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The Interactive Effect of Investment Environment and Research and Development (R&D) on Productive Capacities

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Abstract

Capacity building in production is a potential factor for developing production value, due to the availability of facilities to increase production. Therefore, creating new productive capacities or methods for developing them has always been a topic of interest to economists. Hence, the need for research in the field of identifying factors affecting production facilities in different countries seems essential. One of the requirements for improving productive capacities is investment, which has a direct impact on equipment, facilities, and preparations for starting and expanding the production process, and also has an effect on production capacities. Therefore, this study examines the components of the investment environment on the productive capacity index in selected developing and developed countries during the period 2007-2023 using the Ordinary Least Squares (OLS) approach. Also, in order to examine the effect of knowledge development levels on productive capacity, the interaction of R&D with investment environment indicators on production capacities has been used. The results of the study indicate that in developed countries, the effects of the investment environment index's components and the interactive R&D index on production capacities is positive, but in developing countries, the effect of the two indicators of investor protection and restrictions on international investment on productive capacity is negative. Also, the estimated coefficients of the R&D interactive effect with the components of the investment environment index in all estimated cases are higher in developing countries than in developed countries.

Keywords: Productive Capacity, Investment Environment, Property Rights, Financing Ecosystem, Contract Enforcement, Research and Development (R&D).

JEL Classification: D24, E22, D23, G23, L14, O32.

1. Introduction

Capacity building for production has always been considered as one of the important concerns of politicians and economists at the macro level. Access to higher levels of production capacities by providing structures commensurate with the quantitative and qualitative increase in production, enables the achievement of higher levels of public welfare through the expansion of production facilities and, consequently, the production promotion. Therefore, complete understanding and research in the field of recognizing production capacities and the factors affecting them is important. Many researchers believe that increasing investment, although not a sufficient condition, is a necessary condition for achieving the growth and development of a region or country. Given the limited investment resources in various industries, especially in developing countries, it seems that defining the necessary mechanisms through legal policies and basic guidelines can facilitate the creation of investment capacities and incentives to start or increase investment. Strengthening investment attraction capacities is important due to its "volatile" nature. During periods of economic growth, investments increase, while during periods of recession, investments can fall rapidly. Due to its highly volatile nature, investments are a key macroeconomic variable. At the same time, investments determine the growth of the capital stock and play a central role in the development of the economy's productive capacity in the long run, as well as productivity and technological progress (Bofinger, 2019 and Hein, 2023). Bourveau et al (2025) examine the effect of investor protection regulations among companies listed on the Shanghai Stock Exchange of China in 2012 and state that investor protection in the form of relevant regulations expands financial activity by reducing shareholder costs and, as a result, enhances the added value of service/manufacturing firms. Ketelaars and Kort (2025) consider a sequential investment project that starts with the product innovation stage and subsequently, after the completion of Research and Development, the production stage begins. Therefore, investment decisions include the timing and size of R&D investment and the size of productive capacity. The results of the study show that from a social welfare perspective, R&D projects are often started too late and productive capacity is too low. Subsidizing R&D investment is more effective in reducing these welfare losses than subsidizing productive capacity. Xiong et al. (2025), in their study, examine the critical challenge of balancing energy supply, investment efficiency, and profitability during the transition of natural gas companies to integrated energy systems with higher levels of knowledge and innovation “natural gas+”. Scenario analysis shows that this transition to higher levels of innovation, coupled with increased levels of access to investment, balances competitive objectives and leads to a 14% improvement in energy supply and a 19% increase in profitability. Pal et al. (2024) examine the interrelated effects of geopolitical risk on productive capacity (as a measure of business cycles) in 20 OECD countries from 2000 to 2021. The results show a negative impact of geopolitical risk on productive capacity. The study also reveals a synergistic relationship, showing that the combined effect of globalization and geopolitical risk can enhance productive capacity under certain conditions. Government effectiveness and innovation also have positive effects on productive capacities. Cole (2023) uses econometric and mathematical economics tools to prove that if the central bank does not fix the interest rate at the full employment rate implied by classical economic theory, despite efforts to maintain productive capacities, unemployment will increase by encouraging the exploitation of labor by capital. Donis et al. (2023), in their study, analyze the determinants of production at the country level to help understand the drivers of environmental innovation and focus on the specific characteristics of innovations and explain how these characteristics affect production incentives. Then, they examine the effect of three external variables, including economic complexity, protection of property rights, and the effectiveness of the judicial system, on the number of productions in OECD countries for the period 2007-

2016. The results show that economic complexity and intellectual property rights are key factors of production. Gnangnon (2023) has examined the impact of financial fluctuations and economic structural vulnerability on production capacities in developing countries. The sample studied is 116 countries from 2000 to 2018. The results show that lower financial fluctuations lead to increased production capacities, while higher economic structural vulnerability reduces production capacities. Ikonnikova et al. (2022) examine the relationship between investment and production in the energy industry. The results indicate that increasing investment potential, especially international investments, reducing investment costs, and the financing ecosystem prevalence leads to increased production in this industry. Soysa et al. (2022) examine the role of oil on economic institutions for a sample of 150 countries between 1960 and 2014. The results show that the weakening of economic institutions in the form of lower property protection rights levels is accompanied by higher per capita values of oil production. The findings of this study indicate that oil interest groups use their economic power to obtain weaker property rights to maintain their economic-political position in society. Therefore, countries dependent on oil production suffer from low levels of property rights, and the inability to protect property rights makes it difficult to increase other non-oil production. Totin et al. (2021) examine the effect of property rights and agricultural production in rural areas of Mali. The results show that improving property rights through increasing investment security improves agricultural production. Also, innovations related to food production are strongly affected by improving property rights protection. Ryan (2020) examines the impact of poor contract enforcement on investment reduction in developing countries and examines contract enforcement on investment in procurement auctions of the largest power projects in India. Model estimates show that bidders bid less than the actual price because of the expected value of subsequent renegotiation. Contract enforcement is considered a competitive advantage. Wasseem and Martinez-Vazquez (2006) examine the effect of contract enforcement on the global investment market for 83 developing countries over the period 1982-1997. In their study, the contract enforcement was modeled as a fixed cost that investors incur to obtain the gross contractual return on international investments. The results show that countries with poor contract enforcement impose higher contract enforcement costs and increase uncertainty about their economic structure. Stronger contract enforcement increases international borrowing, makes its maturity longer, and makes it more likely that production will increase.

Investigating the role of investment on production is one of the most repeated and old studies in economics, since the impact of investment on the promotion of aggregate supply and ultimately, production has always been considered as an obvious principle. However, examining production capacities and not just production, which is in fact a concept beyond mere production, can be considered as a missing link in such studies. The production capacities index is an index that includes energy, human capital, Information and Communication Technology (ICT), institutions, natural capital, transportation, private sector, and structural change. As can be seen, although in the concept of production only the value of products in an economy is examined, the production capacities index deals with the state of the requirements and basic needs of production. Also, in the discussion of investment, the concept of investment as a general value has been used in various studies, but the investment environment, which refers to the existence of legal structures that encourage investment, has been neglected. Therefore, given the existing research gap, this study examines the determinants of the investment environment, including five indicators of property rights, investor protection, contract enforcement, financing ecosystem, and restrictions on international

investment, on the productive capacity index in selected developed[1] and developing[2] countries during the period 2007-2023.

The Table 1 shows a summary of the indicators studied in this study as an average in selected developing and developed countries. According to this table, there is a significant gap in all the indicators studied between the two groups of countries. The investment environment index, as an average of five indicators of property rights, investor protection, contract enforcement, financing ecosystem and restrictions on international investment, is 54.6 in developing countries and 74.5 in developed countries, and the productive capacity index is 47.1 in developing countries and 60.9 in developed countries. Also, examining the average of all five investment environment indicators shows the relative superiority of developed countries over developing countries. The highest index recorded among the investment environment indicators between the two groups belongs to the contract enforcement index and the lowest in selected developed countries is the investor protection index and in selected developing countries, restrictions on international investment. Also, the average of the R&D index in selected developed countries is 47.4 and 20.4 in selected developing countries, which shows a gap of more than two times. Therefore, given the significant difference observed based on this table, it seems that the components of the investment environment index and the research and development index can also explain the fluctuations in the productive capacity index to an acceptable extent.

Table 1- Average of the studied indicators in selected developed and developing countries during the period 2007-2023

	Production capacities	Property rights	Investor protection	Contract enforcement	Financing ecosystem	Restrictions on international investment	Investment environment	R&D
Selected Developing Countries	47.1	52.5	54.2	61	56.4	48.8	54.6	20.4
Selected Developed Countries	60.9	73.9	68.6	83.3	75.5	70.9	74.5	47.4

* Source: Researchers' calculations using Legatum Prosperity Index Report Available at: www.prosperity.com and Global Innovation Index Report Available At: www.wipo.int

Based on the statistics presented in the table above, it seems that one of the paths explaining the differences in production capacities between the two selected groups could be the investment environment and R&D indicators. The differences between the two selected groups of countries in the productive capacity index are statistically consistent with their differences in the investment environment and R&D indicators. Therefore, the aim of this study is to examine the impact of the indicators that make the investment environment and the interactive R&D index on the productive capacity index in two selected groups of developed and developing countries. Therefore, in the following, the literature review are introduced, then we will discuss the methodology and introduction of the model, after that, a discussion of the results obtained from the model and finally, conclusions are presented.

[1] - Australia, Austria, Belgium, Bulgaria, Canada, Czech Republic, Cyprus, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Spain, Sweden, Switzerland, Ukraine, United Kingdom and United States.

[2] - Algeria, Argentina, Bangladesh, Belarus, Brazil, Chile, China, Colombia, Egypt, Ethiopia, Hong Kong, India, Indonesia, Iran, Iraq, Malaysia, Mexico, Morocco, Nigeria, Pakistan, Peru, Malta, Singapore, South Africa, Republic of Korea, Thailand, Turkey, Tunisia and Vietnam.

2. Literature Review

2.1 Productive Capacity Index (PCI)

Strengthening productive capacities is a critical prerequisite for achieving structural transformation, inclusive economic growth and sustainable development and is essential for building socio-economic resilience and resisting the negative consequences of external shocks (Summers et al., 2006, and Pavcnik, 2002). The Productive Capacity Index (PCI) is the first comprehensive attempt to measure productive capacities in all economies and to create a multidimensional index that can show the extent of development of productive capacities in each country and provide a complete understanding of the drivers of production and its systematic sources of vulnerability (Ferrier, 2011). The United Nations Conference on Trade and Development (UNCTAD) supports the strengthening of productive capacities in developing countries, and in particular in least developed countries (LDCs)[3], with the aim of promoting structural transformation of economies, sustainable growth and development. The organization provided the first definition of the concept of "productive capacities" in its report on LDCs in 2006. According to this report, productive capacities are: "the productive resources, entrepreneurial capabilities and productive linkages that collectively determine a country's capacity to produce goods and services and enable it to grow and develop." Other definitions of the concept of "productive capacities" have also been provided that focus on some specific aspects of productive capacities, including industrial, commercial or human capacity. For example, in one of these definitions, "productive capacities are a set of different types of productive, organizational, technological and innovative capacities embedded in organizations, institutions and infrastructure, the outcome of which determines a country's capacity to produce goods and services in a competitive global market" (UNCTAD, 2020). The World Trade Organization (WTO) defines "productive capacity as the creation of supply-side capacity and trade-related infrastructure (both hard and soft) that is necessary for the implementation and benefit of WTO agreements and, more broadly, for the expansion of trade in order to increase the production of competitive goods and services in international markets" (WTO, 2005).

Weak productive capacities, weak economies and vulnerable structures threaten many developing countries. This challenge has been exacerbated by the COVID-19 pandemic and the accompanying global economic crisis, which has brought about far-reaching changes in the productive structures, trade relations and domestic livelihoods of these countries and even developed countries. The deepening economic shock resulting from the increasing damage of climate change, the sharp decline in international commodity prices and the decline in confidence in global solidarity threatens to erode the development gains of the past decades. Therefore, there is an urgent need to find new solutions to build economic resilience and address the root causes of vulnerabilities in countries (Du et al., 2023; Wildasin, 2021; Blundell, 1995). As a result, domestic policy strategies should be focused on strengthening productive capacities and shift from fragmented and project-based interventions to coherent, economic and program-based approaches. Development measures and interventions at the domestic level should be complemented by strong investment support. Developing countries, due to their higher degree of vulnerability in the development process, should strive to grow their productive capacities, change economic structures and reverse their isolation from the global economy (Beckers and Rixen, 2003, Hyndman and Shenstone, 2005). The

[3] - LDCs are countries that are recognized by the United Nations as the poorest and most vulnerable to external and environmental shocks (https://www.un.org/ohrlls/).

Productive Capacity Index (PCI), which was first developed by the United Nations and then expanded by UNCTAD, is a composite index consisting of 46 indicators. The PCI is calculated through the geometric mean of these areas, each of which has been selected due to its importance in the conceptual and analytical frameworks for promoting the productive capacity index. Algebraically, the PCI can be expressed as follows:

$$PCI = \sqrt[N]{\pi_{i=1}{}^{N} X_i^{PCA}}$$

According to the latest UNCTAD report (2023), N is the total number of categories, X_i^{PCA} is the average score of the category under study, and $\pi_{i=1}^{N}$ is the score of the index under study. Therefore, the productive capacity index, by fully reflecting the path of economic growth and development of each country, seems to be a complete and comprehensive index for the study and research in this field. The productive capacity index provides an essential roadmap for new policy paths that can rebuild incentive structures to restore socio-economic progress and address persistent vulnerabilities to external economic, health, or other shocks. Therefore, examining the factors affecting production capacities can clarify the path towards sustainable growth and development, and given the undeniable importance of the concept of production capacities, adopting macroeconomic policies with an emphasis on programs to expand the quantity and quality of production potential has been one of the most important priorities of policymakers in the field of economic development. Therefore, it seems necessary to study the range of variables affecting production capacities. Among these variables, the concept of investment environment can be mentioned. This index measures the level of adequate protection of investments through the existence of property rights, investor protection, contract enforcement, financial ecosystem, and restrictions on international investment. This index takes into account the amount of domestic and foreign capital available (both debt and equity) for investment (UNCTAD, 2020). The following introduces each of the investment environment indicators:

2.2.Investor Protection

To achieve the goal of protecting investors while conserving limited regulatory resources, regulators in markets often rely on clear rules such as dividend mandates and adopt a uniform approach to monitoring and enforcement (Chen and Yuan, 2004 and Pistor and Xu, 2005). However, this type of approach is often criticized for being inflexible and distorting economic decisions (Bushee and Leuz, 2005 and Gao et al., 2009). For example, mandating cash dividends may protect investors' cash flow rights, but it can harm growing firms, which typically have a high marginal value for cash (Albuquerue and Wang, 2008 and Bolton et al., 2024). Regulation can minimize economic distortions while protecting investors' interests, thus having significant economic and welfare implications (Bourveau et al, 2025). The effects of investor protection are multifaceted. Most companies provide high-quality risk management disclosures to investors to better understand the reasons for the company's exposure to risks and risk management practices, especially those with higher financial needs. They have an incentive to disclose stronger risk management in investor protection to prove their ability, repay debt to investors, attract investment and reduce the cost of financing (Li et al, 2023, Taylor et al, 2010, Linsley and Shrives, 2006). Therefore, investor protection risk management affects bond prices, which is due to the difficulty of information gathering by investors. Therefore, it is expected that the establishment of investor protection laws will be accompanied by a decrease in investment (Gong and Wei, 2024). Deng et al (2024) also emphasize the effect of investor protection on the volume of investment and state that investor protection in capital markets in most cases leads to an increase in total output, but in cases where the investment is of lower rating or lower return, the

investor protection coefficient is not significant. Deng et al (2024) also state that the establishment of investor protection laws clearly affects profit signaling and in an environment with strong investor protection, current profit changes have a stronger relationship with future profit changes than in companies in environments with weak investor protection. This predictable trend of future profits increases the likelihood of attracting investment and, in this regard, can also affect productive activities. Goethner et al (2021) examine the effect of the adoption of the law on the protection of risky investment in Germany. The results show that after the new rule became mandatory, sophisticated investors on average invested less while casual investors invested more. Furthermore, the signaling capacity of large investments disappeared.

2.3.Fiancial Ecosystem

A financial ecosystem is a set of institutions, instruments, markets, and the legal and regulatory framework that enables transactions through the credit granting. A financial ecosystem has five key functions: 1- generating pre-event information about potential investments and capital allocation; 2- monitoring investments and exercising corporate governance after financing; 3- facilitating trade, diversification, and risk management; 4- mobilizing and integrating savings; and 5- facilitating the exchange of goods and services (IMF, 2023). The development of a financial ecosystem occurs when financial instruments, markets, and intermediaries reduce the effects of information, execution, and transaction costs and, therefore, better perform the key functions of the financial sector in the economy. The development of this ecosystem plays an important role in economic development (Levin, 2005). It promotes increased production through capital accumulation and technological progress by increasing the savings rate, mobilizing and integrating savings, generating information about investment, facilitating and encouraging the inflow of foreign capital, and optimizing capital allocation (World Bank Group, 2021). In the financial literature, it is generally accepted that financial development reduces barriers to business growth and, in this way, brings economic prosperity (Beck and Demirgüç-Kant 2006). Furthermore, a more developed financial system can reduce information asymmetry (Beck, 2012). A better-functioning financial system includes better financial intermediation, better access to financial resources, and more efficient financial markets, all of which reduce external financing constraints that hinder trade and industrial expansion (Levin, 2005). Several theoretical studies have examined the relationship between the financial system and the production. These studies have considered different financial environments. Certain models emphasize the advantages of bank-based systems, while others emphasize the advantages of systems that rely more on financial markets (Beck, 2012; Beck and Levine, 2002; Levine, 2002; Maksimovic and Demirguc-Kant, 2002). All of these models have recognized the relevance of financial development for mobilizing and ultimately accelerating production (Bencivenga et al., 1995; Greenwood and Smith, 1997; Levine, 1991). Most empirical studies confirm the theoretical assumptions and show that the financial development of a country or region positively affects the output growth of these geographical areas (Eng, 2008; Beck and Levine, 2004; Beck et al., 2000; Levine and Zervos, 1998; McCiag and Stengos, 2005). In particular, financial systems play a crucial role in fostering the growth of the innovative economy, which accounts for a good part of a country's economic growth (Demirguc-Kunt and Maksimovic 1998). Vega-Pascual et al. (2024) examine the relationship between resources and actors in the financial system beyond traditional banks, such as crowdfunding, business angels, peer-to-peer lending, accelerators, incubators and venture capital based on a sample of young Spanish small and Medium-sized Enterprises (SMEs) between 2008 and 2015. The results show that the growth of young firms depends on the development of a regional financial ecosystem, suggesting that better access to domestic and external financial resources resulting from a developed financial ecosystem benefits the growth of young firms, especially knowledge-based and

innovation-oriented firms. Andrieu et al. (2021) analyzed the effect of financial development on output growth, focusing on a large sample of European region. The authors find a positive relationship between financial development (financial ecosystem) and output growth. Bank credit, as a proxy for levels of financial development, is positively associated with output growth, with a decreasing pattern over time. Using data from 62 countries, Leon (2020) examines whether the degree of financial sector development affects output growth, particularly in the knowledge-based sector. The results show that financial development, as measured by bank credit to the private sector as a percentage of GDP, stimulates the growth of start-up firms, although this depends on the maturity of available bank resources.

2.4.Property Rights

Protection mechanisms that are commonly in the definition of property rights include patents, copyrights, trademarks and trade secrets, as well as utility and industrial models (Burrone, 2005). (Colombelli et al., 2021) These instruments can grant inventors exclusive rights to the commercialization of their innovations (Krammer, 2015). These protection mechanisms act as barriers to imitation of new products and processes and, as a result, as support mechanisms for those who invest in innovation (Rumelt, 1984). The more prevailing legal system protects investments, for example through property rights, the more investments can lead to improved production. The protection of property rights is considered as one of the components that affect development. Property rights refer to the extent of property's citizens protection that are the results of their work and initiatives. Strong and effective protection of property rights is the essential infrastructure for investment, especially in the research, technology and innovation, which fosters innovation and the creation of technical knowledge, and increases the incentive for entrepreneurship and the attraction of domestic and foreign investment (North et al., 2009 and Chemin, 2009). Intellectual property laws determine what can be patented, how patents are granted and their scope, in addition to the rights of inventors and the duration of these rights (Henry and Stiglitz, 2010). The literature considers intellectual property rights as an incentive for innovation (Chesbrough and Crowther, 2006; Dosi et al., 2006), especially for countries with a high capacity to produce a large volume of inventions (Sharma et al., 2022). Indeed, much of the literature considers the quality of the intellectual property regime to be the most obvious form of institutional support and a necessary condition for capturing the benefits of innovation (Dosi et al., 2006; Hurmaleinna-Laukkanen and Puumalainen, 2007). Furthermore, Hall et al. (2010) show that weak intellectual property rights led to the misallocation of innovation returns and cause losses in innovative activities. Similarly, Athreye et al. (2020) argue that difficulty in capturing the benefits of innovation leads to lower R&D investment.

2.5.Restrictions on International Investment

Increasing national production is a key goal for economies around the world, the achievement and maintenance of which depends on various factors such as amount and security investment (Yusuf and Mohd, 2022). The willingness to invest is conditional on protecting individuals and their assets from local and global risks. This can explain why many countries strive to maintain domestic and international peace and security. In the strategic landscape of the contemporary world, there is a diverse range of threats and challenges, and protecting individuals and their assets from domestic and international risks is crucial for the smooth functioning of markets and creating incentives for investment and innovation (Amana et al., 2020, Apanisile and Okunlola, 2014). Conversely, increasing levels of insecurity and activities that undermine national interests have a significant adverse impact on macroeconomic variables including

production. One of the most important ways in which such threats affect the economy is through the erosion of investment in a country (Izola et al., 2019; Mazumdar and Bhattacharjee, 2019). The prevailing theory is that increased levels of instability and insecurity divert investment from countries with higher risks to countries with lower risks (Chuku et al., 2019; Brodeur, 2018). Regarding the impact of financial systems on investment, Allen (1993) and Allen and Gale (1999) argue that the existence of a progressive financial system allows investors to have different perspectives on investment. According to Boyd and Smith (1998), the relative importance of financial systems varies depending on the stage of development of each economy. In developed economies, due to the high costs of financial supervision, technologies with relatively lower costs are used, therefore, the costs of maintaining the financial system in developed countries are lower and the incentive to invest is also higher (Carlin and Mayer, 2003). Restrictions on international investments affect the investments amount, because with increasing the economy openness, foreign investors find a higher incentive to invest. Restrictions directly and significantly affect the attraction of foreign direct investment (FDI), its interest rate and return. The decision to invest depends on the amount of risk and return on capital in that economy (Sestanovich, 2019). From this perspective, it can be acknowledged that the index of restrictions on international investment as an indicator that indicates the intensity of dominance over foreign investment markets can have two completely different meanings in developing and developed countries. In developed countries, this indicator means restrictions on international investment markets, which naturally indicates the political and economic power of each country. However, in developing countries, it means exclusion from international investments, which naturally indicates the weakness of the aforementioned countries in attracting this type of investment.

2.6.Contract Enforcement

Various economic historians, including North (1990), have argued that contract enforcement has become more involved and consequential with increasing specialization, a larger number of trading partners, and the geographical transactions relocation. Indeed, in modern societies, three forms of exchange and enforcement arrangements (implicit, explicit-informal, and formal) coexist, and even old and seemingly ineffective informal rules can have major effects. The different behavioral consequences in countries with similar rules confirm that informal rules can be powerful (Berkowitz et al., 2003). These historical and theoretical issues are still debated between those who believe that formal enforcement mechanisms (and contract law) are necessary for development and those who believe that informal enforcement mechanisms (and contract arrangements) can be sufficient (North, 1990; Greif, 2006). In between, some argue that different enforcement arrangements can work well at different levels of development and/or for different country contexts. The “types of capitalism” literature argues that liberal economies rely more on standardized market relations and enforceable formal contracts than on coordinated market economies, where dense networks and business associations spread reputation and allow firms to operate on the informal contract’s basis (Hall and Soskice, 2001, Greif, 2005). Trebilcock and Leng (2006) prefer the stages of development argument: for low levels of economic development, enforcement of informal contracts may be a good alternative to formal enforcement, but for higher levels of development, formal contract law and enforcement are essential. Analytically, weak contracts enforcement affects investment through some channels. First, it can directly affect the uncertainty, and thus influence investors’ decisions by increasing costs, reducing its expected return, or generally increasing the value of the “wait” option (Dixit and Pyndick, 1994). Second, poor execution can indirectly affect the willingness or ability of agents to invest: it can force them to choose low-yielding technologies, prevent them from building certain assets when these relationships are contingent on contracts, or exacerbate the adverse effects of infrastructure or

regulatory shortcomings. All of this, in turn, can also affect the firm's access to external financing, while capital markets and the banking industry as a whole may be crippled by an insecure contracts environment (Aboal et al, 2014). These different channels may combine in complex ways. For example, some economists have supported that poor enforcement increases firms' sensitivity to the entry of new technologies and creates greater macroeconomic volatility (Cooley et al., 2004). To the extent that aggregate volatility (leakage) affects investment, there will be a causal chain from contract enforcement to capital accumulation. Monge-Naranjo (2009) has also argued that through financial contracts, poor enforcement affects the size distribution and heterogeneity of firms, which can be reflected in levels of aggregate investment and ultimately, aggregate output.

2.7. Research and Development (R&D)

The Frascati Manual 2015 defines R&D as "experimental research and development" which "comprises creative and systematic work undertaken to increase the stock of knowledge – including knowledge of humanity, culture and society – and to devise new applications of existing knowledge" (Organization for Economic Co-operation and Development, 2015). Knowledge is one of the driving forces of innovation that is crucial for a country seeking growth and development, and R&D activities are crucial for knowledge generation and accumulation (OECD/EUROSTAT, 2018). Many studies have shown a positive relationship between investment in R&D and the utilization of production factors, emphasizing that R&D intensity is an empirical determinant of technological innovation in the production process. Evidence suggests that countries with the highest investment in R&D have higher domestic production values than other countries (Dai et al., 2022, Anzola-Román et al., 2018, Vrontis and Christofi, 2019). Ortiz Henriquez et al (2023) examined the effect of R&D on production in Latin America and concluded that the effect of R&D on production is positive and more significant than other variables. Cuervo-Cazurra et al, (2017) examined the effect of R&D on new products by considering production as the place where new knowledge is created through R&D activities. The results show a positive effect of R&D on production, and the effect is strengthened when R&D is accompanied by investment (both domestic and foreign).

3. Methodology

3.1. Introduction of Variables and Studied Sample

The role of improving production capacities on the economic structures of different countries is important. Strengthening the capacity of manufacturing sectors leads to increased production of competitive goods and services for international markets. Also, improving the productive capacity index can enhance the policy-making capacity of countries through technical assistance and capacity-building activities to implement trade and trade-related policies in accordance with WTO rules (Gnangnon, 2021, Utkovski et al., 2018). Therefore, in this study, the Productive capacity Index (PCI) has been used as the dependent variable. The latest report published by UNCTAD in 2023, the Productive capacity Index (PCI) was calculated among 194 countries. This index ranges from 0 to 100. The dependent variables are the indicators that constitute the investment environment (including property rights, investor protection, contract enforcement, financing ecosystem, and restrictions on international investment) as well as the interactive effect variable of R&D and the five investment environment indicators. It should be noted that the investment environment indicators are also in the range of 0 to 100 and are extracted from the annual reports published by the Legatum Institute (the latest report is 2023). Therefore, given the limitation of the years

studied to calculate the investment environment index, the period studied in this study is from 2007 to 2023. To examine the effect of R&D, the annual reports published by the Global Innovation Index (GII) were used. In these reports, R&D is recognized as one of the innovation inputs and is an average index including the number of researchers relative to the total population, gross R&D expenditure as a GDP percentage, the investment volume of the top three R&D investors in million US dollars, and the top three university rankings. This index ranges from 0 to 100. To conduct a comparative study, two groups of countries were selected, including 31 developed countries and 29 developing countries. Given that the aim of the present study is to present a comparative picture of different countries and to show the gap between the developing and developed countries in the indicators of production capacities, investment environment and R&D to examine the existing relationships through the presented indicators, two groups of developing and developed countries were selected. Figure 1 shows the average indicators of production capacities, property rights, investor protection, contract enforcement, financial ecosystem, restrictions on international investment and R&D in the selected developing countries and selected developed countries during the period 2007-2023.

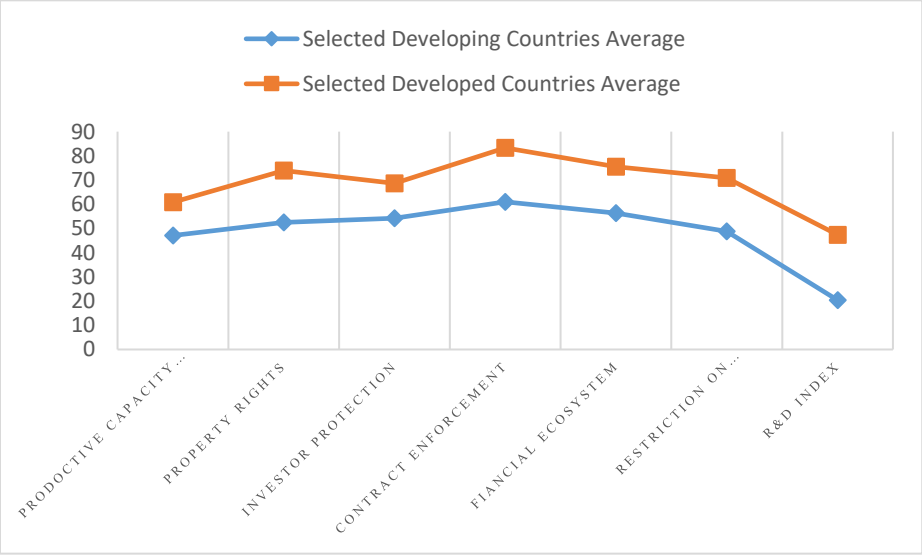


Figure 1 – Average of the indicators studied in selected developing and developed countries in the period 2007-2023
*Source: Researchers' calculations using Legatum Prosperity Index Report Available at: www.prosperity.com and Global Innovation Index Report Available at: www.wipo.int

As the above figure confirms, the average of the investment environment, R&D and productive capacity indicators among developing countries is significantly different from that of developed countries. In all the indicators studied, the average of the selected developed countries is higher than the average of the selected developing countries. In all five investment environment indicators including property rights, investor protection, contract enforcement, financing ecosystem and restrictions on international investment, the productive capacity index and the R&D index, the average of the selected developed countries is higher than the average of the selected developing countries. The contract enforcement index is higher in both groups of selected countries than the other indicators. The lowest investment environment indicator in the group of selected developed countries is investor protection, while in the group of selected developing

countries, it is restrictions on international investment. The gap in the R&D index between the two selected groups is greater than in other variables.

3.2. Methodology and Model Introduction

This study, inspired by the studies previously mentioned, especially the study of Pal et al. (2024) and Gnangnon (2023), examines the effect of the indicators constituting the investment environment and the interactive effect of R&D on the Productive Capacity Index (PCI) in two groups of selected developing and developed countries during the period 2007-2023. Therefore, the following relationship shows the implicit relationship of the selected variables effectiveness:

$$PCI = f(Investment\ Environment\ Indecies, R\&D\ Interactive\ Indecies) \qquad (1)$$

In the following model, the above implicit relationship is expanded:

$$LPCI_{it} = \alpha + \beta_i\ LInvestment\ Environment\ Indecis\ _{it} + \beta_i\ L\ R\&D\ Interactive\ Indecies_{it} + \mu_{it}\ (2)$$

Therefore, according to model 2, the following five cases can be stated for two selected groups of developing and developed countries:

$$LPCI_{it} = \alpha + \beta_1\ LProRights_{it} + \beta_2\ LInvesProtec_{it} + \beta_3\ LContrEnfor_{it} + \beta_4\ LFinaEco_{it} + \beta_5\ LCResonInterInves_{it} + \beta_6 LRDProRights_{it} + \mu_{it}\ (2-1)$$

$$LPCI_{it} = \alpha + \beta_1\ LProRights_{it} + \beta_2\ LInvesProtec_{it} + \beta_3\ LContrEnfor_{it} + \beta_4\ LFinaEco_{it} + \beta_5\ LCResonInterInves_{it} + \beta_6 LRDInvesProtec_{it} + \mu_{it}\ (2-2)$$

$$LPCI_{it} = \alpha + \beta_1\ LProRights_{it} + \beta_2\ LInvesProtec_{it} + \beta_3\ LContrEnfor_{it} + \beta_4\ LFinaEco_{it} + \beta_5\ LCResonInterInves_{it} + \beta_6 LRDContrEnfor_{it} + \mu_{it}\ (2-3)$$

$$LPCI_{it} = \alpha + \beta_1\ LProRights_{it} + \beta_2\ LInvesProtec_{it} + \beta_3\ LContrEnfor_{it} + \beta_4\ LFinaEco_{it} + \beta_5\ LCResonInterInves_{it} + \beta_6 LRDFinaEco_{it} + \mu_{it}\ (2-4)$$

$$LPCI_{it} = \alpha + \beta_1\ LProRights_{it} + \beta_2\ LInvesProtec_{it} + \beta_3\ LContrEnfor_{it} + \beta_4\ LFinaEco_{it} + \beta_5\ LCResonInterInves_{it} + \beta_6 LRDResonInterInves_{it} + \mu_{it}\ (2-5)$$

Given that two samples of developing and developed countries are considered for this research, totally, 10 cases have been estimated. The variables used in above relations are in Table 2:

Table 2- Introduction of variables used in the estimated model

Variable	Symbol	Statistical source
Productive capacity Index (PCI) Logarithm	$LPCI_{it}$	Productive Capacity Index Report Available at: www.unctad.org
Property Rights Index Logarithm	$LProRights_{it}$	Legatum Prosperity Index Report Available at: www.prosperity.com
Investor Protection Index Logarithm	$LInvesProtec_{it}$	Legatum Prosperity Index Report Available at: www.prosperity.com
Contract Enforcement Index Logarithm	$LContrEnfor_{it}$	Legatum Prosperity Index Report Available at: www.prosperity.com
Financial Ecosystem Index Logarithm	$LFinaEco_{it}$	Legatum Prosperity Index Report Available at: www.prosperity.com
Restriction on International Investment Index Logarithm	$LCResonInterInves_{it}$	Legatum Prosperity Index Report Available at: www.prosperity.com
The Product of R&D and Property Rights Logarithm	$LRDProRights_{it}$	Researcher-made using Legatum Prosperity Index Report Available at:

		www.prosperity.com و Global Innovation Index Report Available At: www.wipo.int
The Product of R&D and Investor Protection Logarithm	$LRDInvesProtec_{it}$	Researcher-made using Legatum Prosperity Index Report Available at: www.prosperity.com و Global Innovation Index Report Available At: www.wipo.int
The Product of R&D and Contract Enforcement Logarithm	$LRDContrEnfor_{it}$	Researcher-made using Legatum Prosperity Index Report Available at: www.prosperity.com و Global Innovation Index Report Available At: www.wipo.int
The Product of R&D and financial Ecosystem Logarithm	$LRDFinaEco_{it}$	Researcher-made using Legatum Prosperity Index Report Available at: www.prosperity.com و Global Innovation Index Report Available At: www.wipo.int
The Product of R&D and Restriction on International Investment Logarithm	$LRDResonInterInves_{it}$	Researcher-made using Legatum Prosperity Index Report Available at: www.prosperity.com و Global Innovation Index Report Available At: www.wipo.int
Represents country i at time t	it	-
Latitude from origin	α	-
Elasticity of each independent variable	β_i	-
Error term	ε_{it}	-

*Source: Researchers' calculations using Legatum Prosperity Index Report Available at: www.prosperity.com and Global Innovation Index Report Available at: www.wipo.int

3.3.Model Estimations

Given that the use of panel data (cross-sectional and time simultaneously) improves the reliability and accuracy of the resulting estimates, the panel data method was used in this study. The results of the tests for determining the type of data, type of panel effects, variance heteroscedasticity and unit root are shown in Table 3:

Table 3- Test results

	Test type	Test statistic value	p-value	Test result
Selected Developing Countries	Poolability	52.77	0.0000	Acceptance of hypothesis H1: Panel data
Selected Developed Countries	Poolability	133.42	0.0000	Acceptance of hypothesis H1: Panel data
Selected Developing Countries	Hausman	34.12	0.0000	Acceptance of hypothesis H1: Fixed effects in panel data
Selected Developed Countries	Hausman	41.53	0.0000	Acceptance of hypothesis H1: Fixed effects in panel data
Selected Developing Countries	Wald	52.77	0.0000	Acceptance of hypothesis H1: Based on the absence of variance heterogeneity
Selected Developed Countries	Wald	835.31	0.0000	Acceptance of hypothesis H1: Based on the absence of variance heterogeneity
Selected Developing Countries	Im-Pesaran-Shin	-0.82	0.2045	Acceptance of hypothesis H1: Based on the absence of unit root
Selected Developed Countries	Im-Pesaran-Shin	-0.61	0.2692	Acceptance of hypothesis H1: Based on the absence of unit root

*Source: Research findings

According to the Gauss-Markov theorem, due to the lack of dependence of error terms on each other based on the Wald test, the variance-covariance matrix estimated by the Ordinary Least Squares(OLS) method is valid. Therefore, the OLS method is used.

4. Discussion

In Table 4, the results of estimating five cases for two groups of selected developing and developed countries during the period 2007-2023 are given. According to this table, the property rights index in all estimated cases and also in both groups of selected countries has a positive effect on the Productive capacity Index, but its significance intensity is greater in the selected developed countries. The investor protection index has a positive effect in the selected developed countries and a negative effect in the selected developing countries. The contract enforcement index has a positive effect on productive capacity in both groups of selected countries, but its significance intensity is greater in the selected developed countries. The financial ecosystem index has a positive and significant effect on productive capacity in both groups of selected countries. The index of restrictions on international investment has a positive effect in selected developed countries and a negative effect in selected developing countries. Among the estimated parameters, the coefficient of the financial ecosystem effect is higher than the other coefficients of the variables in all five estimated cases, both in selected developing countries and in selected developed countries.

Regarding the interactive indicators with a fixed R&D component, it can be acknowledged that the same conditions are observed between the two under study samples. All interactive indicators, including the interactive index of R&D and property rights, R&D and investor protection, R&D and contract enforcement, R&D and financial ecosystem, and R&D and restrictions on international investment, have a positive and significant effect on production capacities in both groups of selected countries, but the effect coefficient in the five estimated cases and for all five interactive variables is larger in the selected developing countries than in the selected developed countries. The coefficient positivity of the interactive R&D effects indicates that if both variables increase simultaneously (for example, in case 1, a simultaneous increase in property rights and R&D), production capacities will also increase. It is worth noting that, in the selected developing countries, although variables such as property rights, investor protection, and contract enforcement have low and meaningless coefficients directly, when expressed interactively with R&D, not only their coefficients increase, but also become more significant. This is more evident in the case of restrictions on international investment, which independently has a negative and significant sign in all models, but in case 5, despite the negative and significant sign of restrictions on international investment, the interactive effect of R&D and restrictions on international investment on production capacities is positive and significant. All of these cases indicate the high intensity of the R&D effect in the selected developing countries compared to the selected developed countries. The highest impact coefficient between the interactive variables in the group of selected developing countries belongs to the interactive effect of R&D and investor protection, and among the selected developed countries, it is the interactive effect of R&D and property rights.

Table 4 – Estimation Results of the five model modes for selected developing and developed countries

	Selected Developed Countries					Selected Developing Countries				
Explanatory Variable	Model1	Model2	Model3	Model4	Model5	Model1	Model2	Model3	Model4	Model5
	Test Statistic Value	Test Statistic Value	Test Statistic Value	Test Statistic Value	Test Statistic Value	Test Statistic Value	Test Statistic Value	Test Statistic Value	Test Statistic Value	Test Statistic Value
LProRights	0.107*** (6.64)	0.057*** (3.95)	0.062*** (4.14)	0.058*** (4.03)	0.072*** (4.98)	0.037 (0.58)	0.054 (0.88)	0.059 (0.96)	0.061 (1.01)	0.051 (0.84)
LInvesProtec	0.207*** (10.84)	0.202*** (8.77)	0.226*** (11.47)	0.219*** (10.95)	0.17*** (7.75)	-0.137 (-1.19)	-0.168 (-1.47)	-0.131 (-1.13)	-0.137 (-1.19)	-0.126 (-1.09)
LContraEnfor	0.269*** (12.41)	0.186*** (8.87)	0.186*** (8.84)	0.178*** (8.28)	0.165*** (8.01)	0.029 (0.59)	0.026 (0.54)	0.014 (0.3)	0.028 (0.59)	0.022 (0.45)
LFianaEco	0.398*** (15.06)	0.502*** (14.47)	0.513*** (13.52)	0.497*** (14.96)	0.536*** (25.83)	0.31*** (5.31)	0.305*** (5.22)	0.311*** (5.32)	0.287*** (4.84)	0.308*** (5.28)
LResonInterInves	0.149*** (8.89)	0.161*** (9.17)	0.157*** (8.99)	0.16*** (9.16)	0.158*** (9.32)	-0.292*** (-5.42)	-0.29*** (-5.4)	-0.293*** (-5.44)	-0.291*** (-5.41)	-0.355*** (-6.12)
LProRights*RD	0.074*** (6.87)					0.144** (2.56)				
LInvesProtec*RD		0.052** (2.71)					0.182*** (3.17)			
LContraEnfor*RD			0.023** (2.66)					0.15** (2.86)		
LFinaEco*RD				0.053** (2.97)					0.15** (2.72)	
LResonInterInves*RD					0.066*** (5.9)					0.164** (3.08)
Chi2 (Prob)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Number of obs	527	527	527	527	527	493	493	493	493	493
Number od groups	31	31	31	31	31	29	29	29	29	29

*Source: Research findings

5. Conclusion

One of the important concerns of policymakers and macroeconomic decision-makers is to ensure economic welfare and its expansion in order to improve human living standards. One of the paths that facilitates the possibility of achieving this goal is to improve economic conditions by creating longer prosperity periods and reducing recession periods. For this purpose, it is inevitable to understand the economic foundations of a country, at the top of which are production facilities. Production capacities are one of the components that specifically measure the possibility of production and productive exploitation of available facilities. In this way, understanding the factors affecting production capacities can be helpful in long-term economic policies. One of the factors that can affect production is undoubtedly the concept of investment. Promoting investment, by expanding the reliability coefficient of providing the financial capital required for production activities, can play a significant role in increasing production capacities. Another factor that can affect production is R&D. In today's world, where a major part of production is based on knowledge, innovation and creativity, and the share of knowledge-based and innovation-oriented products in regional and global markets is constantly increasing, Research and Development (R&D) activities that can affect the quality of products have received great attention from the owners of production activities. Therefore, this study examines the interactive effect of the indicators constituting the investment environment and R&D on the Productive capacity Index (PCI) in two groups of selected developing and developed countries during the period 2007-2023 using the Ordinary Least Squares (OLS) approach.

The results of the study show that despite the positive impact of all investment environment indicators, including property rights, investor protection, contract enforcement, financial ecosystem, restrictions on international investment, and the R&D indexes on production capacities in developed countries, this type of impact is not seen in developing countries, and the investor protection and restrictions on international investment have a negative effect on production capacities. As Yusuf and Mohd (2022) and Amana et al. (2020) have stated regarding international investments, ensuring investment security, especially in

international capital, is of doubly important. As developing countries, due to their fragile and underdeveloped economic structure, are subject to extensive restrictions on foreign investment. Naturally, any reduction in foreign investment in the capital-receiving country will have adverse effects on production, which is also confirmed by the estimated coefficient of the model. A major part of the tensions related to the index of restrictions on international investment in developing countries, which leads to a decrease in production capacities, is due to not supporting and accepting foreign investment macroeconomic policies in such countries. Even in the presence of policies favorable to capital attraction, a clear mechanism and a clear definition of its implementation framework have not yet been implemented, so the path of capital movement to developing countries will be difficult and complicated. Therefore, despite the fact that the average index of restrictions on international investment in selected developing countries is the lowest index, it has the greatest effect on reducing production capacities due to the aforementioned inefficiencies.

The investor protection index specifically refers to the legal environment and the quality of legislation in supporting investors. As Deng et al. (2024) and Goethner et al. (2021) state, increasing investor-friendly laws can increase investment, but this is not a general rule. The quality of laws enacted to protect investors, especially to maintain the security of profits earned from investments, as well as the way these laws are implemented to protect investor gains and encourage them to invest in the future, is important. Therefore, it can be acknowledged that legislative and law enforcement institutions regarding investor protection do not have the necessary efficiency and coordination in developing countries, so that increasing investor protection in these countries leads to a reduction in production capacities. The coefficient of the financial ecosystem in both developing and developed countries has a high impact intensity compared to other variables. As Vega-Pascual et al. (2024) and Andrieu et al. (2021) have emphasized, the effect of the financial ecosystem on production is very important and strong, which the estimation of the models in this study also confirms their results. The interactive R&D and investment environment indicators is positive and significant in all estimated models in both selected developing and developed countries, indicating the importance of R&D activities on improving production capacities. Ketelaars and Kurt (2025) and Pal et al. (2024) have also shown the positive effect of innovation-generating activities such as R&D on production. As mentioned earlier, the intensity of the R&D impact in selected developing countries is greater than in selected developed countries. Despite the fact that some variables such as investor protection and restrictions on international investment have a negative effect on production capacities, their interactive effect with the R&D shows a positive effect. This indicates higher levels of R&D impact on production capacities in developing countries. This intensity of effect can be attributed to the existence of a large amount of unused and empty production capacities in developing countries. This means that the same increase in R&D activities leads to a greater increase in production capacities in developing countries than in developed countries. Considering the above, the following suggestions are made to strengthen production capacities:

- Emphasis on expanding activities related to R&D activities, especially in developing countries, through various means such as financial and moral support for idea-based and knowledge-based activities such as innovative startup activities, as well as defining formal and demand-driven training related to R&D activities in academic environments such as universities.

Given the positive interactive effect of the R&D index, it is suggested that promoting high R&D activities be done simultaneously with improving the investment environment indicators that will be mentioned below:

- Reviewing macro policies related to investment in developing countries with an approach to further supporting domestic and foreign investments through implementing the necessary amendments to the laws and monitoring the proper implementation of investment-supporting laws, especially international investments that can also be accompanied by the transfer of knowledge and technology.

- Improving the financial ecosystem through a precise definition of financial relations in the banking and financial system, considering the estimated volume of financing required in each economy.

- Protecting property rights by respecting the limits of personal assets through the enactment of relevant laws.

- Ensuring the implementation of contracts, especially in the international dimension, by establishing a fair mechanism for the contracting parties.

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The authors have no competing interests to declare that are relevant to the content of this article.

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This article does not contain any studies with human participants performed by any of the authors.

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