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The Interactive Effect of Property Rights and Research & Development on Total Factor Productivity

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Abstract

Total factor productivity (TFP) is a pivotal determinant of sustained economic growth, serving as a measure of how efficiently inputs are transformed into output. Elevating TFP is not just a technical goal but a strategic necessity for nations aiming to achieve enduring prosperity and bolster their global competitiveness. This study analyzes the influence of key factors—including domestic R&D accumulation, R&D spillovers via imports, human capital, property rights, and economic freedom—on TFP in selected developing countries between 2011 to 2022. The findings indicate that while domestic R&D accumulation alone yields a positive but statistically insignificant effect on TFP, other variables such as R&D spillovers, property rights, and economic freedom have significant and positive impacts. Importantly, the interplay between strong property rights and domestic R&D acts as a potent driver of productivity gains. These insights suggest that policymakers should not only support innovation and research efforts but also cultivate institutional environments that protect property rights and promote economic liberalization. Such a holistic approach is essential for maximizing productivity, fostering sustainable development, and enhancing a nation's position on the world stage. By understanding and leveraging these mechanisms, developing countries can unlock greater economic potential and chart a path toward long-term growth.

Keywords: Property Rights, Economic Freedom, R & D, R & D Spillovers, Human Capital.
JEL Classification: O32, J24, D24.

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1. Introduction

Total factor productivity (TFP) is widely recognized as the main driver of long-term economic growth, and it measures how efficiently economies convert inputs such as capital and lab our into outputs. In addition to reflecting technological progress, the TFP represents an improvement in the quality of the institution, its innovation capacity and its efficiency in allocating resources (Gollin, 2002; Hall & Jones, 1999). Strengthening the TFP is not only essential for sustainable economic development, but also crucial to improving international competitiveness and social well-being, especially in developing countries where input-led growth models are increasingly constrained by resource constraints and diminishing returns (Aghion *et al.,* 2019; Syverson, 2011).

Despite its importance, TFP growth has remained slow in many developing economies, prompting renewed academic and political interest in identifying key determinants of total factor productivity. A growing body of literature points to the central role of knowledge factors - such as domestic accumulation of R&D, external R&D spillovers via trade and investment, and human capital - as the key drivers of productivity growth (Griliches, 1992; Coe and Helpman, 1995; Kumar and Siddhartha, 2015). In addition to these technological drivers, institutional factors - including protection of property rights and economic freedom - are increasingly being highlighted as key enablers that shape incentives for innovation, reduce transaction costs and support efficient market functioning (Acemoglu and Robinson, 2012; Gwartney *et al.,* 2023). Recent empirical studies further confirm that the interaction between technological skills and institutional quality have a significant impact on productivity performance in different countries (Habib *et al.,* 2019; Pegkas *et al.,* 2020; Markowska-Przybyla, 2020).

However, although these variables have been studied separately or in combination, there is still a significant gap in the literature as to their combined and interactive effects on TPD, especially in the context of emerging economies undergoing structural change. Most existing studies focus either on technological determinants (e.g. Li *et al.,* 2024; Pan *et al.,* 2022) or institutional frameworks (e.g. Zourki and Taherinia, 1403), but rarely integrate both dimensions in a single analytical framework. Moreover, few studies systematically assess how institutional enablers such as economic freedom and property rights dampen the effectiveness of knowledge inputs such as research and development and human capital in increasing productivity (Norouzi *et al.,* 1,400; Shahabadi, 2003).

This study addresses this critical research gap by providing a comprehensive analysis of the combined and conditional effects of domestic accumulation of R&D, import-led R&D spillovers, human capital, property rights and economic freedom on total factor productivity in a panel of developing countries from 2011 to 2022. By modelling both

technological and institutional determinants simultaneously and exploring the potential interactions, this research provides a more nuanced understanding of the mechanism for productivity gains. The findings not only contribute to theoretical discussions about the institutional and technological links in the process of growth, but also provide practical insights for policy makers in designing integrated strategies that combine innovation policies with institutional reforms to accelerate productivity growth and economic convergence.

It should be noted that a number of studies have examined determinants of total factor productivity (TFP), focusing on variables such as digitization and smart manufacturing, technological and innovation spillovers, FDI and trade openness, human capital and migration, financial development, energy resources, governance and institutional quality.

No comprehensive study has been found to assess at the same time the impact of key knowledge variables such as domestic R&D accumulation, R&D spillovers and human capital, together with the contribution of enabling institutional factors such as economic freedom and property rights, on total factor productivity (TFP).

Figure 1, in the form of a graph, clearly illustrates the innovative aspect of this study compared with other studies carried out on total factor productivity.

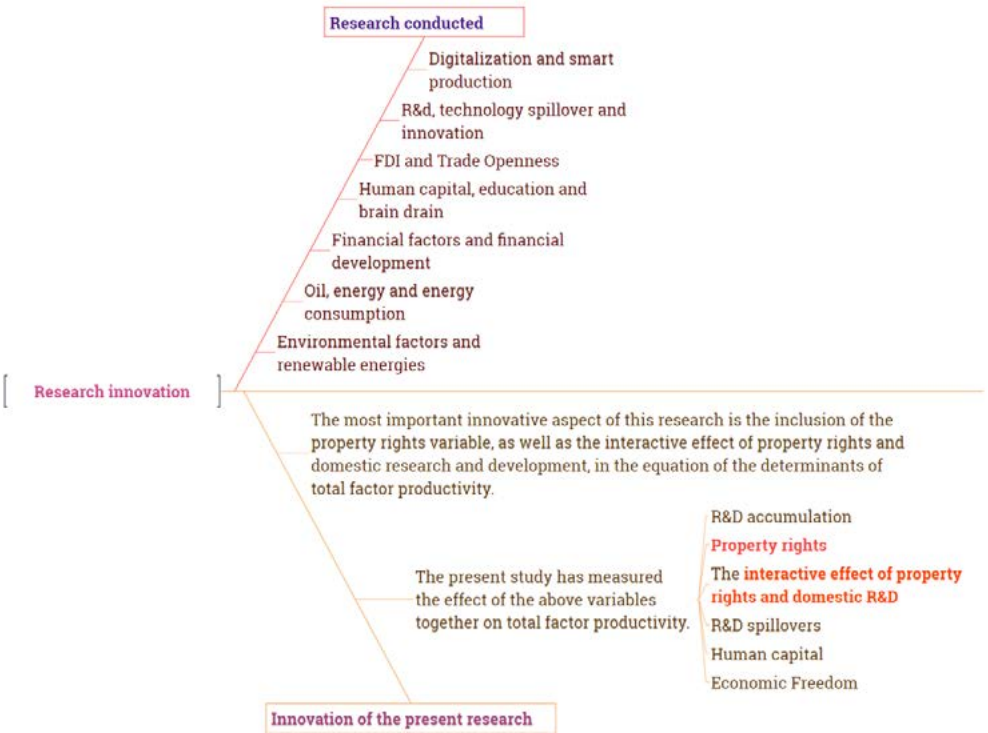

Fig. 1: The innovative aspect of the present study compared to other research conducted in the field of total factor productivity.

The structure of the article is as follows: the second section presents the theoretical basis and explains the mechanism by which explanatory variables influence dependent variables. Part three presents the research background, part four presents statistical evidence, part five presents the research model and methodology, part six assesses the model and analyses the results, and part seven summarizes and presents policy recommendations.

2. Theoretical foundations

Before Solow's growth theory was developed in the 1960s, economists largely attributed economic growth to traditional factors of production, such as labor, physical capital, and land. But Robert Solow (1960) showed that a large part of economic growth can be explained by residual factors--that is, factors other than labor and physical capital. In his model, Solow treated total factor productivity (TFP) as a time-dependent variable and assumed that it was an exogenous variable.

Subsequent economists, in particular Paul Romer and others, have challenged this view by identifying the specific determinants of the TFP. Contemporary theories of growth stress the critical role of the knowledge components in driving productivity. Factors such as domestic accumulation of R&D, international knowledge and technology spillovers and human capital are now seen as integral components of modern productive functions.

Moreover, institutional variables such as economic freedom and property rights are key enablers for productive activity. These factors influence TFP both directly - by shaping incentives and allocation of resources - and indirectly - by increasing the absorptive capacity of economies and stimulating innovation.

Domestic R&D accumulation is closely linked to overall factor productivity growth (TFP). Research and development activities drive technological progress, improving the efficiency and output of manufacturing processes. These activities stimulate innovation and lead to the creation of advanced machines and equipment, helping to accelerate and optimize production, reduce transaction costs and ultimately contribute to the increase of the TPD. In addition, research and development enhance knowledge spillovers, which play an essential role in increasing productivity. Innovations developed through R&D can be taken up and used by other companies and sectors, thus spreading their positive effects to the wider economy (Herzer, 2022).

However, under certain conditions domestic R&D can have a negative impact on TFP. For example, overinvestment in applied research to the detriment of basic research may impede long-term productivity gains. The potential for breakthrough innovations to drive sustainable growth in TFP may be limited by a disproportionate focus on short-term,

incremental improvements (Axquitt & Oates, 2021). This risk is particularly acute when R&D is carried out only under government mandates and is not linked to market mechanisms. Conversely, R&D initiatives that respond to societal needs and market demand - whether led by the public or private sector - are more likely to produce positive productivity outcomes.

Moreover, the omission of complementary investment may undermine the effectiveness of research and development. Without sufficient investment in areas such as training of workers, management practices and infrastructure, research and development alone may not translate into productivity gains (Graman *et al.,* 2005).

Another challenge arises from knowledge spillovers to competitors. If domestic innovations are easily replicated by foreign firms-due to weak intellectual property enforcement or high labor mobility-the originating country may not fully capture the productivity benefits (Jaffee & Lerner, 2011).

In summary, while domestic R&D has the potential to significantly improve TFP, its efficiency depends on strategic planning, on responding to market and societal needs, and on having the right complementarities in place. Misguided R&D policies or misdirected investment may not only fail to improve productivity, but can also have negative consequences.

Property rights are an important factor in creating a competitive environment in the field of economic activities that allows a large number of people and economic activists to operate. In today's world, there are two types of order. On one side, there are societies with a limited access order, in which some people, under the guise of sovereignty or connected to sovereignty, create rent by creating a monopoly and limiting the entry of others into the field of management of political and economic systems. On the other side, there is an open access order that paves the way for individuals to enter the field of free economic and political competition. In such systems, free competition determines the level of access of individuals to the resources of the society. Therefore, governments that seek to establish an open access order pay more special attention to one of the most fundamental components of this structure, which is property rights. Because property rights play a key role in the formation of a healthy and sustainable competitive environment. Because property rights prevent fraud and, on the other hand, ensure the rule of law in society (North *et al.,* 2009). It is noteworthy that in both types of governments with open access and limited access, property rights are relatively respected, but the difference between the two types of governance is that in the open access type, property rights belong to the majority of the people in the society, but in the limited access type, property rights are respected only by a

certain number of people in the society. In a society where free and equal access is provided, people are more motivated and enthusiastic to develop their latent talents. Such an environment encourages them to spend their energy on increasing their knowledge and skills instead of relying on special privileges and rent-seeking. As a result, society will witness the formation of a capable and specialized force that plays an important role in promoting productivity and the prosperity of production. However, in contrast, governments that restrict access to resources and opportunities reduce the motivation of individuals to actively participate in the economic and political arenas and pave the way for increased rent-seeking. These restrictions not only reduce healthy competition, but also contribute to resource scarcity. Because, as mentioned, the lack of open access prevents the development of talents, the growth of technology, and the advancement of research and development. Since the increase in production productivity depends on the creation of acquired advantages in the economy, limited access will directly disrupt the growth of productivity by creating a shortage of resources. Regarding the impact of property rights on the growth of productivity of all factors of production, it is necessary to pay attention to all aspects of property rights in a balanced manner. If a government pays more attention to one type of intellectual property rights or physical property rights than necessary and neglects the other, productivity growth will be slower. Especially in today's technology-hungry world, it is necessary to pay special attention to intellectual property rights.

Property rights play an important role in enhancing total factor productivity growth by creating an environment for innovation, investment, and efficient allocation of resources. Very high of property rights, especially intellectual property rights (IPRs), encourage individuals and organizations to invest in research and development. Because by ensuring that innovators can benefit from their creativity and inventions, property rights reduce the risk of imitation and promote technological advances (Habib *et al.,* 2019). Intellectual property rights provide protection for innovations and inventions. Of course, it is important to note that property rights should be respected by both the innovator and the user of the innovation in order to maximize its positive impact on the productivity of factors of production. Also, when property rights are well defined and enforced, meaning that there is open and maximum access in society, resources are allocated to their most productive uses and the efficient allocation of resources is effectively promoted (Habib *et al.,* 2019). Property rights create a fertile environment for economic activities, as property rights create a framework in which businesses can operate without fear of expropriation or unfair competition. This environment supports economic growth and the development of high-quality companies (Zhu and Sun, 2023).

The interactive effect of property rights and domestic R&D: Strong protection of property rights and expansion of R&D activities are both important drivers of productivity growth, but their interaction can strengthen or moderate their individual effects. Since the relationship between property rights and domestic R&D is a complementary relationship, the consensus of these two variables will lead to the formation of a positive interaction between these two variables, which will be beneficial for the growth of factor productivity. Also, the existence of a high score in patent rights increases the productivity gains from R&D, especially in technology-based sectors (Park and Ginart, 1997). On the other hand, if a positive interaction between property rights and domestic R&D does not form, its effect on total factor productivity growth will be weakened. For example, in weak institutional environments where property rights are weakly and ineffectively enforced, R&D may not lead to TFP growth because it reduces the incentive to engage in R&D (Ajmoglu *et al.,* 2006). Notably, the productivity benefits of R&D are significantly higher in countries with strong legal systems that protect intellectual and physical property (Falvey *et al.,* 2006). Conversely, in countries with weak and limited property rights, R&D may lead to rent-seeking rather than innovation, reducing its productivity impact (Murphy *et al.,* 1993). Thus, the way in which property rights and domestic R&D interact will be influential in their impact on TFP growth.

R&D spillovers: Countries indirectly gain access to the R&D achievements of their trading partners by importing goods and services—especially intermediate and capital goods—from their trading partners. This process operates through two main pathways: first, through learning and imitation of new technologies, which allows for the localization and improvement of domestic production processes; and second, through the use of higher-quality inputs (such as advanced machinery and raw materials) that increase production efficiency (Coe *et al.,* 2009). The higher the share of imports in a country's GDP (the higher the economy's sophistication), the greater its exposure to global advanced technologies and, consequently, the greater its absorption of foreign R&D benefits. R&D activities produce knowledge that can be shared and used by other firms and industries. These knowledge spillovers contribute to the growth of TFP by enabling firms to adopt best practices, improve processes, and innovate (Spittoven and Merloyd, 2023). In addition, the import of high-tech goods acts as a vital conduit for knowledge transfer and contributes to the growth of total factor productivity (TFP) (Blitz and Molders, 2013). If the results of foreign R&D spillovers enter a country in a way that is not in line with the needs of that country, it can lead to misallocation of resources in a direction that is not beneficial to the country's economy and thus cause a waste of resources, which in turn will have a negative

impact on the growth of total factor productivity. Of course, R&D spillovers do not inherently have a negative impact on the productivity of production factors in the economy of countries, but if the import of technology is not in line with the economic structure of the importing country (i.e., it is not in line with its needs for user-, capital-, or knowledge-intensive technology), it cannot be expected that this type of R&D will lead to an increase in total factor productivity. Planning and directing R&D spillovers in the country should be in a way that complements domestic R&D and, on the other hand, is in line with the needs of the importing country's industry and economy in order to improve total factor productivity.

Human capital increases the ability of workers to innovate and adopt new technologies, which in turn strengthens TFP (Kijak, 2020). Human capital can complement research and development activities and lead to innovation in equipment and production processes, which will have a positive effect on the growth of total factor productivity. Of course, human capital can also have different effects on productivity depending on the type of economic structure of countries. In developed economies, where the capacity of human capital is used in a desirable and targeted manner, it will have significant effects on the growth of factor productivity and, consequently, economic growth. However, in developing economies, due to the lack of appropriate space for the demand for human capital by the government or enterprises, human capital not only does not increase the productivity of production factors, but also reduces the productivity of factors in other sectors of the economy due to the high costs incurred for the growth of this factor in the country and the lack of its application in the economy to generate wealth and income. Therefore, although human capital is effective in productivity growth, the role of the quality of governance and scientific management at the level of macro policy-making and economic development of countries is very decisive in maximizing the impact of human capital on the productivity of production factors.

Economic Freedom: According to the definition of the Heritage Foundation (2025), economic freedom is a fundamental right of every individual to control his or her own work and property. In an economically free society, individuals are free to engage in various activities, including work, production, consumption, and investment, without restriction. In such societies, governments facilitate the free movement of labor, capital, and goods, and avoid unnecessary restrictions that might infringe on economic freedoms. Their goal is to protect economic freedom without overly restricting it.

Economic freedom affects factor productivity growth through the allocation of resources and the creation of innovation and entrepreneurship. Economic freedom allows

for a more efficient allocation of resources, which increases productivity. When businesses operate in an environment with less burdensome regulations and less disincentive taxes, they can allocate resources more efficiently, leading to higher TFP. Economic freedom also fosters innovation and entrepreneurship, which are key drivers of TFP. A favorable business environment encourages firms to invest in new technologies and innovative practices, which lead to increased factor productivity (Bjornskov *et al.,* 2010). Economic freedom also affects total factor productivity growth through the channel of institutional quality. High levels of economic freedom are often associated with strong institutions that protect property rights and enforce contracts properly. These institutions create a stable environment for businesses to operate, reduce uncertainty, and promote long-term investments in productivity-enhancing activities (Borowicz *et al.,* 2020). While economic freedom is generally associated with positive economic outcomes, it can sometimes have a negative impact on total factor productivity (TFP) growth under certain circumstances. One of the issues that can lead to the negative effect of economic freedom on total factor productivity is weak institutional frameworks, which are mainly observed in developing countries. In countries with weak institutions, increased economic freedom may lead to regulatory capture or corruption. This can distort resource allocation and reduce productivity growth (Erdem and Toksu, 2012). In fact, it is noted that to benefit from the positive effects of economic freedom on productivity growth, countries should apply it in proportion to their level of development and institutional quality. In this case, they will be able to gain new comparative advantages. In this situation, the growth of total factor productivity in countries will reduce the gap between developed and developing countries in this regard. This is the goal that economic freedom pursues in order to increase total factor productivity. Otherwise, what is expected from the impact of this variable on total factor productivity will not happen.

3. Research Background

The existing literature on total factor productivity (TFP) offers a comprehensive and multi-dimensional understanding of the drivers influencing productivity growth across different economic contexts. A significant body of research emphasizes the transformative role of digitalization and smart manufacturing in enhancing TFP. For instance, Liu and Zhuo (2025), Li *et al.,* (2024), and Cheng *et al.,* (2023) consistently highlight that digital transformation and smart manufacturing policies significantly boost TFP in China by improving industrial chain integration, flexibility, and innovation capacity. These findings are further reinforced by Pan *et al.,* (2022), who identify a positive nonlinear relationship

between the digital economy and provincial TFP, suggesting that digitalization not only drives immediate efficiency gains but also supports long-term sustainable productivity growth. Compared to earlier studies focusing on traditional inputs, these recent works underscore a paradigm shift toward technology-driven productivity, positioning digital infrastructure as a core production factor rather than a supplementary tool.

Another prominent theme revolves around innovation and knowledge accumulation, particularly through research and development (R&D) and human capital. Studies by Haider *et al.,* (2021), Hong *et al.,* (2019), and Habib *et al.,* (2019) confirm the robust positive impact of domestic and foreign R&D investments on TFP, with spillovers from trade partners further amplifying gains. This is especially evident in the works of Shahabadi and his collaborators, who, across multiple studies, demonstrate the critical role of both domestic R&D and international knowledge spillovers in Iran's agricultural and industrial sectors. In parallel, human capital emerges as a key determinant, as shown by Adnan *et al.,* (2020), Al-Shamriya and Al-Rakhsab (2019), and Norouzi *et al.,* (2021). However, some studies, such as Adnan *et al.,* (2019), reveal regional heterogeneity-human capital enhances TFP in East Asia but reduces it in West Asia, possibly due to structural dependencies on resource rents. This contrast highlights the importance of institutional and economic context in shaping the effectiveness of human capital.

Financial and fiscal policies also play a crucial role, though their effects are more nuanced. While Malik *et al.,* (2021) and Shahabadi and Feli (2011) find a positive impact of financial development on TFP, Zourki *et al.,* (2024) reveal an asymmetric negative effect of government size and taxation in Iran, indicating that excessive public sector expansion can hinder productivity. Similarly, Li and Tran (2025) show that higher local budget retention improves public investment efficiency and TFP in Vietnam, suggesting that fiscal decentralization can be beneficial under certain institutional arrangements. In contrast, external shocks such as natural disasters (Malik *et al.,* 2021), drought (Dego & Bekele, 2019), and financial stress (Ghasemifar *et al.,* 2022) are found to have persistent negative effects on productivity, emphasizing the vulnerability of TFP to macroeconomic and environmental instabilities.

International linkages-including foreign direct investment (FDI), trade openness, and financial integration-also yield mixed but generally positive outcomes. Ita and Pedro (2021), Pegkas *et al.,* (2020), and Aref-Al-Rahman and Annabeh (2020) report favorable effects of FDI and financial integration on TFP, while Bakhshali *et al.,* (2021) note that although FDI's direct effect may not always be statistically significant, it contributes to global productivity convergence through technology diffusion. However, Dego and Bekele

(2019) caution that in some developing economies like Ethiopia, FDI and government spending can have long-term negative impacts, possibly due to dependency or inefficiency. Energy use, particularly fossil fuels, is another critical differentiator: Jafari *et al.,* (2019) and Shojaei *et al.,* (2024) find that high oil consumption reduces TFP, especially in resource-dependent economies, whereas renewable energy and energy efficiency contribute positively. Overall, these comparative insights reveal that while technological and human capital investments consistently enhance productivity, the effectiveness of financial, trade, and energy policies depends heavily on institutional quality, economic structure, and regional context.

In general, based on studies conducted on the factors affecting TFP growth, the main emphasis has been on the role of technology (digitalization, smart manufacturing, innovation), macroeconomic policies and variables (inflation, financial development, government size), and institutional variables (good governance, social capital). They have also examined the effect of energy variables (fossil fuel consumption, renewable energy) and geographical-economic factors (urbanization, natural disasters) on total factor productivity. Several studies, mainly by Shahabadi *et al.,* have examined the impact of knowledge components on the growth of total factor productivity in Iran and other selected countries. However, the present study, in addition to using the knowledge-based approach and using components such as domestic research and development, foreign research and development spillovers, human capital, and economic freedom, also includes the property rights variable in its analysis. This is because property rights, in terms of protecting the motivation of economic actors, lead to the growth of innovation and, consequently, the growth of total factor productivity. While in previous studies, this variable has not been considered in the presented models.

3. Statistical facts

The importance of examining the growth of total factor productivity becomes more tangible and clear when the statistical gap between countries is revealed. In this case, it may be better to find the missing link in economies that suffer from low levels of productivity in their production. Although the economic conditions and structures of countries are different, it is possible to better compare countries in terms of the causes of growth or lack of growth in total factor productivity by using the variables of domestic research and development growth, foreign research and development spillovers, human capital, economic freedom, and property rights. In this part of the research, the situation of Iran, as some country rich in resources, each of which can be used as a factor of production, is

specifically compared with other selected developing countries in the present study. Figure 1 shows the comparison of the trend in total factor productivity between selected developing countries and Iran. Of course, the important point is that changes in total factor productivity occur slowly, and for this reason, even a one-unit difference between the group of countries studied in this area indicates a high gap between the economic structure of the two groups of countries studied, and in fact, even a one-unit difference can seem significant to economic thinkers. It is also clear from Figure 1 that there is a very deep gap between the total factor productivity of the Iranian economy and other selected developing and developed countries studied.

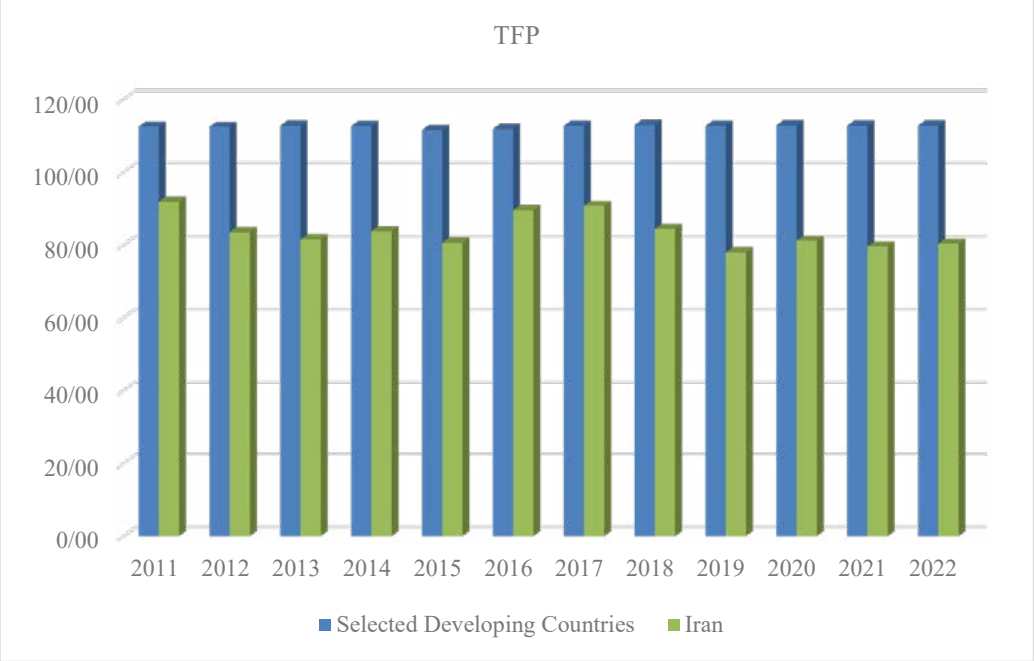

Chart 1: Average Total Factor Productivity Trends in Selected Developing Countries and Iran (Research Findings and https://ourworldindata.org).

Figure 2 compares the trend of the Economic Freedom Index. According to this chart, Iran has always been significantly lower than other selected developing countries. Iran's highest Economic Freedom Index was in 2017, but since then, the index has dropped sharply. Thus, on average, during the period under review, the selected developing countries and Iran have been assigned indices of 7 and 3, respectively.

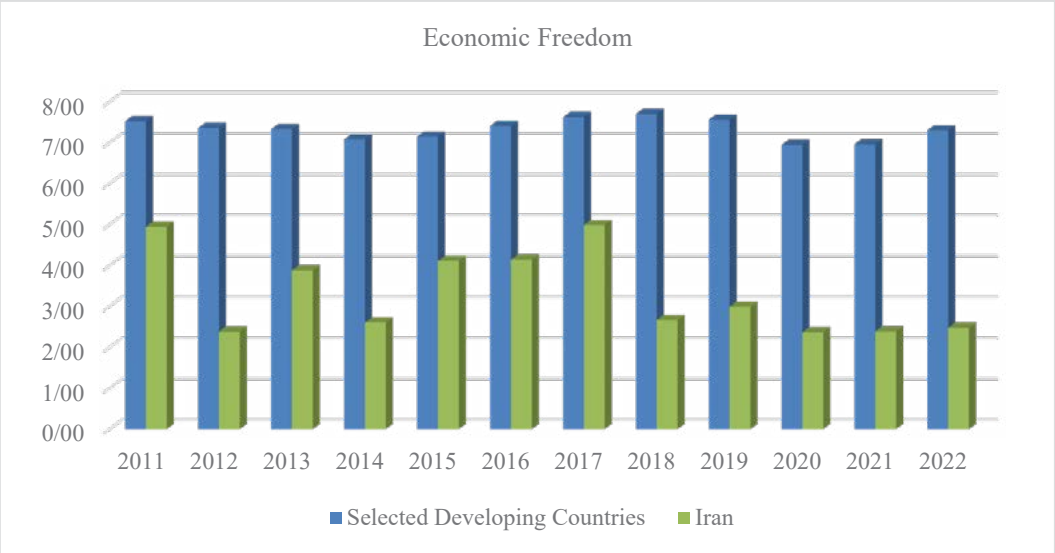

Chart 2: Average trend of the Economic Freedom Index of selected developing countries and Iran (Research findings and https://efotw.org).

Also, Figures 3 and 4 examine the gap in the average trend of domestic R&D and R&D spillovers between selected developing countries and Iran. Thus, it can be seen that there is a deep gap between the selected developing countries and Iran regarding domestic R&D spending and R&D spillovers, and this can explain part of the per capita investment gap between the selected developing countries and Iran. Therefore, according to Figures 5 and 6, we can witness a significant gap in domestic R&D spending and R&D spillovers in Iran compared to the selected developing countries. Of course, the low volume of Iran's R&D spillovers is not without the impact of international sanctions during the period under study.

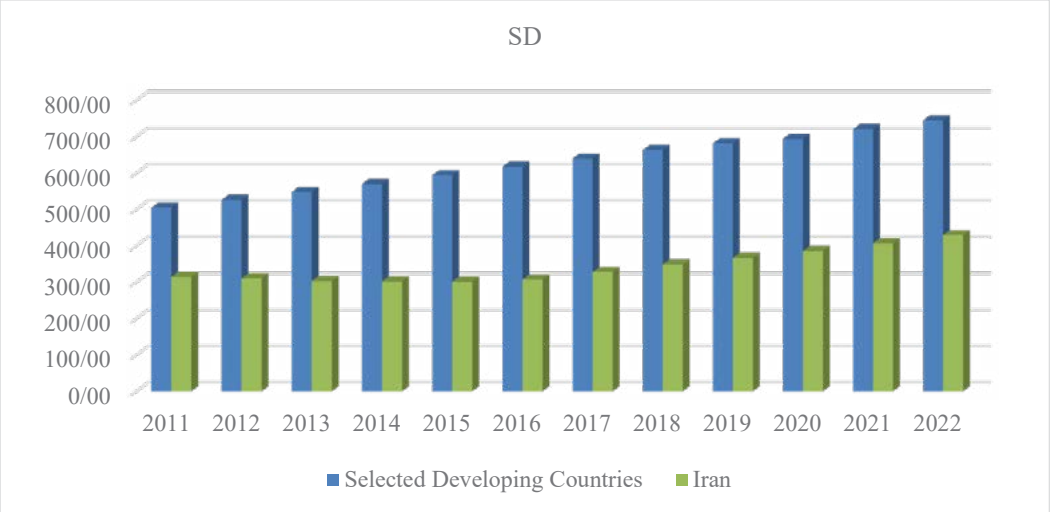

Chart 3: Average trend of domestic R&D in selected developing countries and Iran (Research findings and https://databank.worldbank.org)

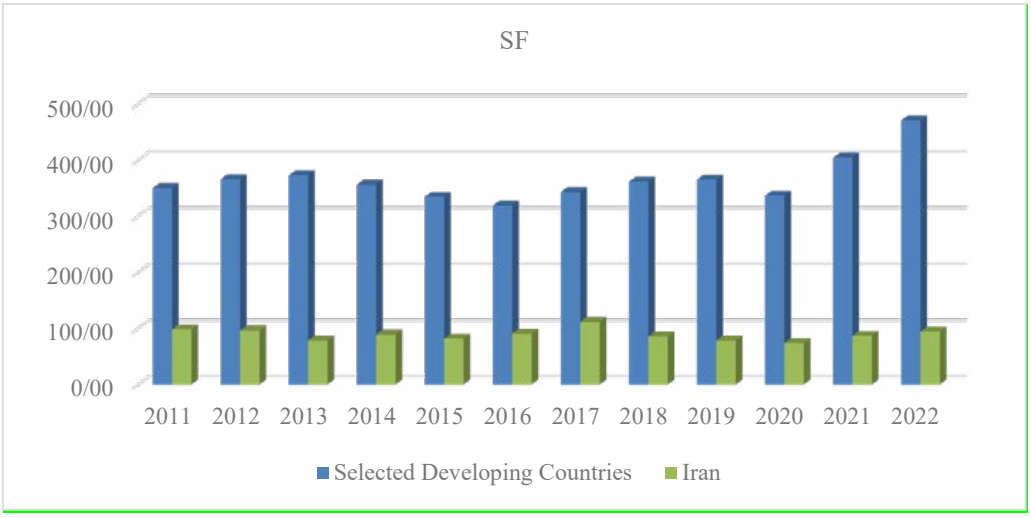

Chart 4: Average trend of R&D spillovers of selected developing countries and Iran (Research findings and https://www.trademap.org)

Also, Figure 5 shows the gap between selected developing countries and Iran regarding the human capital variable. According to the chart, Iran has always been above the average of other selected developing countries in terms of the human capital index.

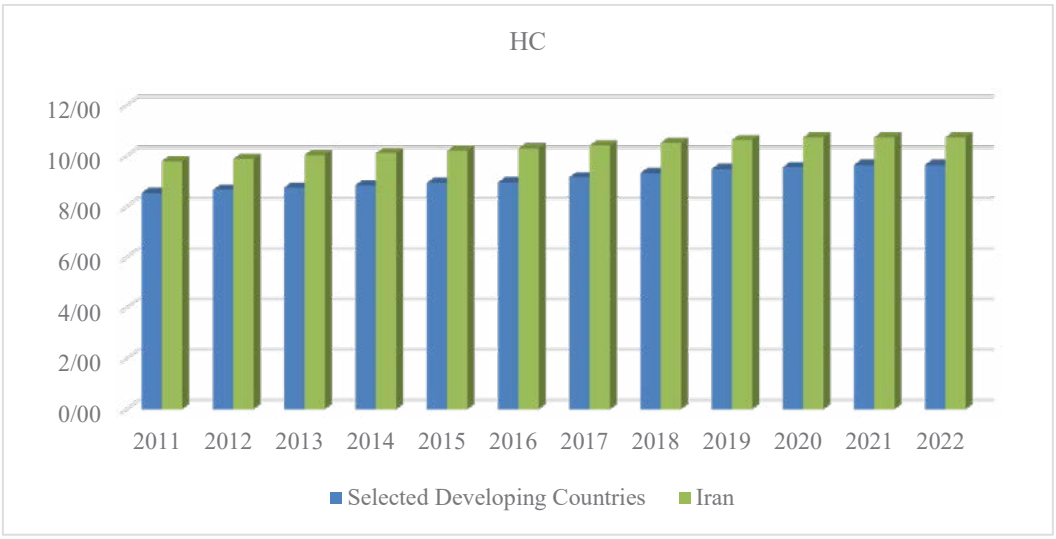

Chart 5: Human Capital Trends in Selected Developing Countries and Iran (Research Findings and https://hdr.undp.org)

Property rights, which are considered to be factors facilitating production in the economy, have 3 components, each of which is shown in Figure 6, in the gap between the two selected developing countries and Iran. The top of the graph is the variable (PR), which has a gap that is almost the same as the gap between the variables LP (legal property rights), IPR (intellectual property rights), and PPR (physical property rights) between the selected

developing countries and Iran. However, this gap is less for the physical property rights variable than for other variables and more for legal property rights and intellectual property rights. In all components of property rights, Iran has a lower score than other selected developing countries, and this has caused the overall property rights index of Iran to decrease compared to other countries studied. Of course, regarding physical property rights, Iran's situation is better than that of other components of property rights, and it has a very small gap with other selected developing countries in this component of property rights.

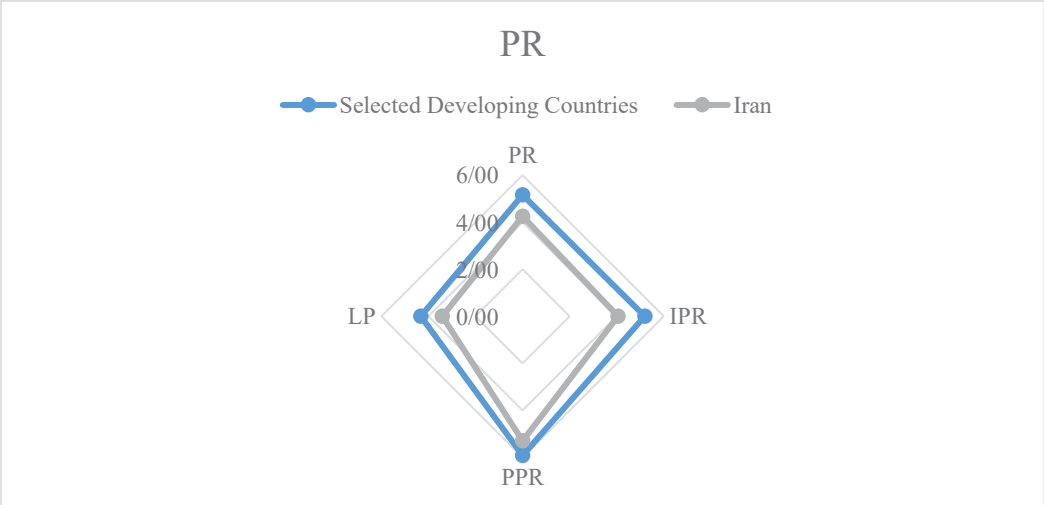

Chart 6: Average property rights index and its three components between selected developing countries and Iran during the period (2011-2017) (Source: Research findings and https://internationalpropertyrightsindex.org)

4. Research Method

In equation (1), based on the mechanisms presented in the theoretical foundations section, the total factor productivity variable is considered as the dependent variable and the variables of domestic R&D accumulation, R&D spillovers, human capital, economic freedom, and property rights are considered as explanatory variables, which is shown in the equation below.

TFP=f(SD, SF, PR, HC, EF)(1)

TFP: Total Factor Productivity, SD: Domestic R&D Stock, SF: R&D Spillovers, EF: Economic Freedom, HC: Human Capital, and PR: Property Rights

The above equation can also be expressed for selected developing countries as follows, where equation (2) considers the general property rights index and equation (3) considers the interactive effect of property rights and domestic R&D:

$$ln(TFP)_{it} = \alpha_0 + \alpha_1 ln(SD)_{it} + \alpha_2 ln(SF)_{it} + \alpha_3 ln(EF)_{it} + \alpha_4 ln(PR)_{it} + \alpha_4 ln(HC)_{it} + \mu_{it} \quad (2)$$

$$ln(TFP)_{it} = \beta_0 + \beta_1 ln(HC)_{it} + \beta_2 ln(SF)_{it} + \beta_3 ln(EF)_{it} + \beta_4 ln(SDPR)_{it} + \vartheta_{it} \quad (3)$$

Equation (2) is fitted using panel data for the period 2011-2022 and its statistical population is a selection of developing countries.

In equation (3), δ is the depreciation rate. The following method has been used to calculate the stock of domestic R&D (SD) (Grillich, 1988):

$$SD_t = (1 - \delta) * SD_{t-1} + R\&D_t \quad (4)$$

The initial value SD_0 is calculated as follows:

$$SD_0 = \frac{R\&D_0}{(\delta+g)} \quad (5)$$

The value of (g) is also calculated from the following equation:

$$g = \frac{\ln\left(\frac{R\&D_{2004}}{R\&D_{1990}}\right)}{15} \quad (6)$$

R&D spillovers (SF) are calculated using the Coe and Helpman method as follows. In other words, R&D spillovers are usually calculated as a weighted sum of the R&D stock of other countries (Coe and Helpman, 1995):

$$SF_{it} = \sum_{j \neq i} \omega_{i,j}.SD_{jt} \quad (7)$$

The following method is used to calculate weight:

$$\omega_{ij} = \frac{Import_{ij}}{\sum_{i \neq j} Import_{ij}} (8)$$

Inspired by theoretical foundations, it is expected that the sign of the estimated coefficients of all explanatory variables introduced in equation (2) will be positive.

Table 1: Statistical source of variables in the interaction effect equation of property rights and research and development

Variable type	Variable name	Latin symbol	Statistical source
Dependent	Total factor productivity	TFP	https://ourworldindata.org
Explanation	Accumulation of domestic research and development	SD	https://databank.worldbank.org
Explanation	Spillovers R&D	SF	https://databank.worldbank.org https://www.trademap.org/
Explanation	Economic freedom	EF	https://efotw.org
Explanation	Property rights	PR	https:// internationalpropertyrightsindex.org
Explanation	Human capital	HC	https://hdr.undp.org/data-center/documentation-and-downloads

5. Model Estimation and Results Analysis

Based on the results of the cointegration test in Table (2), since its probability statistic is less than 5%, the H0 hypothesis that there is no cointegration is rejected, and the existence of a long-term relationship between the variables is confirmed.

Also, based on the results of the F-Limmer test, the data of the variables under study in the equation of determinants of total factor productivity are of a mixed nature. Therefore, according to the probability statistic obtained from this test, the H0 hypothesis that the data is a pool is rejected.

The results of the Hausman test also indicate that the sections do not differ structurally from each other and their difference are random. Thus, considering that the probability statistic is greater than 5%, the H0 hypothesis that there are random effects of having a model is accepted.

The cross-sectional correlation test, whose H0 assumption is that there is no correlation between the cross-sectional areas, is also confirmed, given that the probability statistic value is greater than 5%. Therefore, this H0 assumption is confirmed, so there is no correlation between the cross-sectional areas.

Table 2: Results of the recognition tests of equations 2 and 3

Test	H0 hypothesis	Equation (2)	Equation (3)
Cointegration	No Cointegration	Prob: 0.002 Result: H0 Reject	Prob: 0.000 Result: H0 Reject
Cross-section Dependence	No Correlation	Prob: 0.4229 Result: H0 Accept	Prob: 0.4256 Result: H0 Accept
F-Limmer	Pool	Prob: 0.000 Result: H0 Reject	Prob: 0.000 Result: H0 Reject
Hausman	Random Effect	Prob: 0.5556 Result: H0 Accept	Prob: 0.5346 Result: H0 Accept

(Research findings).

Based on the results of Table (3), all variables are at the non-stationary level and have become stationary in the first-order difference.

Table 3: Results of the stationarity test of variables Equations 2 and 3

Variable	Test	Result
TFP	Stationary	Nonstationary in Level– I(1)
SD		Nonstationary in Level– I(1)
SF		Nonstationary in Level– I(1)
EF		Nonstationary in Level– I(1)
PR		Nonstationary in Level– I(1)
HC		Nonstationary in Level– I(1)

(Research findings).

Table 4 shows the results of estimating equations 2 and 3, which include the coefficients of the explanatory variables along with information on the significance or non-significance of their relationship with the dependent variable. The results obtained in relation to the statistical population of selected developing countries are analyzed as follows:

The growth of domestic R&D accumulation in developing countries can have a positive impact on the growth of total factor productivity (TFP) because R&D activities lead to innovation, technological advancement, and improvement of production processes, which directly contribute to increasing efficiency and reducing costs. Domestic R&D also enhances knowledge spillovers and enables the spread of new technologies to other sectors and industries. These effects are most evident when R&D activities are carried out in line with market needs and real demand in the economy, and are accompanied by the participation of the private and public sectors. Therefore, when R&D is carried out with careful planning, in coordination with domestic capacities, and considering economic conditions, it can play an effective role in improving total factor productivity in developing countries.

The growth of property rights in selected developing countries is due to the creation of a competitive environment, the reduction of rent seeking, and the strengthening of the rule of law, which increases the incentives of economic actors to invest, innovate, and use resources efficiently. When property rights are well defined and enforced, individuals find the necessary confidence to invest in research and development, which leads to technological progress, improved production processes, and increased total factor productivity (TFP). Also, broad and equal access to property rights provides more opportunities for the broad participation of society in economic activities and leads to the flourishing of talents and the increase of the capacity of economic professionals. Therefore, property rights play an important role in promoting productivity growth in selected developing countries by creating incentives, facilitating the optimal allocation of resources, and encouraging innovation.

The positive and significant relationship between the interactive effect of property rights and domestic research and development (PRSD) and total factor productivity (TFP) indicates the complementarity of these two variables. A high score on the property rights index increases the incentive and return on investment in R&D by providing security for intellectual property and preventing the waste of resources in rent-seeking activities. As a result, the interaction of these two factors enhances productive innovations and technological improvements and leads to the growth of production efficiency (TFP).

R&D spillovers can have a positive impact on the growth of total factor productivity (TFP) in selected developing countries, because these spillovers lead to the spread of new technologies and specialized knowledge that help improve production processes, increase efficiency, and innovation. Also, the import of high-tech goods plays an important role in knowledge transfer and enables companies to use better methods and equipment. These effects are highlighted when imported technologies are targeted and tailored to the country's economic needs and capacities, and act as a complement to domestic research and development activities. Therefore, targeted and coordinated planning for the absorption and utilization of these spillovers can effectively contribute to the growth of total factor productivity in these countries.

The impact of human capital growth on total factor productivity growth in selected developing countries has been reported to be negative. When human capital, due to a lack of coordination with the real needs of the labor market and the low willingness of firms and the government to use it, in practice leads to unemployment of educated people or improper use of the skills provided, this negative impact occurs between the two variables. Also, heavy investment in education without the necessary infrastructure to attract and utilize skilled labor causes the country's limited resources to be allocated inefficiently and, instead of increasing productivity, leads to a decrease in productivity in other sectors. Finally, weaknesses in governance and macroeconomic planning prevent human capital from becoming a real force for TFP growth.

The growth of economic freedom in developing countries has had a positive impact on the growth of total factor productivity (TFP) because it helps allocate resources more efficiently by reducing unnecessary regulations, facilitating the flow of capital, labor, and technology, and creating a favorable environment for entrepreneurship and innovation. Economic freedom also reduces uncertainty by strengthening contract-related institutions and encourages long-term investment in productivity-enhancing areas. These effects are more pronounced when economic freedom is accompanied by improved quality of governance institutions and sound policy management, and is applied in proportion to the level of economic development of the country. Therefore, when economic freedom is implemented with careful planning and attention to domestic capacities, it can play an effective role in increasing total factor productivity in selected developing countries.

Table 4: Estimation results of equations 2 and 3[1]

Variable	Equation (2)	Equation (3)
Ln(SD)	0.0362 (0.090)	---
Ln(SF)	0.896 (0.000)	0.1337 (0.000)
Ln(HC)	-0.2377 (0.012)	0.2651 (0.003)
Ln(PR)	0.1296 (0.004)	---
Ln(EF)	0.0549 (0.015)	0.6036 (0.000)
Ln(SD*PR)	---	0.0768 (0.000)
Cons	4.2606 (0.000)	2.0637 (0.000)
R- Squared	0.2730	0.4356

(Research findings).

Based on the findings presented in Table 4, the results of this study regarding the variable "domestic research and development" were consistent with the studies of Haidar *et al.,* (2021) and Pegkas *et al.,* (2020). Also, regarding the variable "foreign research and development spillovers", the results are consistent with the studies of Siller *et al.,* (2021) and Habib *et al.,* (2019). Regarding the variable "human capital", the results of this study are consistent with the findings of the studies of Adnan *et al.,* (2020) and Shahabadi and Sarigol (2017). In addition, regarding the variable "property rights", the results obtained are consistent with the results of the study of Shahabadi and Amiri (2014). However, no study focusing on the variable of economic freedom, as well as the interactive effect of property rights and research and development, and their effect on total factor productivity has been observed; therefore, it is not possible to compare the results of the present study with other studies.

6. Conclusion

Total factor productivity (TFP) is one of the main indicators determining sustainable economic growth and competitiveness of countries. This concept indicates the effectiveness of the use of productive resources, including labor, physical capital, and technology. In many developing countries, the growth of total factor productivity faces challenges that prevent increased production and economic growth. Therefore, in order to

[1] The numbers without parentheses are the coefficients obtained from the estimation, and the numbers in parentheses are the P-Value coefficients.

remove obstacles to the growth of factor productivity in selected developing countries examined in this study, the following recommendations are presented:

Given that in the results of estimating the interactive effect of property rights and research and development on the growth of total factor productivity, the human capital variable has a negative estimated coefficient, this result was unexpected. In developing societies, although large investments are often made in the growth of human capital, governments do not create the appropriate conditions for the use of this human capital in production. Thus, the growth of human capital in these societies has not led to the growth of total factor productivity. It is recommended that macroeconomic policymakers in selected developing countries pay special attention to reforming the relative prices of factors in order to reform the economic structure in order to reform and stimulate the behavior of economic actors and the desire to use new factors of production, especially human capital, at the forefront of macroeconomic planning, because the frequency of prices, which is based on the relative prices of factors and can be determined by the government, plays a very important role in the use of human capital by the government sector and enterprises in production and the growth of total factor productivity. In fact, the government can create alignment between physical relative abundance and price relative abundance through policy tools to effectively use the human capital factor in production. Also, in order to fill the considerable technical gap with advanced economies and to optimally utilize natural resource rents in order to convert them into renewable wealth, it is necessary to avoid completely leaving prices to the market mechanism, but it is necessary to gradually move towards price determination by the market mechanism by reforming the economic structure.

Based on the estimation results, the coefficient of the property rights variable on total factor productivity is positive and significant. This shows that the protection of property rights (intellectual, physical and legal) provides the necessary incentive for innovation and investment. Thus, by maintaining and improving intellectual, physical and legal property rights, countries witness an increasing positive impact of the property rights variable on total factor productivity. In this regard, it is recommended that policymakers of countries include the independence of the judicial system, the effective implementation of antitrust laws and the prevention of illegal government interference in the market, the creation of a stable and predictable environment for asset owners (both physical and knowledge-based), and increased transparency in the transfer of national assets and resources on their agenda and attach special importance to it.

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Observation Contribution

All authors contributed adequately to this study from its beginning to its end. They all read and approved the final document.

Conflict of Interest

Authors declared no conflict of interest.

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چکیده

بهره‌وری کل عوامل تولید به‌عنوان یکی از شاخص‌های کلیدی رشد اقتصادی بلندمدت و نشان‌دهندهٔ کارایی استفاده از نهاده‌های تولید در فرآیند تولید است. بهبود بهره‌وری کل عوامل تولید نه‌تنها منجر به رشد اقتصادی پایدار می‌گردد، بلکه نقش بسیار تعیین‌کننده‌ای در افزایش قدرت رقابت‌پذیری بین‌المللی ایفا می‌کند؛ بدین‌ترتیب، ارتقاء بهره‌وری کل عوامل تولید به‌عنوان موتور محرکهٔ رشد اقتصادی پایدار، همواره یکی از دغدغه‌های اصلی سیاست‌گذاران و پژوهشگران اقتصادی بوده است. این پژوهش با تمرکز بر نقش انباشت تحقیق‌وتوسعهٔ داخلی، سرریز فناوری ازطریق تحقیق‌وتوسعه شرکای تجاری، سرمایهٔ انسانی، حقوق مالکیت و آزادی اقتصادی، درپی تبیین سازوکارهای مؤثر بر بهره‌وری کل عوامل تولید کشورهای منتخب درحال توسعه در بازهٔ زمانی ۲۰۲۲-۲۰۱۱م. است. براساس یافته‌های تحقیق، متغیرهای انباشت تحقیق‌وتوسعهٔ داخلی تأثیر مثبت و بی‌معنا و سرریز تحقیق‌وتوسعهٔ خارجی، حقوق مالکیت و آزادی اقتصادی اثر مثبت و معناداری بر بهره‌وری عوامل تولید داشته‌اند؛ هم‌چنین اثر تعاملی حقوق مالکیت و تحقیق و توسعهٔ داخلی بر بهره‌وری کل عوامل تولید نیز مثبت و معنادار بوده است.

کلیدواژگان: آزادی اقتصادی، تحقیق و توسعه، حقوق مالکیت، سرریز فناوری، سرمایهٔ انسانی.
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