İstanbul İktisat Dergisi - Istanbul Journal of Economics
74, 2024/1, s. 159-191
E-ISSN: 2602-3954

RESEARCH ARTICLE

Panel Causality Analysis of the Relationship among the Rule of Law, Technological Advances, Competitiveness, and Value-Added*

Doğan KEŞAP[1], Ali Rıza SANDALCILAR[2]

ABSTRACT

The status of countries within the global value chain varies depending on the importance of national production capabilities in the global economy. From this perspective, there is a need for a value-added production approach that focuses on innovation and competitiveness. Technological advances and institutions are considered to play a significant role in transforming the economy towards an innovation-driven one to meet these needs. The aim of this paper is to investigate the relationship among technological advances, the rule of law as a proxy for institutions, value-added production, and competitiveness in a way that reflects cross-country divergence. Through an analysis employed independently of countries' existing levels of development, it will be possible to evaluate whether the factors associated with institutions and innovation can produce similar results in all circumstances and for each country. In this context, a panel causality analysis that considers cross-sectional heterogeneity is employed. The analysis shows bidirectional causality between the variables, except for value-added to the rule of law. However, the results also support the existence of cross-country divergence. These findings suggest that future policy plans should be designed to consider the multidimensional nature of country-specific factors, alongside technological advances and the rule of law, and to ensure the integration of both national and international economic objectives.

Keywords: Technological advance, The rule of law, Competitiveness, Value-Added production
JEL Classification: F10, P48, O32, O47

DOI: 10.26650/ISTJECON2023-1298039

* This paper is derived from an ongoing doctoral thesis titled "Examınıng The Relationship Between Institutional Structure and Export Based on Technological Intensity".

[1]Res. Asst., Recep Tayyip Erdoğan University, Faculty of Economics and Administrative Sciences, Department of Economics, Rize, Türkiye

[2]Prof. Dr., Recep Tayyip Erdoğan University, Faculty of Economics and Administrative Sciences, Department of Economics, Rize, Türkiye

ORCID: D.K. 0000-0001-7338-0698; A.R.S. 0000-0002-9185-6968

Corresponding author:
Doğan KEŞAP,
Recep Tayyip Erdoğan University, Faculty of Economics and Administrative Sciences, Department of Economics, Rize, Türkiye
E-mail: dogan.kesap@erdogan.edu.tr

Submitted: 16.05.2023
Revision Requested: 11.03.2024
Last Revision Received: 25.03.2024
Accepted: 04.04.2024

Citation: Keşap, D., & Sandalcılar, A.R. (2024). Panel causality analysis of the relationship among the rule of law, technological advances, competitiveness, and value-added. *İstanbul İktisat Dergisi - Istanbul Journal of Economics 74*(1), 159-191. https://doi.org/10.26650/ISTJECON2023-1298039

1. Introduction

As a natural consequence of globalisation and internationalisation trends in supply processes, concepts such as production diversification, economic complexity, and competitiveness are frequently referenced. In a world where international competition is intense, developments in production processes have become crucial for enhancing and maintaining economic performance. As a reflection of this fact, it is noteworthy that the multidimensional relationship among these factors is considered in the policy texts and objectives of national and supranational organisations (e.g. European Commission, 2021; T.C. Strateji ve Bütçe Başkanlığı, 2019).

Several factors stand out in the development of the manufacturing industry and its sub-sectors, which are fundamental drivers of economic output. These factors are considered as inputs used in production, and among these inputs, technology deserves special mention, as it directly shapes product sophistication in a way that other inputs may not be able to achieve sufficiently. Technological advances enable a nation to transition from a cost- and factor-driven economy to an innovation-driven one. The phenomenon of technology, which can be formulated within the framework of economic growth and international trade theories (Grossman ve Helpman, 1991; Aghion ve Howitt, 1992; Posner, 1961), ensures economic performance and comparative advantage of a nation in a dynamic structure.

Technological advances that pave the way for innovation are crucial for countries seeking to gain a place in the global economy through foreign trade. Indeed, reports demonstrating a significant relationship between technological innovations and the competitiveness of countries support this statement (Schwab, 2010; IMD, 2022). Accordingly, it is possible to interpret these sectors that utilise technology intensively can produce more competitive and value-added products. On the other hand, it can be argued that technological inadequacies may hinder the competitiveness of countries by restricting production based on factor endowment and cost.

However, it would be incomplete to evaluate competitiveness and value-added production on the basis of technological advances alone. Therefore, considering country-specific factors would be the right approach (Dosi, Pavitt, and Soete, 1990). Institutions are a factor considered in this framework (Amendola, Dosi, and Papagni, 1993; Rodrik, 2009). Institutions determine the set of incentives and constraints for social actors by establishing the rules of the game and the governance structure (North, 1991; Williamson, 1998) and have various dimensions that shape entrepreneurs' decisions, productivity and specialisation, including the way in which technology evolves (Acemoğlu and Robinson, 2000; Baumol, 1996). The impact pathways of institutions include activities such as influencing transaction costs, re-allocating resources and human capital, increasing predictability, and addressing asymmetric information issues (Lin and Nugent, 1995; Tebaldi and Elmslie, 2008). In this framework, institutions are assumed to influence cross-country divergence in productivity and competitiveness and technological advances.

There are several reasons for using the rule of law as a proxy for institutions. First, a well-designed legal framework is one of the most effective ways to understand the institutional structure that reduces economic and social uncertainty (D'Ingiullo et al., 2023). Second, the rule of law is a broad phenomenon that includes the legal framework, contract enforcement, and property rights (Kaufmann, Kraay, and Mastruzzi, 2011). It also interacts with institutional factors such as regulatory quality and corruption (Haggard, MacIntyre, and Tiede, 2008), which affect transaction costs, ease of doing business, and trust.

It is believed that the evaluation of the potential effects of technological advances and the rule of law on value-added and competitiveness and the design of effective policies based on the findings at the cross-country level are important. This paper investigates the response of competitiveness, which refers to the comparative advantage of nations, and value-added production with respect to developments in technological capacity and the rule of law, particularly with country-specific dimensions. The analysis focuses on 29 countries for which data are available in the European Innovation Scoreboard (EIS). The EIS is a valuable index as it provides an evaluation of European Union innovation, industry, and competition policies and the outputs achieved (European Commission, 2022).

This paper is expected to contribute to the literature in two ways. First, in the existing literature, the effect of technology and technological advances on value-added and competitiveness is discussed separately. This study analyzes the relationship between these factors from a holistic perspective, considering the rule of law, and provides multidimensional explanations among the factors. Second, we employed a panel causality analysis to consider possible cross-country divergence. By doing so, we can evaluate both the results for the panel and those at the cross-country level and see the possible effect of the rule of law in explaining country patterns. In this context, the Dumitrescu and Hurlin (2012) panel causality method, which considers heterogeneity and allows for both panel and cross-sectional causality analysis, is employed. The findings are expected to provide useful outputs in terms of the integration and objectives of national and international economic policies.

The rest of the paper is structured as follows: Section 2 provides an explanation of the concepts of technological advances, the rule of law, value-added, and competitiveness, including their relationships. In Section 3, previous studies from the literature are included. Sections 4 and 5 present the data and the econometric model employed in the analysis and the findings, respectively. The final section includes concluding remarks.

2. Conceptual Framework

2.1. Technological advances and value-added

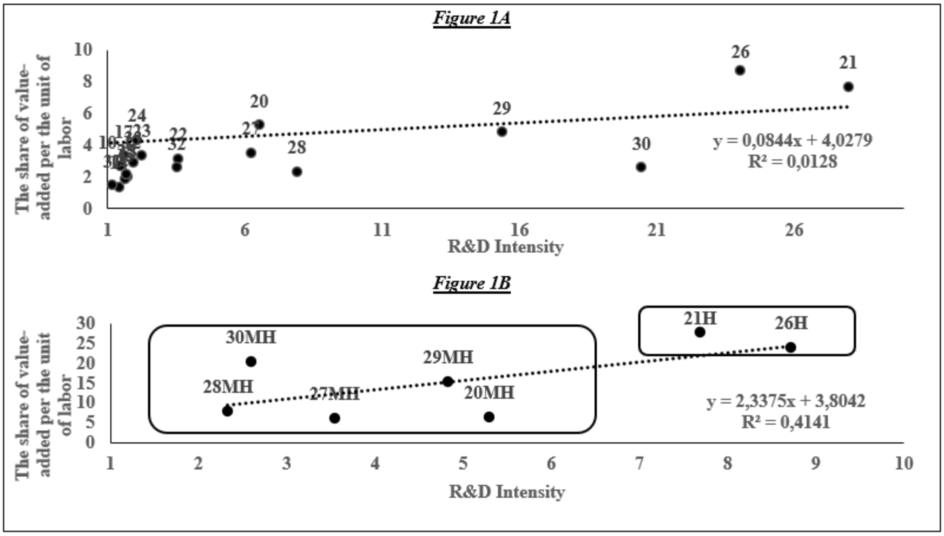
According to Lundvall (2010:28), technology is defined as the technical knowledge utilised in production processes. In addition, increases in existing knowledge that contribute to the economy are referred to as innovation. From this perspective, the commercialisation of technical knowledge emerges as innovation. From the Schumpeterian perspective, technological advances in terms of increases in the stock of technical knowledge enable the unveiling of innovation by transforming it into new products and processes (Mokyr, 1992: 6; Dosi and Nelson, 2010: 91).

Technological advances and innovation are widely recognised as the fundamental drivers of long-term economic performance. Within the process of creative destruction, technological advances that emerge as a conscious effort driven by competitive pressure and profit-seeking will ensure economic transition and sustain economic growth (Aghion and Howitt, 1992: 323-324). Explaining this fact, it has been revealed that there is a strong relationship between industrial transformation triggered by technological changes and economic development cycles in the historical process (Ayres, 1990: 3). Industries based on new technologies emerge as the engine of growth in every new cycle. Two concepts arise with respect to the effects of technological advances that can be observed on a national and international scale: *value-added production* and *competitiveness.*

Gross value added, which is equal to the difference between output and intermediate consumption, is a concept that emphasises the surplus value created in the production process (United Nations, 2009: 34). The change in value-added can occur in two ways. Value-added increases by producing more output with the same input compared with the previous period or by diversifying the product range. Technological advances play a crucial role in both cases. Technological advances shaped by R&D activities enable more efficient and high-quality intermediate goods to be used in the production process. Thus, increases in cost and innovation-based productivity and value-added per unit of labour are achieved (Lentz and Mortensen, 2008: 1318-1321). For instance, technological innovation may enable efficiency and value-added increases in the long term by allowing more effective use of energy (Zheng et al., 2022: 11). Similarly, long-term productivity gains can be achieved through the widespread adoption of automation processes in production (Camiňa, Diaz-Chao, and Torrent-Sellens, 2020: 2). Simultaneously, the sustainability of productivity is a function of the persistence of R&D. This is because the productivity-enhancing effect of R&D tends to diminish over time (Kafouros, 2005: 482). In other words, having invested in R&D in the past does not guarantee future productivity. Therefore, firms must continue investing in R&D uninterruptedly to maintain productivity and profitability (Baumann and Kritikos, 2016: 1264).

To observe the innovation-driven positive effects of technological advances on value-added at the sectoral level, it would be appropriate to understand the link between the two factors. This link is illustrated in Figure 1, which was compiled using data on sectoral value-added and R&D intensity for the manufacturing industry. Figure 1 consists of 1A, which includes all manufacturing industry sectors, and 1B, which is derived from section 1A and includes only sectors with high R&D intensity.

Figure 1. LightGBM SHAP summary plot.



Source: Galindo-Rueda ve Verger, (2016); UNIDO (2023).
Note: Sectoral classification is based on ISIC Rev. 4. R&D intensity data belongs to 2011 and value-added per unit of labour data belongs to 2019. MH: Medium-High Sector and H:High Sector

Figure 1A indicates that most of the manufacturing industry are characterised by low R&D and value-added levels. Furthermore, the effect of R&D activities on value-added in these sectors is relatively small. Considering the R^2 value (0.0128), the explanatory power is quite low. However, it is observed that some sectors lead in value-added production in parallel with the increase in R&D activities. The status of these sectors can be seen more clearly in Figure 1B. Among these sectors, chemicals and chemical products (20), electrical equipment (27), machinery and equipment, nec (28), motor vehicles and trailers (29), and other transportation vehicles (30) are medium-high technology sectors, whereas pharmaceuticals (21), computer, electronic, and optical products (26) are high technology sectors. The figure shows that the link between R&D intensity and value-added intensifies depending on the sectoral technological classification. R^2 value (0.4141) also supports this. While the effect of R&D is limited in sectors where technology use is relatively low, technological advances play a major role, especially in innovative sectors, depending on the sectoral technological intensity. This significant interaction affects national production and the country's export potential. The composition of production would directly affect export sophistication and intensity.

2.2. Technological advances and competitiveness

For a country to be competitive in global trade, it is important that it first understands the dynamics of global competition and adopts industrial policies in this direction. Otherwise, policies may have a temporary effect on the country's economy in the short term. Competitiveness can be defined differently depending on the level of competition. These definitions include the concept of competitiveness at the micro-scale, such as firm and/or national competitiveness (Chikán, 2008: 24), and at an intermediate scale, such as regional competitiveness (Filo, 2007: 324). Within the macro perspective, competitiveness is defined as "the set of institutions, policies, and factors that determine the level of productivity of a country" (Schwab, 2010: 4).[1] As the definition suggests, a competitive country has a multidimensional structure. Optimal alignment of these factors is essential for comprehensive competitiveness.

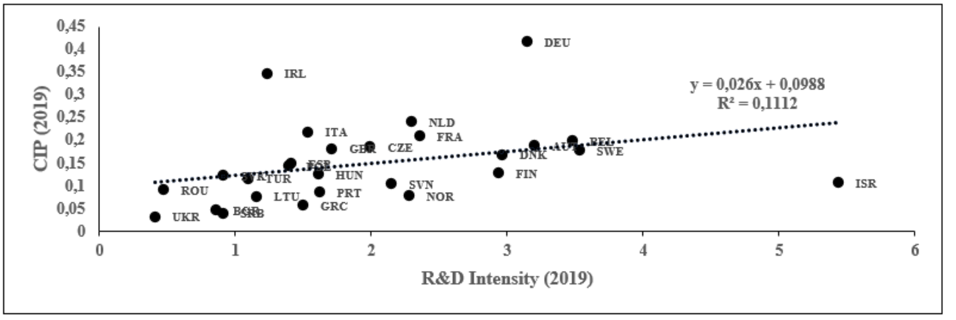
[1] This paper, on the other hand, considers macro-scale, innovation-oriented, and broadly defined competitiveness. In this context, competitiveness, as defined by UNIDO (2020), is largely determined by technological advances and knowledge required to produce new products. However, it is recognised that institutions may play a role in cross-country divergence.

The fact that technological innovation is a key factor of long-term economic performance due to its direct impact on production and triggering economic transition (Ayres, 1990) suggests that it is also a key determinant of competitiveness (Fagerberg, 1996: 49). Thus, technological advances play a key role in accelerating the creation of value-added and competitiveness by reshaping production processes. The use of new technologies in production will lead to cost-reducing and/or product diversification-enhancing developments. However, in the dynamic structure of the global economy, the sustainability of competitiveness depends on innovation-driven product competition rather than price competition (Aiginger, 1998: 160). In such an economic order, what countries produce becomes as important as how much they produce. This is consistent with the fact that a sophisticated and highly innovative production approach provides better export performance (Hausmann, Hwang, and Rodrik, 2007: 23-24).

Competitiveness can also influence technological advances. Increased competition may disadvantage domestic firms as more efficient multinational corporations enter established markets (Gandolfo and Trionfetti 2014: 145). Therefore, domestic firms will either invest in R&D to gain competitiveness or exit the market. Moreover, in the context of Schumpeterian competition, monopoly profits from innovation are elevated during periods of limited market competition. However, these profits decline with the introduction of new entries, subsequently hindering innovation and diminishing productivity. This dynamic posits an inverted U-shaped relationship between market competition and innovation activity (Aghion et al., 2005: 720-721).

Figure 2 demonstrates the link between R&D intensity and Competitive Industrial Performance (CIP) values when considering the countries analysed in this paper. Figure 2 shows a direct link between R&D intensity and CIP. Moreover, countries such as Germany, Austria, Belgium, Sweden, and Belgium have more competitive economies in return for their high R&D expenditures. On the other hand, Israel has a relatively low level of competitiveness despite its high R&D intensity, whereas Ireland has achieved a high level of competitiveness despite its relatively low R&D activities. In these cases, as discussed earlier, several factors, along with technological advances, may be considered important in these countries.

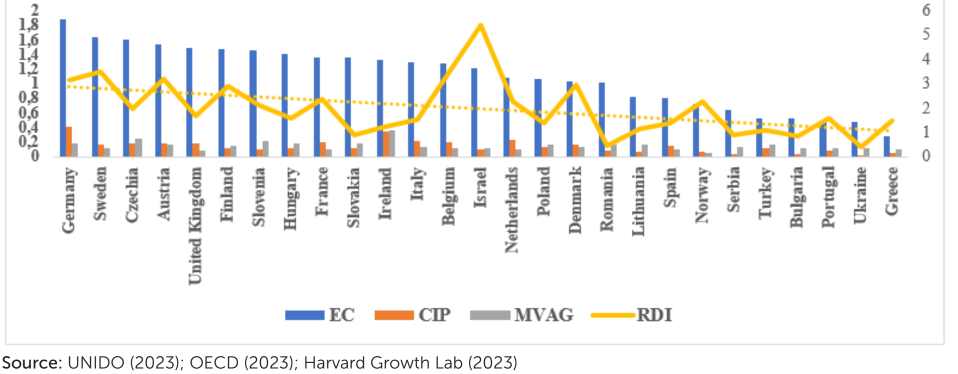
Figure 2. R&D intensity and competitiveness by country



Source: UNIDO (2023); OECD (2023)

The level of economic complexity of a country provides a better understanding of the relationship between technology, value-added and competitiveness. Economic complexity is a concept that emphasises the ability of an economy to obtain productive output from the available stock of knowledge (Hausmann et al., 2014: 18). Depending on sectoral technological intensity, sectoral complexity also increases and countries that export-related products are more competitive (Erkan and Yildirimci, 2015: 524). Figure 3 illustrates this multidimensional relationship.

Figure 3. Economic complexity, R&D intensity, value-Added, and competitiveness outlook



Source: UNIDO (2023); OECD (2023); Harvard Growth Lab (2023)
Note: EC: Economic Complexity, MVAG: The Share of Manufacturing Value-Added in GDP, RDI: R&D Intensity.

According to Figure 3, countries' levels of economic complexity increase in line with trends in R&D intensity. Similar to Figure 2, countries such as Germany, Austria, and Sweden stand out in terms of ranking economic complexity and competitiveness. At the bottom of the ranking, countries such as Greece, Ukraine, and Bulgaria have low levels of competitiveness and value-added production in parallel with low R&D intensity and lag behind in terms of economic complexity. Increases in value-added arising from cost-effective production and new products enable countries to gain advantages in terms of both price and product competition in world trade. For the sustainability of competition, a technology-intensive product composition characterised by a complex production structure must be adopted.

2.3. Institutional effects

Under today's complex production and trade structure, it is important to assess many other factors together to build a competitive economy. Although technological advances have a positive effect on productivity and competitiveness, this effect is subject to the influence of the education system and the quality of institutions in the country. As innovation and technological change are social processes, they are characterised by cumulative learning, knowledge diffusion, etc. (Lall, 2000: 345). This underscores the symbiotic relationship between technological advances and skills. More technology-intensive production is possible with more skilled labour. Reciprocally, technological innovation restructures the production process, foregrounding the necessity of an adaptable, proficient workforce (Goldin and Katz, 1998: 696-697). Institutions come into the equation by direct productivity and human capital allocation (Tebaldi and Elmslie, 2008: 5). Institutions establish the social infrastructure that can ensure the accumulation of skills and provide an environment in which firms can transform their capital accumulation into production (Hall and Jones, 1999: 84). In doing so, it can directly and indirectly influence how the firm performs. This reflects the productivity and competitiveness of the firm.

Institutions are a set of incentives and constraints that regulate political, economic, and social interactions and are created by human beings to maintain order and reduce uncertainty (North, 1991: 97). The significance of institutions lies in their ability to restructure the rule of games, thereby incentivizing entrepreneurs to augment productive capacity (Rodrik, 2009: 189). Institutional structure is particularly important in countries that mostly export complex products (Demir and Hu, 2022: 1215-1216). This shows that as the economic structure and production processes become more complex, the importance of institutional arrangement increases (Lin and Nugent, 1995: 2313). An effective institutional structure will pave the way for technological advances and encourage the use of new technologies in the production process (Tebaldi and Elmslie, 2008: 49-50). Weak institutional frameworks elevate the costs associated with the launch of novel products and render the returns on innovation uncertain, thereby diminishing the appeal of high-risk investments (Silve and Plekhanov, 2018: 340). In other words, the direction of technological advances can be shaped on the basis of the incentive and constraint structure of institutions. Countries with strong economic institutions are expected to specialise in sectors with high levels of innovation.

However, as innovation emerges in a society, the institutional structure may be forced to change accordingly. For instance, as the economic and social benefits of technological advancements in the 19th century became clear, patenting institutions gained importance (Khan and Sokoloff, 2004: 2-3). This situation is also related to why institutions promote technological advances. The potential economic and social returns of technological innovations make them important to countries (Lundvall, 2010: 6). However, the importance of the expected outcome force institutions to change. Increases in welfare driven by advancements in productivity and competitiveness also lead to increased societal demands for institutional features such as equal opportunity and sustainable democracy (Friedman, 2008: 131-132).

The rule of law is a concept characterised by its ability to reduce risk, uncertainty, and transaction costs. It provides an effective legal framework that encompasses contract enforcement and the protection of property rights (Kaufmann et al., 2011: 233). It promotes the competitiveness of firms by encouraging the entrepreneurial class in society to channel capital into productive investment (D'Ingiullo et al., 2023: 548). The rule of law mitigate conflict and encourages cooperation between social actors by providing both deterrence and reassurance (Rodrik, 2009: 165-166). This is achieved through the establishment of a framework of incentives and constraints that ensure that all actors act within a delineated legal space.

A well-defined and effective legal framework and property rights help prevent rent seeking and corruption while also hindering expropriation (Chaudhry and Garner, 2007: 36). These factors are important for entrepreneurial capacity and investment. High-risk, large-scale investments seek an environment of trust and avoid uncertainty. This in turn affects productivity, technological advances, and competitiveness. Contract enforcement and the quality of the legal system are particularly prominent for complex products that are quality-based (Nunn, 2007: 570). Potential reasons for this include reducing uncertainty regarding investments and resolving disputes between conflicting actors (Levchenko, 2007: 791-795). The rule of law can play a role in the divergence of value-added production and the competitive advantage between countries.

3. Literature Review

3.1. Technological advances and value-added

Griliches (1986), the first comprehensive empirical study on this relationship, focuses on the link between R&D expenditures and value-added as a proxy for productivity in the US manufacturing industry. The analysis states that R&D expenditures provide high returns, which are relatively higher with basic research and private R&D expenditures. Hall and Mairesse (1995) employed a similar analysis to Griliches (1986) for the French manufacturing industry data. The findings show that while R&D has a positive impact on value-added per employee, this effect may also vary with firm-specific/sector-specific factors.

Tsang, Yip, and Toh (2008) investigated the link between R&D expenditures and value-added in Singapore. It is observed that the R&D effect yields better results in foreign firms than in domestic ones. Moreover, this effect plays a dominant role in technology-intensive sectors. Roper and Arvanitis (2012) established a relationship between product and process innovations and value-added per unit of labour, which is taken as a proxy for productivity. Employing analysis on data from Ireland and Switzerland, it is found that cost-based process innovations in Ireland and product innovations in Switzerland are important for productivity.

Türker and İnel (2013) comparatively analysed the relationship between innovation-driven activities and value-added levels in Turkey and 23 European countries. Descriptive and correlation analysis were employed using 2011 data. The study emphasises that in Turkey, where product innovation is particularly prominent, low R&D expenditures and a lack of skilled employment are behind low value-added production. Similarly, Chandran, KKV, and Devadason (2017) emphasise the effect of R&D and human capital on value-added and argue that the R&D effect varies depending on the type of R&D activities. Arjun et al. (2020) also draw attention to technology transfer.

Padula, Novelli, and Conti (2015) analysed the profitability and invention performance of 550 firms in nine countries. The study finds that firms' invention performance increases due to technological specialisation. However, due to market structure and commercialisation issues, the study finds that firm profitability remains relatively low. Related to this study, Woo, Jang, and Kim (2015) showed that R&D activities strengthened by intellectual property rights have a direct effect on value-added creation.

Soltmann, Stucki, and Woerter (2015) analysed the relationship between green inventions and innovation and industrial value-added for 12 countries. The analysis revealed a U-shaped relationship, indicating that sectors with a high stock of invention and innovation may benefit from the positive effects of green innovation.

Overall, the positive effect of R&D expenditures and activities on value-added seems cleared. However, the magnitude of this effect varies depending on several

R&D-related factors. In addition to property rights and a knowledge-oriented employment structure, knowledge property and technology transfer stand out as the factors driving the gains from R&D investments. Nonetheless, the firm production approach and sector-specific technology utilisation shape the expected returns on R&D expenditures.

3.2. Technological advances and competitiveness

The first comprehensive study that can be considered as a pioneering work in the literature is Fagerberg (1988). This paper differs from other studies of the era with its criticism of cost-oriented competitiveness and empirical analysis that provides evidence for technology-oriented competitiveness. Fifteen OECD countries were included in the analysis. This study shows that technology and productive capacity shaped by R&D and patent activities are the key determinants of competitiveness in the medium and long term. It is stated that the impact of unit labour cost is limited. Amendola et al. (1993) criticise the cost-oriented view of competition and consider Fagerberg's (1988) static analysis inadequate by emphasising the dynamic nature of competitiveness. Within the framework of the evolutionary approach, it is concluded that the "technological gap" directly affects foreign trade performance. The study covers 16 OECD countries. Besides the "technological gap" approach, Milberg and Houston (2005) highlight the concept of "social gap" and conclude that competitiveness based solely on technology would be insufficient.

Narula and Wakelin (1998) focus on technology in shaping competitiveness. Because of the analysis, technology-related factors were found to be effective in explaining both export performance and FDI flows. It is emphasised that this effect is more significant, especially for developing countries.

Gustavvson, Hansson, and Lundberg (1999) investigated the relationship between technology and competitiveness in OECD countries. The study finds that R&D activities, factor endowment, and prices affect competitiveness. This effect becomes stronger depending on sectoral technology utilisation. In contrast to this study, Dosi, Grazzi, and Moschella (2015) showed that product and process innovation, rather than cost-driven factors characterised by resource allocation and low-cost labour, have a significant effect on competitiveness. Consistent with these findings, Ollo-López and Aramendía-Muneta (2012) emphasise that ICTs that enhance the emergence of product and process innovation promote firm competitiveness.

Barge-Gil and Modrego (2011) employed a field study and regression analysis on Spanish firms. It is concluded that a research- and technology-oriented institutional structure increases firm competitiveness through factors such as learning, skill development, and knowledge sharing. Similarly, Ivanova et al. (2017) discussed the multidimensional relationship between economic complexity, which represents a global market trend, patent diversification, knowledge, and wealth creation. The study emphasises that the relationship is reflected in the national innovation system. Petrakis, Kostis, and Valsamis (2015) evaluated innovation with cultural structure and concluded that having a culture that promotes innovation positively affects economic performance and competitiveness.

Costantini and Mazzanti (2012) investigated the effect of environmental regulation and innovation on the competitiveness of EU15 countries. Green innovation policies and activities can result in a competitive advantage. Fankhauser et al. (2013) focussed on the sustainability of competitiveness through green transition. This study shows that countries may lose their existing market shares under conditions where innovative transitions towards the green economy do not occur. Fernando et al. (2021) analysed such a relationship in terms of circular economy and ecological innovations. A positive relationship was found between the market-oriented performance of recycled products and competitiveness.

Hchaichi and Ghodbane (2014) highlight that R&D expenditures and innovation through human capital are at the core of competitiveness. Similarly, Popkova, Gornostaeva, and Tregulova (2018) stated that innovative activities are the background of the competitive advantage in Russia, Belgium, and the Czech Republic. The analysis indicates that demand-driven radical innovations positively affect competitiveness. Supporting these results, Androniceanu et al. (2020)

found that more innovation-oriented investments lead to higher competitiveness and welfare levels. Dobrzański et al. (2021) investigated a similar relationship in African countries. It is emphasised that incremental increases in R&D expenditures are required for innovation-driven growth and competitiveness.

When the literature is considered as a whole, we come across a set of major findings. The first notable point is that studies on technology-oriented competitiveness accelerated in the 1990s and declined in the early 2000s. On the other hand, it is observed that the scale at which competition is considered may affect the results of the relationship between technological advances and competitiveness. As we move from national competitiveness to firm competitiveness, the impact of technology and non-technology factors varies. The findings indicate that, just as in value-added, social and institutional factors, policies and regulations should be considered as a whole in addition to technology in competitiveness. However, because of the dynamic nature of competition, innovative activities characterised by product and process innovations remain at the centre of competitiveness.

3.3. Selected literature on institutional effects

Within the broader framework of institutional literature, several key sub-components hold particular significance: the rule of law, control of corruption, regulatory quality, government effectiveness, and accountability. The rule of law is the most emphasised factor among these subcomponents. These factors have both constraining and stimulating roles and are heterogeneous. The relationship between institutions and technological advances/innovation is evident. Institutions affects transaction costs, cooperation, reallocation of resources, and reduction of uncertainty. Institutions both promote and drive innovation and play a dominant role in innovation/technology-intensive sectors. Technological transformation is also associated with institutional transformation. However, this relationship varies across countries, regions, and even sectors. It is influenced by the socioeconomic conditions of the country or region. Finally, for the incentive role of institutions to be prominent, they must be flexible. The following studies are summarised, with a focus on their major findings.

Nunn (2007) found that contract enforcement and the quality of the legal system are significantly related to relationship-specific investments. There is also evidence of specialisation in relation to these investments. Relationship-specific investments refer to investments in which an input is customised to the needs of the producer of the final good. Moreover, the results show that specialisation in certain industries fosters certain types of institutional structures. Focussing on institutional similarities, Demir and Hu (2022) make a similar finding. Countries that export complex products are highly sensitive to contract enforcement. A better contract structure leads to increased trade in these products with countries with similar institutions.

Ranjan and Lee (2007) concluded that contract enforcement and property rights are particularly crucial for quality-oriented sophisticated products (heterogeneous goods). This depends on the transaction costs and the sensitivity of the contract. Lin et al. (2021) also found that institutional factors play a role in exporting complex products although their effects vary.

Khandelwal, Schott, and Wei (2013) showed that there are significant productivity gains when the allocation of quotas enforced by inefficient institutions is reallocated (from a political to an auction-based allocation). The findings highlight the importance of institutions in reallocating resources. Sharma, Sousa, and Woodward (2022) stated that strict patent practises can have a negative impact on patenting activities in countries with low technological capabilities. However, they also note that strong institutions, such as intellectual property rights, are not sufficient to promote innovation in countries with weak innovative capacity. Krammer (2015) posits that institutional quality affects productivity through two channels: foreign direct investment and trade flows. The heterogeneous impact of institutions is emphasised.

Tebaldi and Elmslie (2013) investigated the relationship between institutions and innovation. The impact mechanism occurs through different channels such as knowledge diffusion, property rights, and uncertainty, all of which strengthen R&D activities. In the long run, the allocation of human capital emerges as a key element shaping institutions. Boudreaux (2017) argues that institutions promote innovation through two primary channels: creativity and knowledge. Enhancing the quality of the legal system fosters an environment that encourages creativity within the institutional framework. Conversely, promoting free trade stimulates knowledge creation.

Silve and Plekhunov (2018) claim that specialisation in innovation-intensive industries is common in countries with strong economic institutions. Specialisation in these industries has a positive impact on productivity. Levchenko (2007) argues that institutional dependence, particularly contracts and property rights, is a technological input to the production process in several industries. The quality of institutions determines the extent of the barriers to transactions that arise from production relations. Barbero et al. (2021) found that institutional quality has heterogeneous sectoral impacts, with institutional effectiveness particularly intensive in information and communication technologies (ICT) and financial and professional services.

Hu, Sun, and Dai (2021) found that environmental regulations can hinder technological advances and competition because of several factors, including uncertain functions and powers of authorities and regulatory rigidity. This highlights the importance of flexible and well-defined institutions. Yasmeen et al. (2023) emphasise the significance of environmental taxation and green technology for energy efficiency, highlighting the rule of law as a determinant in the implementation of green technology and tax reform.

D'Ingiullo et al. (2023) studied the relationship between domestic institutions and export performance in Italian regions. The rule of law was found to be effective only in the northern regions. This result implies that the socioeconomic and institutional characteristics of the regions as a whole tend to influence export performance. Agostino et al. (2020) investigated the role of institutions in business creation in Italian regions. Their findings demonstrate that the effectiveness of different institutions, such as the rule of law and regulatory quality, varies across regions. The study also concludes that the impact of institutions is reduced during crisis periods, when innovation, human capital, and infrastructure become more relevant.

4. Data and Methodology

In this paper, the relationship among the rule of law, technological advances, competitiveness, and value-added is tested through panel causality analysis. In this context, 29 countries that are indexed in the European Innovation Scoreboard (European Commission, 2022) and for which data access is available have been included in the analysis. These countries are listed in Appendix 1. The longest possible time interval has been selected to reflect both past and current country experiences, and the annual data from 1996 to 2020 has been selected for analysis. Within the framework of the analysis investigating bidirectional causality between variables, the following 10 models have been established and estimated:

Model 1: $CIP_{i,t} = \alpha_{0i} + \beta_{1i}RDI_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.1)*

Model 2: $RDI_{i,t} = \alpha_{0i} + \beta_{1i}CIP_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.2)*

Model 3: $MVA_{i,t} = \alpha_{0i} + \beta_{1i}RDI_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.3)*

Model 4: $RDI_{i,t} = \alpha_{0i} + \beta_{1i}MVA_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.4)*

Model 5: $CIP_{i,t} = \alpha_{0i} + \beta_{1i}ROL_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.5)*

Model 6: $ROL_{i,t} = \alpha_{0i} + \beta_{1i}CIP_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.6)*

Model 7: $MVA_{i,t} = \alpha_{0i} + \beta_{1i}ROL_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.7)*

Model 8: $ROL_{i,t} = \alpha_{0i} + \beta_{1i}MVA_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.8)*

Model 9: $RDI_{i,t} = \alpha_{0i} + \beta_{1i}ROL_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.9)*

Model 10: $ROL_{i,t} = \alpha_{0i} + \beta_{1i}RDI_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.10)*

In the models, $MVA_{i,t}$, $CIP_{i,t}$, $RDI_{i,t}$, and $ROL_{i,t}$ indicate manufacturing value-added production per capita of country *i* in year *t*, competitiveness score of country *i* in year *t*, R&D intensity of country *i* in year *t*, and the rule of law score of country *i* in year *t*, respectively. The share of research and development expenditures in gross domestic product, also known as R&D intensity, is employed to measure technological advances. On the other hand, manufacturing value-added production per capita is taken as a proxy for value-added, while the Competitive Industrial Performance (CIP) Index, developed by the United Nations Industrial Development Organisation (UNIDO), is taken as a proxy for competitiveness. The variable "the rule of law" is taken from the World

Governance Indicators. The rule of law score ranges from -2.5 to 2.5. A high score indicates a strong legal system, secure property rights, and effective contract enforcement. Table 1 provides the definitions and sources of these variables.

Table 1: Definition of variables

Variable	Definition	Source
MVA	Manufacturing value-added per capita (2015-$)	UNIDO
CIP	Competitive industrial performance score	UNIDO
RDI	R&D Intensity	OECD
ROL	The Rule of Law	World Bank

The models established within the framework of panel causality analysis are employed using the Dumitrescu and Hurlin (2012) causality test. Granger causality analysis evaluates the panel as a whole and ignores the potential causality relationship between cross-section units. Heterogeneity assumption emphasises that the causality that is valid for the panel may not be valid for all units (Dumitrescu and Hurlin, 2012: 1451). Therefore, employing panel causality analysis that considers heterogeneity enables more reliable and comprehensive results. In this context, Dumitrescu and Hurlin (2012) developed the Granger causality test for heterogeneous panels.

Within the framework of the test, the model based on two stationary variables is as follows:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} x_{i,t-k} + \varepsilon_{i,t} \qquad i: 1,....N \text{ and } t: 1,...,T \qquad \textit{(Eq.11)}$$

In Equation 11, y_{it} is the dependent variable and $x_{i,t-k}$ is the explanatory variable. $\gamma_i^{(k)}$ and $\beta_i^{(k)}$ denote autoregressive and slope parameters of the model, respectively, and these parameters differ across groups. Additionally, α_i, $\varepsilon_{i,t}$, and k denote the time-invariant constant of the model, error term, and lag order, respectively. Within the model, the null hypothesis states that there is no homogeneous causality between the variables, whereas the alternative hypothesis states that there may be heterogeneous causality for some of the cross-section units. The hypotheses are described as follows:

H_0: $\beta_i = 0$ $i=1,\ldots\ldots,N$
H_1: $\beta_i = 0$ $i=1,\ldots\ldots,N_1$
$\beta_i \neq 0$ $i=N_1 + 1, N_1 + 2,\ldots\ldots\ldots,N$

Under the null and alternative hypotheses, it is assumed that there is no causality for $N_1<N$. Although N_1 is unknown, the condition $0 \leq N_1/N<1$ is satisfied. In case $N_1>0$, there is a heterogeneous causality. In testing the null hypothesis, the average of Wald statistics calculated for the individuals is considered and the following two test statistics are computed.

$$Z_{N,T}^{HNC} = \sqrt{\frac{N}{2K}}\left(W_{N,T}^{HNC} - K\right) \xrightarrow{T,N \rightarrow \infty} N(0,1) \quad \textit{(Eq.12)}$$

$$\tilde{Z}_{N}^{HNC} = \frac{\sqrt{N}\left[W_{N,T}^{HNC} - N^{-1}\sum_{i=1}^{N} E\left(W_{i,T}\right)\right]}{\sqrt{N^{-1}\sum_{i=1}^{N} Var\left(W_{i,T}\right)}} \xrightarrow{N \rightarrow \infty} N(0,1) \quad \textit{(Eq.13)}$$

$Z_{N,T}^{HNC}$ gives strong results when N<T, but is likely to reject the null hypothesis as N tends to infinity. In the case of N>T, $\tilde{Z}_{N}^{HNC}$ is effective even in small samples. Because N (29) and T (25) are close to each other in the sample, both test results are reported.

5. Estimation Results

Before proceeding to panel causality analysis, it is important to perform selected diagnostic tests to verify the robustness of the estimates. CD, CD_{LM}, LM, and LM_{adj} tests were used to determine cross-sectional dependence. Among the two tests developed by Pesaran (2004), CD_{LM} test gives strong results in the case of N>T, while CD test is efficient when N and T tend to infinity. While Breusch and Pagan (1980) LM test is valid for N<T, Pesaran, Ullah, and Yamagata (2008) LM_{adj} test is robust when N and T tend to infinity. Although the sample size in the paper is N<T, with N (29) and T (25) being quite close to each other, it is considered appropriate to report the results of all tests. Table 2 shows the results of the cross-sectional dependence test. According to these results, the null hypothesis is rejected for all models, and it is concluded that there is cross-sectional dependence.

Table 2: Cross-sectional dependence test results

Test	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
LM	3666***	4190***	2278***	2233***	2063***	1999***	2625***	2452***	2610***	2269***
LM_{adj}	116***	136***	66***	65***	59***	57***	79***	72***	78***	66***
CD	181***	209***	75***	73***	50***	46***	180***	166***	121***	102***
CD_{LM}	114***	132***	65***	64***	58***	55***	77***	71***	77***	65***

Note: ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

Due to the presence of cross-sectional dependence, the stationarity of the variables is analysed with the Pesaran (2007) CADF test, which takes into account the cross-sectional dependence issue and is among the second generation panel unit root tests. Table 3 shows the results of the CADF unit root test. According to the test results, all variables are stationary in the first difference. In this context, the variables are included in the analysis considering their stationarity levels.

Table 3: CADF unit root test results

Değişken	Düzey	Fark
MVA	-1.480	-3.021***
CIP	-0.951	-3.135***
RDI	-1.827	-2.660***
ROL	-1.851	-3.553***

Note: ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively. According to the significance levels, the critical values are 2.300, 2.150, and 2.070. The values in the level and difference columns indicate t-bar test statistics.

Identifying the homogeneity of the model coefficients is important for the choice of methodology. Pesaran and Yamagata (2008) developed a test to analyse whether the slope coefficients differ across units. The null hypothesis of the test is that the slope coefficients are homogeneous. Table 4 shows the homogeneity test results. According to the results, the null hypothesis is rejected for both models, and the slope coefficients are heterogeneous.

Table 4: Homogeneity test results

Test	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Δ	35***	35***	32***	27***	19***	26***	15***	20***		20***
$\tilde{\Delta}_{adj}$	37***	38***	34***	29***	20***	28***	16***	22***	22***	22***

Note: ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively. Decimals are excluded to save space.

Considering the results of the diagnostic tests employed before panel causality analysis, it is feasible to employ Dumitrescu and Hurlin (2012) panel causality test. Table 5 shows both panel and cross-sectional results for all models.

When panel causality results are considered, it is found that there is bidirectional Granger causality between variables for panel except from value-added to rule of law. Both technological advances and the rule of law are Granger causes of competitiveness and value-added. In addition, there is a bidirectional causality relationship between the rule of law and technological advances. The results show a multidirectional relationship between the variables.

When examining cross-sectional findings, it becomes clear that the effects of technological advances and the rule of law vary among countries. On the other hand, the effect of technological advances and the rule of law on value-added and competitiveness emerges independently of the countries' level of development. This finding is consistent with studies that indicate technological advances and the rule of law on countries' production and foreign trade performance exhibiting a heterogeneous structure in terms of development (see Amendola et al., 1993; Dosi et al., 2015; Demir and Hu, 2022).

To take it separately, the effect of technological advances on competitiveness and value-added production differs across countries. Cyprus, France, Israel, Lithuania, Poland, and Romania have strong links between technological advances and value added/competitiveness. On the other hand, the relationship between the rule of law and value-added/competitiveness is strong in Czechia, Ireland, Romania, and Turkiye. Considering the rule of law and technological advances together, they jointly affect competitiveness in five countries and value added in six. The common effect is achieved through both competitiveness and value-added in Czechia, Lithuania, Romania, and Turkiye. Among these countries, the causality relationship between the rule of law to technological advances is found to be significant only for Czechia, Lithuania, and Turkiye. For these countries, the relationship between the rule of law, technological development, competitiveness, and value-added is evident. For other countries, the findings vary in terms of

Table 5: Dumitrescu-Hurlin Panel Causality Test Results

	rdi→cip		cip→rdi		rdi→mva		mva→rdi		rol→cip		cip→rol		rol→mva		mva→rol		rol→rdi		rdi→rol	
CS	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**
AUT	2.93	→	5.59	→*	2.40	→	18.55	→***	1.72	→	1.48	→	0.00	→	3.70	→*	2.27	→	1.15	→
BEL	0.00	→	1.52	→	0.10	→	0.33	→	0.03	→	1.25	→	0.22	→	0.49	→	0.04	→	2.92	→*
BGR	4.24	→**	0.77	→	2.25	→	0.04	→	0.08	→	1.43	→	0.26	→	0.19	→	0.12	→	0.14	→
CYP	6.87	→***	0.00	→	9.63	→***	13.90	→***	0.20	→	0.69	→	1.65	→	9.02	→***	3.34	→*	5.70	→**
CZE	3.54	→*	2.11	→	3.93	→**	0.25	→	83.34	→***	2.23	→	6.76	→***	0.05	→	4.04	→**	0.65	→
DNK	0.16	→	8.22	→***	0.54	→	0.33	→	0.48	→	0.97	→	0.67	→	1.92	→	0.06	→	3.85	→**
FIN	24.70	→***	7.27	→***	5.64	→*	0.04	→	8.33	→***	0.56	→	0.20	→	0.16	→	11.16	→***	17.42	→***
FRA	8.18	→***	0.04	→	5.45	→**	0.00	→	0.59	→	0.58	→	0.03	→	0.28	→	0.88	→	0.24	→
DEU	1.77	→	4.44	→**	7.76	→***	3.20	→*	4.97	→**	0.54	→	0.34	→	0.00	→	0.95	→*	0.17	→
GRC	3.44	→*	0.71	→	5.47	→*	0.28	→	2.00	→	4.07	→**	7.16	→**	6.94	→**	0.13	→	0.61	→
HUN	0.12	→	5.61	→**	1.35	→	2.20	→	0.07	→	6.39	→**	0.25	→	1.82	→	5.58	→**	0.06	→
IRL	1.22	→	8.08	→***	0.10	→	1.0	→	20.25	→***	5.98	→**	30.67	→***	0.49	→	21.40	→***	3.75	→
ISR	19.49	→***	0.75	→	19.88	→***	6.52	→*	0.17	→	0.21	→	1.62	→	2.63	→	0.03	→	1.07	→
ITA	0.85	→	8.42	→***	2.72	→*	5.97	→**	1.62	→	0.01	→	0.01	→	2.43	→	1.84	→	0.17	→
LVA	11.05	→***	2.78	→	3.57	→*	0.98	→	1.82	→	0.26	→	5.36	→**	0.11	→	1.30	→	7.69	→***
LTU	6.85	→***	0.04	→	8.03	→***	0.07	→	9.55	→***	1.00	→	3.20	→*	0.00	→	12.43	→***	0.28	→
NLD	0.17	→	11.86	→***	0.98	→	3.49	→*	5.15	→**	4.05	→**	0.39	→	0.93	→	20.37	→***	0.82	→
NOR	2.19	→	8.69	→***	6.44	→**	4.37	→**	1.06	→	0.01	→	0.05	→	0.75	→	0.16	→	4.99	→**
POL	7.61	→***	11.12	→***	8.50	→***	11.66	→***	0.28	→	0.32	→	0.34	→	0.37	→	0.06	→	1.47	→
PRT	5.96	→*	1.39	→	5.21	→**	0.36	→	0.07	→	0.07	→	0.84	→	0.50	→	0.06	→	5.28	→**
ROU	5.22	→**	1.00	→	4.39	→**	3.42	→*	5.28	→**	3.89	→**	6.19	→**	0.04	→	0.00	→	2.18	→
SRB	4.47	→**	0.52	→	0.91	→	0.00	→	0.35	→	5.60	→**	4.50	→**	3.21	→*	0.68	→	2.59	→
SVK	2.56	→	1.97	→	2.21	→	0.03	→	4.93	→**	1.97	→	3.22	→*	1.12	→	0.00	→	2.19	→
SVN	8.64	→***	2.89	→*	1.85	→*	0.00	→	1.85	→	14.27	→***	0.98	→	1.29	→	6.05	→	3.30	→
ESP	0.17	→	3.27	→*	11.51	→***	20.24	→***	3.68	→*	0.16	→	0.73	→	2.49	→	0.77	→	0.28	→
SWE	0.05	→	1.03	→	0.05	→	0.04	→	3.69	→*	0.44	→	1.81	→	0.02	→	0.92	→	6.21	→**
TUR	3.76	→*	1.26	→	12.18	→***	6.69	→*	4.73	→**	1.99	→	9.39	→***	2.02	→	4.70	→**	0.00	→
UKR	1.05	→	2.48	→	0.55	→	1.47	→	0.03	→	2.42	→	1.80	→	2.23	→	4.25	→	9.03	→**
GBR	3.73	→*	3.54	→*	1.70	→	1.44	→	1.18	→	1.50	→	1.11	→	0.12	→	2.92	→*	0.44	→
$Z_{N,T}^{HNC}$	13.30	→***	9.16	→***	11.44	→***	8.14	→***	16.37	→***	3.88	→***	7.23	→***	1.68	→	8.09	→***	5.55	→***
$\tilde{Z}_{N}^{HNC}$	10.47	→***	7.10	→***	8.75	→***	6.11	→***	12.97	→***	2.79	→***	5.60	→***	1.02	→	6.07	→***	4.04	→***

Note: The test statistics denote $W_{i,T}$ for cross-sections and and for the panel. The maximum lag order is three, and the Schwarz information criteria are considered. ***, **, * indicate significance 1%, 5%, and 10% levels, respectively. *CS: Cross Section. Caus.: Causality. Lag lengths are not included to save place.*

technological development and the rule of law. The causal relationship between competitiveness/value-added and technological advance and rule of law shows a similar divergence, except for the relationship between value added and rule of law.

A number of factors affecting cross-country divergence have been considered in the literature review. These include market structure (Padula et al., 2015), social and institutional factors (Demir and Hu, 2022; Milberg and Houston, 2005), the nature of R&D activities (Chandran et al., 2017), changes in their cyclical effects (Soltmann et al., 2015), and innovation culture (Petrakis et al., 2015), and sector-specific factors (Hall and Mairesse, 1995). As an essential proxy for institutions, this study considers the rule of law as a possible factor of cross-country divergence. The findings showed that the analysis revealed significant results for several countries.

Institutions and technological innovation are the drivers of long-term economic performance (Fagerberg, 1988; Rodrik, 2009). However, a number of factors influence the channels of interaction for both technological advances and institutions. First, both the lagged effects of R&D activities (van Elk et al., 2019) and the changing nature of institutions over a long period of time (Williamson, 1998) may require a longer time-dimensional analysis of economic performance. Second, it is difficult to directly observe the effects of R&D activities and institutions. Institutions are often perceptive (Rodrik, 2009), and R&D is mostly embodied in product and process innovation. Third, the impact of institutions may also vary across regions and sectors (D'Ingiullo et al., 20-23; Levchenko, 2007). Therefore, further regional or sectoral analysis would be valuable in better understanding the interaction between variables in question.

6. Conclusions

The production and competitive landscape characterised by economic complexity drives nations to endlessly search for new opportunities. Technological advances and innovations are at the core of economic transition and performance. However, country-specific factors are at least as important as technological advances in terms of determining the direction and intensity of technology. Institutions are important both in their ability to direct technological advances and in affecting productivity. In this context, this study aims to analyse the relationship between technological development, value added and competitiveness across countries, considering institutions. The findings show that both technological advances and the rule of law are Granger causes of value added and competitiveness. However, this causality relationship diverges irrespective of a country's economic outlook. These results support the existence of cross-country divergence. In some countries, it appears that institutions and technological advances are related. On the other hand, the results also show that, in addition to institutions, other country-specific factors must be considered. In this context, technology-centred economic policy, considering these other factors in policy design processes, is crucial for unlocking and sustaining economic performance and gains from foreign trade.

Ethics Committee Approval: N/A.
Peer-review: Externally peer-reviewed.
Author Contributions: Conception/Design of Study- D.K., A.R.S.; Data Acquisition- D.K.; Data Analysis/Interpretation- D.K.; Drafting Manuscript- D.K., A.R.S.; Critical Revision of Manuscript- D.K., A.R.S.; Final Approval and Accountability- D.K., A.R.S.
Conflict of Interest: The authors have no conflict of interest to declare.
Grant Support: The authors declared that this study has received no financial support.

References

Acemoğlu, D., & Robinson, J. A. (2000). Political losers as a barrier to economic development. *American Economic Review*, *90*(2), 126-130. DOI: 10.1257/aer.90.2.126.

Aghion, P., & Howitt, P. (1992). A model of growth through creative destruction. *Econometrica, 60*(2), 323-351. https://doi.org/10.2307/2951599.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P. (2005). Competition and innovation: An inverted-U relationship. *The quarterly journal of economics*, *120*(2), 701-728. https://doi.org/10.1093/qje/120.2.701.

Agostino, M., Nifo, A., Trivieri, F., & Vecchione, G. (2020). Rule of law and regulatory quality as drivers of entrepreneurship. *Regional Studies*, *54*(6), 814-826. https://doi.org/10.1080/00343404.2019.1648785.

Aiginger, K. (1998). A framework for evaluating the dynamic competitiveness of countries. *Structural change and economic dynamics*, *9*(2), 159-188. https://doi.org/10.1016/S0954-349X(97)00026-X

Amendola, G., Dosi, G., & Papagni, E. (1993). The dynamics of international competitiveness. *Weltwirtschaftliches Archiv*, *129*(3), 451-471. https://doi.org/10.1007/BF02707997.

Androniceanu, A. M., Kinnunen, J., Georgescu, I., & Androniceanu, A. (2020). A multidimensional approach to competitiveness, innovation and well-being in the EU using canonical correlation analysis. *Journal of Competitiveness*, *12*(4), 5-21. https://doi.org/10.9770/ird.2019.1.1(3).

Arjun, K., Sankaran, A., Kumar, S., & Das, M. (2020). An endogenous growth approach on the role of energy, human capital, finance and technology in explaining manufacturing value-added: A multi-country analysis. *Heliyon*, *6*(7), e04308. doi.org/10.1016/j.heliyon.2020.e04308.

Ayres, R. U. (1990). Technological transformations and long waves Part I. *Technological Forecasting and Social Change*, *37*(1), 1-37. doi.org/10.1016/0040-1625(90)90057-3.

Barbero, J., Mandras, G., Rodríguez-Crespo, E., & Rodríguez-Pose, A. (2021). Quality of government and regional trade: evidence from European Union regions. *Regional Studies*, *55*(7), 1240-1251.

Barge-Gil, A., & Modrego, A. (2011). The impact of research and technology organizations on firm competitiveness. Measurement and determinants. *The Journal of Technology Transfer*, *36*, 61-83. https://doi.org/10.1007/s10961-009-9132-4.

Baumann, J., & Kritikos, A. S. (2016). The link between R&D, innovation and productivity: Are micro firms different?. *Research Policy*, *45*(6), 1263-1274. https://doi.org/10.1016/j.respol.2016.03.008.

Baumol, W. J. (1996). Entrepreneurship: Productive, unproductive, and destructive. *Journal of Business Venturing*, *11*(1), 3-22. https://doi.org/10.1016/0883-9026(94)00014-X.

Boudreaux, C. J. (2017). Institutional quality and innovation: some cross-country evidence. *Journal of Entrepreneurship and Public Policy*, *6*(1), 26-40. https://doi.org/10.1108/JEPP-04-2016-0015.

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange multiplier test and its applications to model specification in econometrics. *The Review of Economic Studies*, *47*(1), 239-253. https://doi.org/10.2307/2297111.

Camiňa, E., Diaz-Chao, A., & Torrent-Sellens, J. (2020). Automation technologies: Long-term effects for Spanish industrial firms. *Technological Forecasting and Social Change*, *151*, 119828. doi.org/10.1016/j.techfore.2019.119828.

Chandran, V. G. R., KKV, G. K., & Devadason, E. S. (2017). Value-added performance in Malaysian manufacturing: to what extent research and development and human capital matter?. *Institutions and Economies*, *9*(4), 31-51.

Chaudhry, A., & Garner, P. (2007). Do governments suppress growth? Institutions, rent-seeking, and innovation blocking in a model of Schumpeterian growth. *Economics & Politics*, *19*(1), 35-52. https://doi.org/10.1111/j.1468-0343.2007.00301.x.

Chikán, A. (2008). National and firm competitiveness: a general research model. *Competitiveness Review: An International Business Journal*, *18*(1/2), 20-28. doi.org/10.1108/10595420810874583.

Costantini, V., & Mazzanti, M. (2012). On the green and innovative side of trade competitiveness? The impact of environmental policies and innovation on EU exports. *Research Policy*, *41*(1), 132-153. https://doi.org/10.1016/j.respol.2011.08.004.

D'Ingiullo, D., Di Berardino, C., Odoardi, I., & Quaglione, D. (2023). Rule of law as a determinant of the export performance of Italian provinces. *Journal of Institutional Economics*, *19*(4), 548-563. https://doi.org/10.1017/S1744137422000480.

Demir, F., & Hu, C. (2022). Institutional similarity, firm heterogeneity and export sophistication. *The World Economy*, *45*(4), 1213-1241. https://doi.org/10.1111/twec.13201.

Dobrzański, P., Bobowski, S., Chrysostome, E., Velinov, E., & Strouhal, J. (2021). Toward innovation-driven competitiveness across African countries: an analysis of efficiency of R&D expenditures. *Journal of Competitiveness*, *13*(1), 5-22. http://dx.doi.org/10.7441/joc.2021.01.01.

Dosi, G., Pavitt, K., & Soete, L. (1990). *The Economics of Technical Change.* New York: Harvester.

Dosi, G., Grazzi, M., & Moschella, D. (2015). Technology and costs in international competitiveness: From countries and sectors to firms. *Research Policy*, *44*(10), 1795-1814. https://doi.org/10.1016/j.respol.2015.05.012.

Dosi, G., & Nelson, R. R. (2010). Technıcal change and industrial dynamics as evolutionary processes. In B. H. Hall & N. Rosenberg (Eds.). *Handbook of The Economics of Innovation, Vol.1.* Oxford: North-Holland.

Dumitrescu, E. I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. *Economic Modelling*, *29*(4), 1450–1460. doi.org/10.1016/j.econmod.2012.02.014.

Erkan, B., & Yildirimci, E. (2015). Economic complexity and export competitiveness: The case of Turkey. *Procedia-Social and Behavioral Sciences*, *195*, 524-533. https://doi.org/10.1016/j.sbspro.2015.06.262.

European Commission (2021). *Updating the 2020 new industrial strategy: building a stronger single market for Europe's recovery.* Brussels: European Commission.

European Commission (2022). *European innovation scoreboard 2022.* Luxembourg: Publications Office of the European Union.

Fagerberg, J. (1988). International competitiveness. *The Economic Journal*, *98*(391), 355-374. https://doi.org/10.2307/2233372.

Fagerberg, J. (1996). Technology and competitiveness. *Oxford Review of Economic Policy*, *12*(3), 39-51. doi.org/10.1093/oxrep/12.3.39.

Fankhauser, S., Bowen, A., Calel, R., Dechezleprêtre, A., Grover, D., Rydge, J., & Sato, M. (2013). Who will win the green race? In search of environmental competitiveness and innovation. *Global Environmental Change*, *23*(5), 902-913. https://doi.org/10.1016/j.gloenvcha.2013.05.007.

Fernando, Y., Tseng, M. L., Sroufe, R., Abideen, A. Z., Shaharudin, M. S., & Jose, R. (2021). Eco-innovation impacts on recycled product performance and competitiveness: Malaysian automotive industry. *Sustainable Production and Consumption*, *28*, 1677-1686. doi.org/10.1016/j.spc.2021.09.010.

Friedman, B. M. (2008). Economic well-being in a historical context. In Pecchi, L., & Piga, G. (Eds.). *Revisiting Keynes: economic possibilities for our grandchildren*. London: MIT Press.

Filo, C. (2007). Territorial competitiveness and the human factors. *International Conference of Territorial Intelligence*, 323-336.

Galindo-Rueda, F., & Verger, F. (2016). OECD taxonomy of economic activities based on r&d intensity. *OECD Science, Technology and Industry Working Papers 2016/04.* dx.doi.org/10.1787/5jlv73sqqp8r-en.

Gandolfo, G., & Trionfetti, F. (2014). *International trade theory and policy*. Berlin, Heidelberg, New York: Springer.

Goldin, C., & Katz, L. F. (1998). The origins of technology-skill complementarity. *The Quarterly Journal of Economics*, *113*(3), 693-732. https://doi.org/10.1162/003355398555720.

Griliches, Z. (1986). Productivity, r&d, and basic research at the firm level in the 1970's. *The American Economic Review*, *76*(1), 141-154.

Grossman, G. M., & Helpman, E. (1991). *Innovation and growth in the global economy.* Cambridge: The MIT Press.

Gustavsson, P., Hansson, P., & Lundberg, L. (1999). Technology, resource endowments and international competitiveness. *European Economic Review*, *43*(8), 1501-1530. https://doi.org/10.1016/S0014-2921(98)00027-0.

Haggard, S., MacIntyre, A., & Tiede, L. (2008). The rule of law and economic development. *Annual Review of Political Science*, *11*, 205-234. https://doi.org/10.1146/annurev.polisci.10.081205.100244.

Hall, R. E., & Jones, C. I. (1999). Why do some countries produce so much more output per worker than others?. *The Quarterly Journal of Economics*, *114*(1), 83-116. https://doi.org/10.1162/003355399555954.

Hall, B. H., & Mairesse, J. (1995). Exploring the relationship between R&D and productivity in French manufacturing firms. *Journal of Econometrics*, *65*(1), 263-293. https://doi.org/10.1016/0304-4076(94)01604-X.

Harvard Growth Lab (2023). *The atlas of economic complexity database.* https://atlas.cid.harvard.edu/rankings.

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., & Simoes, A. (2014). *The atlas of economic complexity: Mapping paths to prosperity*. The Mit Press.

Hausmann, R., Hwang, J., & Rodrik, D. (2007). What you export matters. *Journal of Economic Growth*, *12*, 1-25. DOI 10.1007/s10887-006-9009-4.

Hchaichi, R., & Ghodbane, S. B. (2014). Empirical analysis of determinants of international competitiveness. *International Journal of Business and Social Science*, *5*(5), 203-209.

Hu, Y., Sun, S., & Dai, Y. (2021). Environmental regulation, green innovation, and international competitiveness of manufacturing enterprises in China: From the perspective of heterogeneous regulatory tools. *PLoS One*, *16*(3), e0249169. https://doi.org/10.1371/journal.pone.0249169.

IMD (2020). *IMD World competitiveness booklet.* Lausanne: International Institute for Management Development.

Ivanova, I., Strand, Ø., Kushnir, D., & Leydesdorff, L. (2017). Economic and technological complexity: A model study of indicators of knowledge-based innovation systems. *Technological Forecasting and Social Change*, *120*, 77-89. https://doi.org/10.1016/j.techfore.2017.04.007.

Kafouros, M. I. (2005). R&D and productivity growth: Evidence from the UK. *Economics of Innovation and New Technology*, *14*(6), 479-497. https://doi.org/10.1080/1043859042000269098.

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2011). The worldwide governance indicators: Methodology and analytical issues. *Hague Journal on the Rule of Law*, *3*(2), 220-246. https://doi.org/10.1017/S1876404511200046.

Khan, B. Z., & Sokoloff, K. L. (2004). *Institutions and technological innovation during the early economic growth: evidence from the great inventors of the United States, 1790-1930.* National Bureau of Economic Research No. w10966.

Khandelwal, A. K., Schott, P. K., & Wei, S. J. (2013). Trade liberalization and embedded institutional reform: Evidence from Chinese exporters. *American Economic Review*, *103*(6), 2169-2195.

Krammer, S. M. (2015). Do good institutions enhance the effect of technological spillovers on productivity? Comparative evidence from developed and transition economies. *Technological Forecasting and Social Change*, *94*, 133-154. http://dx.doi.org/10.1016/j.techfore.2014.09.002.

Lall, S. (2000). The technological structure and performance of developing country manufactured exports, 1985-98. *Oxford Development Studies*, *28*(3), 337-369. https://doi.org/10.1080/713688318.

Lentz, R., & Mortensen, D. T. (2008). An empirical model of growth through product innovation. *Econometrica*, *76*(6), 1317-1373. doi.org/10.3982/ECTA5997.

Levchenko, A. A. (2007). Institutional quality and international trade. *The Review of Economic Studies*, *74*(3), 791-819. https://doi.org/10.1111/j.1467-937X.2007.00435.x.

Lin, Y., Lin, S., Wang, X., & Wu, J. (2021). Does institutional quality matter for export product quality? Evidence from China. *The Journal of International Trade & Economic Development*, *30*(7), 1077-1100.

Lin, J. Y., & Nugent, J. B. (1995). Institutions and economic development. *Handbook of Development Economics*, *3A*, 2301-2370. https://doi.org/10.1016/S1573-4471(05)80010-5.

Lundvall, B. (2010). *National systems of innovation: toward a theory of innovation and interactive learning.* London: The Anthem Press.

Milberg, W., & Houston, E. (2005). The high road and the low road to international competitiveness: Extending the neo-Schumpeterian trade model beyond technology. *International Review of Applied Economics*, *19*(2), 137-162. https://doi.org/10.1080/02692170500031646.

Mokyr, J. (1992). *The lever of riches: technological creativity and economic progress.* New York: Oxford University Press.

Narula, R., & Wakelin, K. (1998). Technological competitiveness, trade and foreign direct investment. *Structural Change and Economic Dynamics*, *9*(3), 373-387. https://doi.org/10.1016/S0954-349X(98)00034-4.

North, D. C. (1991). Institutions, *Journal of Economic Perspectives*, *5*(1), 97-112.

Nunn, N. (2007). Relationship-specificity, incomplete contracts, and the pattern of trade. *The Quarterly Journal of Economics*, *122*(2), 569-600. https://doi.org/10.1162/qjec.122.2.569.

OECD (2023). *OECD.ai policy observatory database. https://oecd.ai/en/trends-and-data.*

Ollo-López, A., & Aramendía-Muneta, M. E. (2012). ICT impact on competitiveness, innovation and environment. *Telematics and Informatics*, *29*(2), 204-210. https://doi.org/10.1016/j.tele.2011.08.002.

Padula, G., Novelli, E., & Conti, R. (2015). SMEs inventive performance and profitability in the markets for technology. *Technovation*, *41*, 38-50. doi.org/10.1016/j.technovation.2015.01.002.

Pesaran, M. H. (2004). *General diagnostic tests for cross section dependence in panels*. CESifo Working Paper No. 1229.

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, *22*(2), 265-312. https://doi.org/10.1002/jae.951.

Pesaran, M. H., Ullah, A., & Yamagata, T. (2008). A bias-adjusted LM test of error cross-section independence. *The Econometrics Journal*, *11*(1), 105-127. https://doi.org/10.1111/j.1368-423X.2007.00227.x.

Pesaran, M. H., & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of Econometrics*, *142*(1), 50-93. https://doi.org/10.1016/j.jeconom.2007.05.010.

Petrakis, P. E., Kostis, P. C., & Valsamis, D. G. (2015). Innovation and competitiveness: Culture as a long-term strategic instrument during the European Great Recession. *Journal of Business Research*, *68*(7), 1436-1438. https://doi.org/10.1016/j.jbusres.2015.01.029.

Popkova, E., Gornostaeva, Z., & Tregulova, N. (2018). Role of innovations in provision of competitiveness and innovational development of economy and overcoming of "underdevelopment whirlpools" in Russia and countries of Eastern Europe. *Journal of Entrepreneurship in Emerging Economies*, *10*(3), 511-523. doi.org/10.1108/JEEE-12-2017-0100.

Posner, M. V. (1961). International trade and technical change. *Oxford Economic Papers*, *13*(3), 323-341. https://doi.org/10.1093/oxfordjournals.oep.a040877.

Ranjan, P., & Lee, J. Y. (2007). Contract enforcement and international trade. *Economics & Politics*, *19*(2), 191-218. https://doi.org/10.1111/j.1468-0343.2007.00308.x.

Rodrik, D. (2009). *One Economics, Many Recipes.* Princeton and Oxford: Princeton University Press.

Roper, S., & Arvanitis, S. (2012). From knowledge to added value: A comparative, panel-data analysis of the innovation value chain in Irish and Swiss manufacturing firms. *Research Policy*, *41*(6), 1093-1106. doi.org/10.1016/j.respol.2012.03.002.

Silve, F., & Plekhanov, A. (2018). Institutions, innovation and growth: Evidence from industry data. *Economics of Transition*, *26*(3), 335-362. https://doi.org/10.1111/ecot.12148.

Schwab, K. (2010). *The Global competitiveness report 2010-2011.* Geneva: World Economic Forum.

Sharma, A., Sousa, C., & Woodward, R. (2022). Determinants of innovation outcomes: The role of institutional quality. *Technovation*, *118*, 102562. https://doi.org/10.1016/j.technovation.2022.102562.

Soltmann, C., Stucki, T., & Woerter, M. (2015). The impact of environmentally friendly innovations on value added. *Environmental and Resource Economics*, *62*, 457-479. doi.org/10.1007/s10640-014-9824-6.

T.C. Strateji ve Bütçe Başkanlığı (2019). *On birinci kalkınma planı (2019-2023).* Ankara: Strateji ve Bütçe Başkanlığı Yayınları.

Tebaldi, E., & Elmslie, B. (2008). Institutions, innovation and economic growth. *Journal of Economic Development*, *33*(2), 27. http://dx.doi.org/10.35866/caujed.2008.33.2.002.

Tebaldi, E., & Elmslie, B. (2013). Does institutional quality impact innovation? Evidence from cross-country patent grant data. *Applied Economics*, *45*(7), 887-900. https://doi.org/10.1080/00036846.2011.613777.

Tsang, E. W., Yip, P. S., & Toh, M. H. (2008). The impact of R&D on value added for domestic and foreign firms in a newly industrialized economy. *International Business Review*, *17*(4), 423-441. https://doi.org/10.1016/j.ibusrev.2008.02.005.

Türker, M. V., & İnel, M. N. (2013). Is it enough to be entrepreneurial? enhancing the 'Value added'created by SMEs in turkey through innovation. *Procedia-Social and Behavioral Sciences*, *75*, 397-406. doi.org/10.1016/j.sbspro.2013.04.044.

UNIDO (2023). *UNIDO Statistics Data Portal. https://stat.unido.org/.*

United Nations (2009). *System of national accounts 2008.* New York: United Nations.

Van Elk, R., ter Weel, B., van der Wiel, K., & Wouterse, B. (2019). Estimating the returns to public R&D investments: Evidence from production function models. *De Economist*, *167*, 45-87. https://doi.org/10.1007/s10645-019-09331-3.

Williamson, O. E. (1998). The institutions of governance. *The American Economic Review*, *88*(2), 75-79.

Woo, S., Jang, P., & Kim, Y. (2015). Effects of intellectual property rights and patented knowledge in innovation and industry value added: A multinational empirical analysis of different industries. *Technovation*, *43*, 49-63. doi.org/10.1016/j.technovation.2015.03.003.

Yasmeen, R., Zhang, X., Tao, R., & Shah, W. U. H. (2023). The impact of green technology, environmental tax and natural resources on energy efficiency and productivity: Perspective of OECD Rule of Law. *Energy Reports*, *9*, 1308-1319.

Zheng, L., Abbasi, K. R., Salem, S., Irfan, M., Alvarado, R., & Lv, K. (2022). How technological innovation and institutional quality affect sectoral energy consumption in Pakistan?: Fresh policy insights from novel econometric approach. *Technological Forecasting and Social Change*, *183*, 121900. doi.org/10.1016/j.techfore.2022.121900.

Appendix-1: Countries in the analysis

Austria (AUT)	*Belgium (BEL)*	*Bulgaria (BGR)*	*Cyprus (CYP)*	*Czechia (CZE)*	*Denmark (DNK)*	*Finland (FIN)*	*France (FRA)*
Germany (DEU)	*Greece (GRC)*	*Hungary (HUN)*	*Ireland (IRL)*	*Israel (ISR)*	*Italy (ITA)*	*Latvia (LVA)*	*Lithuania (LTU)*
Netherlands (NLD)	*Norway (NOR)*	*Poland (POL)*	*Portugal (PRT)*	*Romania (ROU)*	*Serbia (SRB)*	*Slovakia (SVK)*	*Slovenia (SVN)*
Spain (ESP)	*Sweden (SWE)*	*Turkiye (TUR)*	*Ukraine (UKR)*	*United Kingdom (GBR)*			