population	–	–	3.905 (4.119)	3.776 (10.863)	–
GEI	–	–	–	0.035 (0.035)	–
Econ. complexity	–	–	–	–	−0.070** (0.028)
log (Tech. diversity)	–	–	–	–	−0.671* (0.325)
log (FDI)	–	–	–	–	0.050 (0.109)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	543	543	543	254	505
R ²	0.181	0.302	0.306	0.171	0.286
Adjusted R ²	0.145	0.270	0.272	0.080	0.249
Residual Std. Error	2.654 (df = 519)	2.453 (df = 518)	2.449 (df = 517)	2.107 (df = 228)	2.468 (df = 479)

Note: **P* < 0.1; ***P* < 0.05; ****P* < 0.01.



higher TFP growth, potentially due to their “catch-up” development phase. Furthermore, our analysis revealed a significant negative effect of economic complexity on TFP, implying that increases in economic complexity do not necessarily lead to improved technological efficiency or productivity. This supports Hypothesis 3b, affirming a negative relationship between economic complexity and technological efficiency. The relationship between technological diversity and TFP also appears complex and is not straightforwardly positive.

The study shows that greater diversity in technological classes does not necessarily lead to higher TFP. It is possible that efficiency gains are more likely to come from specialization than from diversity. This implies that focusing on specific technological areas and developing expertise in these areas may be more effective in driving productivity improvements than pursuing a broader range of technologies. Other factors, such as GEI and FDI, were not significant, although GEI is an important determinant of the embeddedness of elements in an economy. Some other limitations of the study lie in the fact that the complexity comes as a holistic aspect of countries’ export or patenting activity, and it is hard to give specific advice and what costs that would imply for specific countries. The unbalanced panel models are also not perfect, but perhaps the best we could use to measure the current hypothesis with the data we have. In addition, the Eastern European countries are rarely involved in innovative activities and patenting, but rather in technology imitation and exploitation, so the study may be biased towards patenting countries. Despite the use of clustered standard errors, logarithmic transformation, and fixed effects, we cannot claim causality because complexity is a measure of economic activity, and it is not clear what leads to a certain level of growth in a system.

5. DISCUSSION AND CONCLUSION

In this study, we analyse the economies of the Eastern European countries, using the new frameworks of economic complexity and entrepreneurship ecosystems. Although our research suggests that the Eastern European countries have completed the transition from socialist to market economies and are already developed countries, they remain economically fragile and dependent. To identify the dangers these countries face, we analyse complexity indicators through the lens of economic development, rather than as a measure of economic growth per se. The results presented may seem to contradict the mainstream literature, or at least to be taken in a negative tone, but they do present the situation about the capabilities of these countries and their situation. This only warns us that the effects may be context specific in countries, and thus, may serve as a lesson for the developing nations.

First, we find that the Eastern European countries score significantly lower on indicators of technological or knowledge complexity, although they score well on indicators of economic complexity. This can be explained by the fact that their export basket of sophisticated industries does not depend on their capacity to produce the goods they have acquired in building these industries, but rather on foreign capacity and knowledge. In today’s globalized and market-driven economy, the CEE countries are vulnerable, with the exception of Poland, which have successfully combined production capacity (ECI) and innovation capacity through technological complexity. Moreover, spillovers of production technologies and knowledge to society are impossible without the involvement of local research centres when a few exporters dominate the economies. Austria and Hungary can be compared on the basis of the relative comparative advantage of economic and innovation activities, but we can observe a divergence between the



technologies that Hungary exports and those that it innovates. The solution is to combine physical work (manufacturing) with creative and innovative knowledge-based activities. Separating them leads either to specialization without innovation or to scientific research that an industry doesn't need. It is possible for these countries to fall into the "assembler trap," where they produce complex technological products for other countries, while being completely dependent on foreign capital and destroying local industries. They are also importers of most other materials for consumption. Not to mention the finding that the gap between economic and technological complexity leads to a decline in the liberal-democratic CEE countries. This shows the long-term effects of exploitative FDI, which leads to deindustrialization and later to discontent regarding low wages and lack of advancement, and therefore, fuel the populist governments. This finding is in line with our conceptual model, and once again, warns us about the dangers of the assembler trap.

We reiterate that countries with high manufacturing levels do not necessarily possess strong local technological capabilities. Our analysis across 83 countries shows that technological complexity has little effect on productivity, indicating that non-innovative countries struggle to convert new knowledge into economic growth. Furthermore, there's a risk that foreign firms may displace local, productive high-tech companies.

Current economic strategies suggest creating industries linked to existing strengths or latent advantages. Yet, the Eastern European countries, including the Visegrad group, often remain locked as assembly hubs for global industries, missing out on the added value opportunities. These countries are advised to support the emerging local industries that have potential for rapid growth and technological innovation. This is crucial as these domestic industries are often undercut by global firms with lower production costs.

Despite the lack of evidence linking FDI to the development of complex knowledge, it does contribute to economic sophistication. The policy recommendation is to selectively allow FDI that includes agreements for joint research and development and technology transfers, aligning with local industrial goals. Additionally, promoting local firm participation in supply chains could foster innovation, although it may require careful negotiation to avoid the pitfalls of coerced partnerships. Although FDI enhances economic sophistication by stimulating investment and improving infrastructure, the Eastern European countries have overlooked the critical role of human capital and advanced research. The result is the "assembler trap," where reliance on FDI leads to a focus on infrastructure at the expense of education and research. To counter this, examples from the Baltic States and Ireland demonstrate the benefits of investing in education, local industries and human capital development. Strategic priorities should include strengthening integrated education, fostering research collaboration, and building business networks.⁴ Recommendations also include enhancing local business linkages, optimizing the blend of foreign and local knowledge, and prioritizing domestic innovation systems. Future research should differentiate between the impacts of local and foreign knowledge on economic complexity. Policymakers need to monitor technological and economic complexity trends, adjusting strategies to prevent a widening gap and mitigate the risks of excessive dependence on foreign capital and technology.

⁴The Fraunhofer Institute model exemplifies a balanced approach to knowledge production and application, promoting entrepreneurship.



Countries lagging behind in economic and technological complexity should prioritize upgrading technological capabilities, not just increasing manufactured exports. Absorptive capacity and the ability to innovate matter more than short-term growth. At the same time, entrepreneurial discovery of new opportunities in line with local capabilities can be facilitated by fostering entrepreneurial ecosystems with strong links between universities, industry and government. In addition, industrial policy theory suggests that protecting specific domestic industries, rather than fully opening markets, may help protect emerging local firms, enabling their growth. What about entry into new industries? We recommend diversifying into related industries that build on existing knowledge bases, rather than over-specializing in the assembly industries.

Data availability: All the annexes, additional materials and evidence was uploaded on this repository link: <https://zenodo.org/records/10996601>.

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