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Unleashing The Global Potential: The Impact of Quality of Life on Knowledge Spillover and Productivity Disparities

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ABSTRACT

The purpose of this study is to look into the relationship between knowledge spillover, productivity differences, and the impact of quality of life in different countries. In order to accomplish this goal, the econometric technique known as Cross Sectional Augmented Autoregressive Distributive Lag (CS-ARDL) is utilized throughout this work. The findings point to the existence of complementarities between knowledge spillovers and the factors of quality of life in terms of their influence on total factor productivity. The findings imply that there is a contribution of knowledge spillovers to the national level of production. On the other hand, the relationship between knowledge spillovers and domestic productivity is contingent on a predetermined level of human capital as well as economic liberty. Hence, countries with more developed human capital and high economic freedom get more benefited from knowledge spillovers. This study has far-reaching ramifications. These findings can be used by policymakers to develop policies and initiatives that emphasize quality of life improvements, provide a conducive climate for knowledge spillover, and support productivity development across nations. Such approaches could help reduce economic inequities and propel global progress toward sustainable and inclusive growth.

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1. Introduction

Exploring the phenomena of "why some countries are rich and some are very poor" is the most debatable issue over the years. Over the past five decades, some countries have shown remarkable growth performance while some countries have not grown at all. Variations in the growth performance of countries often pass down to dissimilarities in factors of production and in total factors productivity (TFP). Technological advancement has a considerable contribution in bringing economic prosperity. Furthermore, it is considered as a major source of cross-country income differences. Academia and policy makers both recognize the importance of innovation and technology in increasing total factor productivity and escaping poverty across nations. According to Maddison (2005), technology and innovation significantly raise world per capita income. Furthermore, technological advancement also improves production process and advances the way of doing business. Thus, advance Technology and economic prosperity are interlinked. For continuous economic growth, nations need to introduce innovations and improve technology. Essentially, the process of growth decelerates if the level of technology and innovation do not improve over time. Thus, innovation and technology are the key factors of rapid growth of developed economies.

Economies that have seen quick and persistent growth have been particularly receptive to importing new techniques, technologies, and other forms of informational input from elsewhere in the world. Although these economies did not have to create much of this new information from scratch, they did need to absorb a lot of it very quickly. For sure, we are aware of that. But we don't know how they achieved it, or how policymakers can speed things up as well as we'd like to. Therefore, economic catch-up and sustained growth depend critically on knowledge gained from the global economy (Shibata, 2006). In today's rapidly evolving global economy, the price of knowledge cannot be overstated. Indeed, creativity and fresh ideas are crucial to the development of industrialized economies. More countries than ever before are benefiting from the rapid export of cutting-edge technologies developed in their midst. The telegram had reached 80 percent of developing countries ninety years after its introduction. The cell phone only needed 16 years to accomplish this feat (Argote et al., 2000).

Knowledge spillover from highly industrial countries, such as from OECD member countries and G7 countries is considered to be a key determinant of TFP growth in developing economies. FDI and imports are the potential channels of such transmission of knowledge spillover from these highly industrial countries to developing countries. The appropriation of knowledge from technologically intensive imports or FDI, However, it necessitates a certain level of absorptive capability (Cantner & Pyka, 1998), and firms R&D activities, not limited to innovate, but on top to develop competencies, which allows them to absorb external knowledge (Cohen & Levinthal, 1989). Put on this idea at the macro level, absorptive capability can be linked to human capital. From this perspective, a country with higher human capital will have more aptitude to absorb knowledge spillover from rest of the world. It is therefore important to understand whether, at the macro level, higher human capital helps countries to absorb knowledge flows from imports and FDI.

1.1. Knowledge Spillover, Human Capital and Total Factor Productivity

Economists have looked at human capital from many angles because of its complexity. The radical findings of Schultz (1961) pave the way for a more thorough investigation of human capital's impact on economic expansion. As with other repeatable components, human capital is considered an input in the aggregate production function as part of the conventional growth accounting approach. The aggregate production function typically exhibits diminishing returns to the repeatable inputs, which includes human capital. The pragmatic approach to human capital accumulation holds that it is achieved through "changing humans so as to give them skills and capabilities that make them able to act in new ways" (Barro, 1996). Endogenous growth models adopt this strategy for developing human capital. Models that focus on the expansion of R&D often hold that the increase in total factor productivity (TFP) is proportional to the number of scientists and engineers working on the project. However, human capital is distinct from R&D-generated knowledge in that it is a competing good and can be almost completely excluded from competition. The authors simulate expanding output by adding up inputs and total factor productivity, which is consistent with the conventional growth accounting approach. An innovative aspect of their approach is that human capital is not included as a factor in the aggregate production function but nevertheless helps boost TFP. This has a double repercussion. As a first step, human capital is what ultimately determines how quickly a lagging nation or region can close the technology gap with a frontrunner. Second, human capital affects how well a country or region can copy foreign innovations and, in turn, how quickly this happens.

Some models allow for the possibility of nonlinearity in the relationship between human resources and collective productivity (Hanushek, 1996). In most cases, thresholds in human capital levels are responsible for the nonlinear impact of HC on GC production. A threshold is defined as "radical disparities in dynamic behavior stemming from local variances in social returns to scale". To achieve threshold externalities, where possibilities for aggregate production may expand rapidly, a critical mass of human capital is required. Multiple steady-state growth paths may be possible due to the nonlinearities produced by the presence of threshold externalities in human capital creation (regimes). Low levels of human capital result in a low rate of return on investments in human capital if the economy is on a low-growth trajectory. Therefore, Maynes (2011) argues that with a low starting point for human capital, one may see either rising or falling returns on investment in human capital, with the former being the more likely scenario. Yet, a high-growth trajectory demonstrates that heavy investment in human capital pays off handsomely.

To summarize, there hasn't been a lot of research done on the topic of the connection between human capital and knowledge overflow. The current study investigates how a selection of countries' levels of human capital and knowledge spillover affect total factor productivity (TFP). This research also determines the amount of human capital below which there is no positive effect of knowledge spillover on total factor productivity. As a consequence of this, we anticipate that countries that have already developed their human capital will experience increased levels of productivity as a direct result of the spillover of knowledge. In contrast to previous research, which implicitly assumed that all countries had the same human capital and economic policies, the current investigation adopts a novel method by employing panel data growth regressions to investigate the knowledge spillover-led TFP phenomena.

1.2. Knowledge Spillover, Economic Freedom and Total Factor Productivity

Human dignity, autonomy, and personal empowerment are all enhanced by economic independence, which is also valued in and of it. However, the fact that economic freedom provides a tried-and-true recipe for economic growth and prosperity cannot be overlooked. There is a strong correlation between the many facets of economic freedom and the rate of productivity and overall prosperity. Expanding individual liberties across the board is a tried and true method of fostering economic development. And growth is crucial to alleviating poverty and establishing long-term prosperity because it creates new pathways for individuals to better their financial situations. There is no nation on Earth that offers its residents complete freedom, and even among those that do allow a great deal of individual autonomy, priorities vary. That's in keeping with how freedom works: by letting people and communities choose their own courses toward prosperity. According to Erdem and Tugcu (2012), various regulations on economic activity have been implemented by governments throughout history. These limitations are occasionally enforced in the name of equality or some other seemingly good societal aim. However, they are typically imposed for the benefit of powerful groups in society. After all, it is these organisations that wield the most sway and power over the state and its institutions. As a society, we pay a heavy price when the government meddles too much in many areas of the economy. When the government makes economic decisions instead of the market, it forces business owners to focus their efforts on what economists call "rent seeking," or the pursuit of economic rewards without having to work for them. Consequently, productivity falls, the economy stalls, and our standard of living deteriorate.

Numerous nations limit their people' freedom to buy and sell abroad without restrictions. Tariffs, export levies, trade quotas, and outright prohibitions on international trade are all examples of trade restrictions. However, nontariff barriers associated to various licensing, standard-setting, and other regulatory acts may also impede the freedom to trade. With the proliferation of international production networks and supply chains, companies are placing a higher emphasis on trade policy predictability. Therefore, arbitrary government measures that raise concerns about the predictability of future trade circumstances may have an adverse influence on trade freedom beyond their purely economic consequences. According to Azman-Saini, Baharumshah, and Law (2010), government restrictions on international trade have a direct impact on people's opportunities to pursue their economic aspirations and achieve their full economic potential. For instance, tariffs not only raise the costs that local consumers pay for imported goods, but they also distort the production incentives for local producers, leading them to make more of a protected good than is optimal or make more of a good in which they have no comparative advantage. Efficiency and growth in the economy as a whole are stunted as a result. Trade restrictions often slow the growth of local businesses because they make it hard for them to get cutting-edge goods and services.

In a nutshell, the current study investigates how a set of countries' levels of economic freedom and knowledge spillover affect total factor productivity (TFP). The study also determines the amount of economic freedom below which there is no positive effect of knowledge spillover on total factor productivity (TFP). As a result, we postulate that nations that enjoy a larger degree of economic freedom will have increased levels of productivity as a direct outcome of the spread of knowledge.

2. Review of Literature

Knowledge creation, innovation and diffusion remains at the heart of global development agenda, due to its significant contribution in boosting sustainable economic growth (Arrow, 1962). Evidence suggests that cross-country income differences and the variations in total factor productivity (TFP) can be attributed not only to the difference in physical and natural capital but also to publicly available stock of technical knowledge and ideas that flows across firms and regions (Prescott, 1998). This perspective is also supported by endogenous growth theory which suggests that expertise in the form of training and the capacity to create i.e. human capital is central to economic growth (Jednak & Kragulj, 2015). There is a widespread consensus among scholarly cohorts and policymakers on the nexus between the importance of knowledge and economic growth. Human capital and knowledge accumulation are crucial to bring innovation, improved productivity and structural transformation in society.

2.1. Interrelationships between Knowledge Spillover, Human Capital, Innovation, and Productivity

The link between human capital and economic growth is a topic with a large body of literature, including conceptual and empirical (Arrow, 1962). The beneficial impacts of human capital on economic expansion have been demonstrated in numerous studies; these studies, especially cross-country comparisons, implicitly assume that this link holds true for all economies. Though, these publications have generally ignored the role played by socio-economic and institutional features responsible for differential economic performance across countries. Similarly, theoretical analyses of human capital also pay heed to the impact of inflation, health and opportunity costs of investments. Moreover, many studies emphasized the contribution of social capabilities along with human capital, which are crucial in determining the economic growth trajectory across countries (Abramovitz, 1986). A key component of social capabilities is the standard of government and other institutional frameworks. According to Olofsdotter (1998), developing countries need to focus on well-functioning and inclusive institutions besides human capital in order to catch-up the technologically advanced nations of the world.

The role of human capital in promoting economic growth is well documented in the economic literature. At the beginning of 21st century, the tremendous growth in the field of artificial intelligence, automation and robotics is attributed to the vital role played by human capital. Among the major drivers of growth revealed by empirical research, knowledge and human capital occupies central place and are vital in bringing innovations and technological advancements witnessed on a planetary scale. Because of this, human capital has been identified as one of the most significant, if not the most significant, contributors to economic expansion in both theoretical and empirical studies (Arrow, 1962; Romer, 1986).

Research into the nexus between human capital and economic growth have shown that human capital and quality of education are the most significant factors in facilitating knowledge spillovers across countries. A study by Elias and Fernandez (2000) in Latin American countries has revealed positive results of income and education on long-term economic expansion. The results of this study shows positive relationship between investment in primary education and economic growth by using school enrolment ratios as proxy for human capital in 1960s. However, it shows the relationship between secondary and high school spending and growth was not significant due to the fact that these countries had low investment rates in secondary and high school category. Similarly, with inclusion of life expectancy, secondary and high school outlay reveals a positive and interaction that is highly significant in terms of growth. The study of Elias and Fernandez (2000) further reveals that with better education, skills, work habits and life expectancy; a country can reap the benefits of knowledge spillovers and increase its productivity.

Many studies have revealed positive and significant statistical relationship between total factor productivity (TFP) and human capital, both in level and in first-order differences. A set of OECD statistics was examined from 1973 to 1999, and the author found that for every additional year of education, per capita GDP rises by 6.5%. In addition, another study by Seck (2012) show that the incorporation of human capital as a production component has no appreciable effects on GDP growth., however, with regard to total factor productivity, human capital can determine the internal rate of innovation as also revealed by Romer (1990) and also the rate of technological diffusion. As indicated by Romer (1990) research, human capital stock is a major factor in a country's capacity to catch up to the technological advancement of other nations. These studies also found that a 1% increase in the capital stock results in a 0.14% increase in the rate of growth.

The research that was provided by Banerjee (2012) looked at the effects that human capital had on economic growth by analyzing data for 55 different nations spanning the years 1980 to 2007. The authors stated that the quality of human capital is required for economic growth because it is one of the essential factors in determining the speed of economic growth through its impacts on total factor productivity and technological diffusion. In other words, the quality of human capital is required for economic growth because it is one of the crucial factors in determining the pace of economic growth. In addition, this research highlighted the significance of the stock of persons who have completed secondary and primary school rather than tertiary education as a crucial factor in determining the rate of economic growth. As a consequence of this, there may not be any direct and sufficient effects of basic education on advanced research and development (R&D), but it is very essential to enable the population to raise its absorptive capacities in order to improve the quality of human capital and contribute to growth.

2.2. Interrelationships between Knowledge Spillover, Economic Freedom and Productivity

Because economic growth is determined by a complex interplay of various elements or determinants, economic theories are unable to provide an accurate representation of the full range of these determinants. Smith was the first person to put forward the concept that economic freedom is one of the most important aspects that influence economic growth. Similarly, economic freedom has recently attracted the attention of researchers due to its importance for economic growth. Economic freedom refers to the extent to which people freely make choices, decisions and the right to protect their properties which affect their lives (Gwartney, Holcombe, & Lawson, 2004). Economic freedom determines various aspects of economy and individual consumers as well as entrepreneurs. According to Nikolaev and Bennett (2016), economic efficiency of firms and countries increases with increase in economic freedom.

Research on the absorptive capabilities of countries shows that economic freedom determines interaction of country with foreign agents and world economy and influence the economic decisions like financial liberalization, free trade, foreign direct investment and government effectiveness. The economic freedom index also evaluates the openness of the labour and financial markets. Economic freedom is associated with the reduced role and interference of government in the economic affairs of the state. It suggests that a decline in a country's wealth is caused by the government getting more involved and putting limits on business activities. These things limit or interfere with people's freedom and may cause companies to shift their resources and productive activities to things to unearned benefits. Gonçalves, Taveira, Labrador, and Pio (2021) is of the view that technological advancement is a key factor for long-run increase in TFP due to its crucial role in almost all areas of economy. Most recent literature on knowledge spillovers shows that, besides attracting knowledge spillover and foreign technology, it is also necessary for host countries to possess certain quality and absorptive capacities in order to internalize the technology and knowledge generated abroad (Azman-Saini et al., 2010). Moreover, it is also true for economic freedom, because countries possessing sufficient economic freedom are able to absorb and internalize knowledge spillovers and new technologies transferred through various channels. The willingness of firm to engage in risky investment projects and introduce innovative ideas and technologies increases when the economic environment is free and constraints are fewer. In the same vein, it also motivates domestic industries to absorb foreign technology in local market.

In spite of the obvious benefits of economic freedom, few studies indicated to the negative externalities associated with economic freedom that negatively affects economic growth. According to the findings of this study, businesses that have low levels of operating efficiency, international standards, and technology are unable to compete with other domestic and worldwide competitors that have more advanced capabilities and may experience the negative impacts of economic freedom in the form of low productivity. Similarly, The findings revealed that reduced government intervention in the markets leads to increased vulnerability of the economy to economic shocks and systematic risks. Economic freedom increases the interconnection among economic players, which increases the probability of systematic risks that may snowball into the international economic system and freeze international financial markets within a short span of time, thus reducing economic growth across countries.

2.3. Theoretical Background

Transfer of know-how through trade and are an important and relatively effective factor for the home economy, although the fiction on the idea of endogenous technological progression provides conflicting data on these points. Grossman and Helpman (1991) create a theoretical model of creation diversity wherein the TFP in an economy rises as more semi-processed variations are produced and sold. Changes in an economy's degree of openness, assessed by the extent to which trade is encouraged or protected are shown to have effects on the long-term rate of growth, stable transition, flow of trade relations, and social welfare. Zachariadis (2004), examine the significance of knowledge spillovers resulting from overseas innovation. The authors contend that the rate at which domestic technological advancement occurs is influenced not only by the innovative efforts of domestic entrepreneurs as evaluated based on how well they generate a profit from their research and development efforts but also by the innovative actions of other countries. Because of this relationship, TFP is measured regarding both national and foreign investments in R&D. It's possible for overseas R&D to affect homegrown economies in two ways: immediately, and indirectly, through downstream industries. Direct transfer of technology has an immediate effect, but transmission mechanisms like trade and FDI have longer-term positive effects. According to their report, the level of international trade openness determines how much of these outside invention and research can be outsourced. Using data on OECD nations from 1971 to 1990 the authors conclude that there is a strong correlation between TFP and across the board, at home and abroad R&D capital stocks. Furthermore, it is discovered that trade performs a crucial part in the decimation of know-how pertaining to research and development from trading partners to their home countries. Additional empirical research, like that of Griffith, Redding, and Reenen (2004). In recent years, foreign direct investment (FDI) and trade have both been given serious consideration as possible pathways for the productivity equation's spillover effects. In particular, Deschryvere (2014) finds inconsistent findings when they evaluate the connection between MNC operations (outward FDI) and trade in capital goods and technology diffusion for 20 industrialized economies between 1974 and 1995. This research was conducted over the course of 20 years. Results demonstrate that overseas R&D spillovers have a sizeable, favorable impact on local TFP through the mechanisms of global trade and outward FDI, but no similar effect is found with respect to inward FDI. The researchers asserted that more attention should be paid to econometric issues, but they provide an explanation for the results that relies on methodological restraints and a dearth of high-quality data. Proximity is crucial for the dissemination of knowledge, and they employ this idea to propose a theoretical framework for assessing the effect of global trade and FDI on the country's economic growth. Moreover, the author asserts that there is a correlation between the two channels, and that studies designed to better comprehend this link should concentrate on doing just that.

2.4. Bridging Literature Gap

Existing studies on knowledge spillover and economic growth have studied the direct relationship between these two aspects of economy. It has generally ignored the effects of socio-economic factors or complementarity variables in recipient countries to explain the income convergence or divergence. The role of innovation and technology in addition to other factors in influencing growth performance across countries is well documented in academic literature. Thus, it is inevitable to incorporate essential socio-economic factors in order to examine the major differences in technological capabilities and efficiency among countries. Because it employs a comprehensive group of institutional and economic variables as a moderator for the knowledge spillover and growth nexus, this research is an effort to contribute something novel to the current body of work that has been compiled up to this point. The said aspect has been the missing from the existing literature, which has been incorporated by the present study to capture the role of absorptive capabilities of recipient countries and its impacts on knowledge spillover growth nexus.

In addition, it has been observed that the impacts of knowledge spillovers may vary in different countries depending upon the level and pace of economic development. Thereby, for explaining cross-country convergence and divergence, it is inevitable to examine why some countries have reaped the benefits of knowledge spillover, as did by East Asian economies, while others have not despite massive inflow of FDI and trade which are considered the major channels of knowledge spillover. Therefore, a comprehensive study is deemed necessary to primarily emphasize the identification of various factors responsible for income variations across countries.

3. Methodology

3.1. Model Specification

The influence that knowledge spillover has on total factor production is the focus of this study. The baseline model is given as:

$$TFP_{i,t} = \alpha_{0+}\, \alpha_1 Yo + \alpha_2 R\&D_{i,t} + \alpha_3 ImportSpill_{i,t} + \alpha_4 X_{i,t} + \mu_{i,t} \quad (1)$$

Where i and t refer to the nation i during the given time period. The acronym TFP stands for total factor productivity, R&D refers to the costs associated with research and development, KS is used to refer to knowledge spillovers, and X is a vector of determinants that have an effect on TFP. TFP is calculated by the following formula:

$$\mathrm{TFP}_{i,t} = \frac{Y_{i,t}}{Y_{i,t-1}} Q_{t,t-1} \quad (2)$$

Where $Q_{t,t-1} = \frac{1}{2}\,(\beta_{t,t-1} - \beta_{t-1})\ \frac{K_t}{K_{t-1}}) + [1- \frac{1}{2}(\beta_{t,t-1} - \beta_{t-1})]\ ln \frac{L_t}{L_{t-1}}$

Where Y, L, and K represent, respectively, the actual GDP, the capital stock, and the labor force that is being utilized. In a similar vein, denotes the output elasticity of capital, and the method for calculating import spillover is as follows;

$$\mathrm{ImpSpill}_i = \sum_{j=1}^{n-1} \frac{\mathrm{Imports}_{i,j}}{Y_i} \mathrm{Log\ R\&D}_j$$

Where "j" denotes the country that is serving as the host. Model 3 is further developed as follows in order to answer the question of whether the nexus between knowledge spillovers and domestic productivity is dependent on a set of complimentary elements of the country that receives the information.

$$TFP_{i,t} = \alpha_{0+}\, \alpha_1 Yo_{i,t} + \alpha_2 R\&D_{i,t} + \alpha_3 ImportSpill_{i,t} + \alpha_4 X_{i,t} + \alpha_5 (ImportSpill * M)_{i,t} + \mu_{i,t} \quad (3)$$

Where M represents the quality of life determinants, the model is extended with a dynamic term to account for differences in the knowledge spillovers-productivity linkage based on countries quality of life. To describe the indirect effect of knowledge spillovers-led productivity phenomena, this study introduces a term that describes how knowledge spillovers and different institutional and structural elements interact.

Through equation 3, this study explores whether or not the host country quality of life determinants affects the knowledge spillovers driven productivity nexus. Hence, the interaction terms enable us to check whether the link between knowledge spillover and total factor productivity depends on the host country's complementary policies?

3.2. Classification of Data and Its Origins

This research looked at a sample size of 59 countries from 1996 to 2020 and covered the years in question. In this analysis, panel data ranging from 1996 to 2020 are used for a variety of countries located all over the world. For the sake of analysis, this study classifies the sample countries into one of three broad categories. There is a significant amount of information sharing that takes place between OECD members, of which 35 of the 59 sample nations are members. In addition, the remaining 24 nations are categorized according to their level of income, which results in three distinct groups: those with high incomes, those with moderate incomes, and those with low incomes.

3.2.1. The Quality Adjusted Human Capital (QAHC)

The quality-adjusted human capital represents the more widely used proxies in the available research to assess quality of life.

QAHC = HC * (Publication/L + Patents/L)

For the sake of this investigation, QAHC will act as the focal point.

3.2.2. Economic Freedom

High productivity growth is linked to economic freedom. Lagging economies are unable to benefit from knowledge spillover and technology transfer from industrialized economies because of a lack of economic freedom.

Table 1: Data Description and Correlation of Proxies of Quality of life

Descriptive Statistics	HCQ	EFI
Mean	2.52	6.63
Median	2.56	6.57
Maximum	4.35	9.19
Minimum	1.35	2.88
Std. Dev.	0.54	1.10
Skewness	0.18	-0.10
Kurtosis	2.68	3.87
Jarque-Bera	6.10	20.08
Probability	0.04	0.00
Correlation	**HC**	**EFI**
HC	1	0.14
EFI	0.14	1

3.3. Analytical Technique

3.3.1. Cross-Section Dependence (CSD) tests

It is vital to investigate the cross-sectional reliance of variables since cross-sectional dependence is a significant problem that arises when working with panel data. In order to achieve this objective, this research makes use of the CSD tests that were created by Hsiao and Pesaran (2004). The test equation for Hsiao and Pesaran (2004), and M. Hashem Pesaran (2004) are given as:

$$CD_{Adjusted\ one} = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{k=i+1}^{N}\hat{\tau}_{ik}\right)\frac{(T-j)\hat{\tau}_{ik}{}^{2}-E(T-j)\hat{\tau}_{ik}{}^{2}}{V(T-j)\hat{\tau}_{ik}{}^{2}} \tag{4}$$

$$\mathrm{CSD_{TN}} = [\tfrac{TN(N-1)}{2}]^{1/2}\hat{\bar{\rho}}_{N} \tag{5}$$

Where, $\hat{\tau}_{ik}$ in equation 4 and $\hat{\bar{\rho}}_{N}$ in equation 5 represent pair-wise correlation coefficient, T and N represent cross sections (24) and time period (25 in our case) respectively.

3.3.2. Slope Heterogeneity Test

Another potential source of concern that may emerge from the use of panel data is the possibility of slope heterogeneity. In this study, the slope heterogeneity test, was applied to the models that were being investigated in order to identify whether or not they displayed slope heterogeneity. The P&Y test equation is:

$$\tilde{\Delta}_{SH}= (N)^{\frac{1}{2}}(2k)^{-\frac{1}{2}}\left(\frac{1}{N}\tilde{S}-k\right) \tag{6}$$

$$\tilde{\Delta}_{ASH}= (N)^{\frac{1}{2}}\left(\frac{2k(T-k-1}{T+1}\right)^{-\frac{1}{2}}\left(\frac{1}{N}\tilde{S}-2k\right) \tag{7}$$

The decision regarding the slope heterogeneity is made on the basis of delta tilde ($\tilde{\Delta}_{SH}$) and adjusted delta tilde ($\tilde{\Delta}_{ASH}$).

3.3.3. Panel Unit Root Test

This research makes use of a technique that was developed by M Hashem Pesaran (2007) and is known as the Cross-Sectional Augmented Im, Pesaran, and Shin (CIPS) unit root test in order to determine the variables' respective unit roots.

The test equation of CIPS unit root test is given as:

$$\Delta W_{i,t} = \varphi_i + \varphi_i Z_{i,t-1} + \varphi_i \overline{W}_{t-1} + \sum_{l=0}^{p}\varphi_{il}\Delta\overline{W_{t-l}} + \sum_{l=1}^{p}\varphi_{il}\Delta W_{i,t-l} + \mu_{it} \tag{8}$$

Where, the cross-section averages ($\overline{w}$) is given as:

$$\mathrm{W}^{\mathrm{i,t}} = \varphi^{1}\overline{\mathrm{EG}}^{\mathrm{i,t}} + \varphi^{2}\overline{\mathrm{FD}}^{\mathrm{i,t}} + \varphi^{3}\overline{\mathrm{GCE}}^{\mathrm{i,t}} + \varphi^{4}\overline{\mathrm{INV}}^{\mathrm{i,t}} + \varphi^{5}\overline{\mathrm{HC}}^{\mathrm{i,t}} \tag{9}$$

CIPS's test statistic is displayed as:

$$\widetilde{\mathrm{CIPS}} = \mathrm{N}^{-1}\sum_{\mathrm{i=1}}^{\mathrm{n}}\mathrm{CADF_i} \tag{10}$$

Whereas, CADF is cross-sectionally augmented Dickey-Fuller (CADF).

3.3.4. Cointegration Westerlund Test (2007)

Aiming to investigate the link between total factor productivity (TFP) and its determinants for the 24 sample countries included in 3 income groups, this study uses the Westerlund (2007) cointegration method. When the error terms are cross-sectional in nature, this method becomes especially useful and reliable. Furthermore, there is no constraint on the test for the presence of common factors. Typical panel data methods neglect to take into consideration the cross-sectional dependence of error components, leading to erroneous conclusions. The Westerlund (2007) cointegration test compares the H0: (that there is no cointegration) to the alternative HI: (that there is cointegration). To do the cointegration test proposed by Westerlund (2007), the following equation can be used:

$$\alpha i\,(L)\Delta yit = \gamma 1i + \gamma 2i\,t + \beta i\,(yit - 1 - \acute{\alpha}\,i\,xit - 1) + \lambda i\,(L)'vit + \eta i \tag{11}$$

Where, $\delta_{1i} = \beta_i\,(1)\,\hat{\vartheta}_{2i} - \beta_i\,\lambda_{1i} + \beta_i\hat{\vartheta}2_i$ and $\gamma 2_i = -\,\beta_i\lambda 2_i$

The cointegration between x and y is represented by the vector αi in Eq. (11). The error-correcting coefficient is denoted by β_i. These are the test statistics:

$$G_t = \frac{1}{N}\sum_{i-1}^{N}\frac{\acute{\alpha}_i}{SE(\acute{\alpha}_i)} \tag{12}$$

$$G_\alpha = \frac{1}{N}\sum_{i-1}^{N}\frac{\mathrm{T}\acute{\alpha}_i}{\acute{\alpha}_i(1)} \tag{13}$$

$$P_T = \frac{\acute{\alpha}}{SE(\acute{\alpha})} \tag{14}$$

$$P_\alpha = \mathrm{T}\acute{\alpha} \tag{15}$$

Group means are represented by $\mathrm{G_a}$ and $\mathrm{G_t}$, while panel statistics are shown by $\mathrm{P_a}$ & $\mathrm{P_t}$. The Westerlund (2007) test can be used to determine how quickly a system will reach long-run equilibrium. The error correction parameter ($\acute{\alpha}$) in equation (15) may be computed by inserting the value of $P_\alpha = \mathrm{T}\acute{\alpha}$. Since this is the case, the parameter for error correction is $\acute{\alpha} = \frac{P_\alpha}{\mathrm{T}}$, this indicates the annual error correction percentage if short-term equilibrium needs to be restored.

3.3.5. Cross-sectionally Augment Distributive Lag (CS-ARDL)

Defining the cointegration vector is the next step in measuring the long-term effect of knowledge spillover on TFP in the sample group of nations. The CS-ARDL method, cointegration methods like ARDL, FMOLS, DOLS, and others. These first-generation cointegration methods assume no dependence between cross sections. Since the fundamental variable in this analysis is knowledge spillover, which is likely to vary from one study to the next, the more knowledge is shared, the more doors are opened, and the more interdependent the various parts of the system become. Conventional cointegration techniques assume cross-sectional independence, but if the dependence of cross sections is also associated with unobserved shocks like oil price shocks and financial crises, this assumption may be thrown into question by the high correlation between cross-sectional error terms. Any global shock will affect these factors across the sample group of nations because this study looks at the connection between knowledge spillover and TFP in several groupings of countries. Such previously unknown shared features can affect TFP and knowledge spillover simultaneously. That being said, if it turns out that there are hidden common components in TFP and those factors are linked to explanatory variables,

The following CS ARDL equation is computed in this research (for model 1):

$$\mathrm{TFP_{it}} = \alpha_0 + \sum_{j=1}^{p}\lambda_{\mathrm{it}}\mathrm{TFP_{i,t-j}} + \sum_{j=0}^{p}\acute{\alpha}_{\mathrm{it}}\mathrm{IMPKS_{i,t-j}} + \sum_{j=0}^{p}\beta_{\mathrm{it}}\mathrm{X_{i,t-j}} + \sum_{j=0}^{p}\gamma_{\mathrm{it}}\mathrm{X_{i,t-j}} + \sum_{j=0}^{p}\varphi_{\mathrm{it}}\mathrm{M_{i,t-j}} + \sum_{j=0}^{3}\ddot{\upsilon}_{\mathrm{it}}\bar{A}_{\mathrm{i,t-j}} + \mu_{\mathrm{it}} \tag{17}$$

Where $\bar{A}_t = (\Delta\overline{TFP}_{it}, \bar{X}_t{}', \overline{IMPKS}_{it}{}', \overline{M})')'$ and $X_{it} = (R\&D_{it}, MES_{it}, INV)'$.

The following CS ARDL equation is computed in this research (for model 4):

$$\mathrm{TFP_{it}} = \alpha_0 + \sum_{j=1}^{p}\lambda_{\mathrm{it}}\mathrm{TFP_{i,t-j}} + \sum_{j=0}^{p}\acute{\alpha}_{\mathrm{it}}\mathrm{IMPKS_{i,t-j}} + \sum_{j=0}^{p}\beta_{\mathrm{it}}\mathrm{X_{i,t-j}} + \sum_{j=0}^{p}\gamma_{\mathrm{it}}\mathrm{M_{i,t-j}} + \sum_{j=0}^{p}\delta_{\mathrm{it}}(\mathrm{IMPKS} * \mathrm{M})_{\mathrm{i,t-j}} + \sum_{j=0}^{3}\ddot{\upsilon}_{\mathrm{it}}\bar{A}_{\mathrm{i,t-j}} + \mu_{\mathrm{it}} \tag{18}$$

4. Results and Discussion

4.1. Results of Slope Heterogeneity Test

Slope heterogeneity findings indicate that all models experience the issue of heterogeneity, indicating that traditional unit root tests and co-integration approaches would yield biased results. All of the models have statistically meaningful test statistics.

Table 2: Pasaran and Yamaguta (2007) Slope Heterogeneity

Models	Statistics	Values	P-value
Model 1a	$\tilde{\Delta}$	15.046***	0.000
TFP= f (IMPKS R&D MES INV HC)	$\tilde{\Delta}$adjusted	17.731***	0.000
Model 1b	$\tilde{\Delta}$	13.233***	0.000
TFP= f (IMPKS R&D MES INV HC IMP*HC)	$\tilde{\Delta}$adjusted	16.047***	0.000
Model 2a	$\tilde{\Delta}$	13.16***	0.000
TFP= f (IMPKS R&D MES INV EFI)	$\tilde{\Delta}$adjusted	15.457***	0.000
Model 2b	$\tilde{\Delta}$	10.268***	0.000
TFP= f (IMPKS R&D MES INV EFI IMP*EF)	$\tilde{\Delta}$adjusted	12.452***	0.000

4.2 Results of Cross-Sectional Dependency Test

When there is cross-sectional dependence in panel data, one of the main issues that can develop is that the variables or error terms are interrelated throughout panel lengths, leading to low power and size distortions of the techniques. In this investigation CSD test are used. It is clear from the findings that the sample countries are interdependent on one another; both in terms of knowledge spillover and other factors, and that they are vulnerable to the effects of both domestic and international shocks.

Table 3: Cross-Section Dependence Test

Variables	Breusch-Pagan LM	Pesaran Scaled LM	Bias-Corrected Scaled LM	Pesaran CD
TFP	146.31***	18.88****	18.69***	0.611
IIMPKS	128.36***	16.93***	17.58***	-3.12*
HC	148.56***	28.22***	18.88***	9.42***
EF	140.71***	17.43***	15.08***	-3.03*

In addition, the Cross-Section Dependence Test developed by M. Hashem Pesaran (2004) is utilised here. The existence of CSD is supported by statistically significant results from CD testing. When there is a lot of reliance between the cross sections of different panel variables, the correlation coefficients are high. This investigation demonstrates that there are elements that reflect on both time and space. A sudden shock in a sample variable in one country could have big effects in the other.

Table 4: Results of Cross-Section Dependence (Pesaran, 2004) test

Variable	CD-test	Correlation
TFP	2.08*** (0.000)	0.487
IMPKS	7.27*** (0.000)	0.772
HC	77.540*** (0.000)	0.652
EF	10.490*** (0.000)	0.690

4.3. Results of Panel Unit Root Test

We employ the Cross-Sectional Augmented Dickey-Fuller (CADF) and Cross-Sectional Augmented IPS (CIPS) panel unit root test to examine the integration order across several variables. The CADF and CIPS is a unit root test of the second generation. The CIPS and CADF unit root test findings suggest that the variables are mixed order integrated. As a result of the mixed integration orders, Westerlund (2007) and CS-ARDL cointegration approaches are used.

Table 5: Results of Panel Unit Root Tests

	Cross-Sectionally Augmented (CADF)			Cross-Sectional Augmented IPS (CIPS)		
TFP	-1.431	-2.886***	I(1)	- 1.532	-3.311*	I(1)
IMPKS	-2.136**	------------	I(0)	-2.140***	---	I(0)
HC	-1.901	-3.336***	I(1)	-2.608	5.231*	I(1)
EF	-1.114	-3.221***	I(1)	-1.909	-5.063*	I(1)

Note: ***, **, * represents significant at 1, 5 and 10% respectively.

4.4. Results of Westerlund's Panel Cointegration Test

Westerlund (2007) investigates whether there is a long-term connection between total factor productivity and knowledge spillover through the channel of trade and FDI and the role of complementarity policies like start-up procedures, the quality of human capital, institutional quality, and financial development. Group mean statistics for total cointegration are shown in the initial two columns of Table 6. (Gt, Ga), whereas panel statistics are shown in the second and third (Pa, Pt). The findings corroborate model 1's prediction of a steady long-term connection between the modelled variables. When substituting a value for $P_{\alpha} = \mathrm{T}\acute{\alpha}$ of equation 15, the error correction parameter ($\acute{\alpha}$) can be determined. Since this is the case, Model 1's error correction parameter is $\acute{\alpha} = \frac{P_{\alpha}}{\mathrm{T}} =$ -16.766/25 = -0.65; models 2's is -0.54; model 3's is -0.59; model 4's is -0.61; model 5's is -0.60; and model 6's is 0.61. This means that every year, corrections are made to different models that account for more than half of the error between TFP and its determinants. Thus, in all six TFP models, any shorter period imbalance is resolved in the extended period of time.

Table 6: Findings of Cointegration with the Westerlund Test (2007)

Models	G_t	G_a	P_t	P_a
Model-1	-7.327***	-13.978**	-18.889***	-16.766***
Model-2	-6.745***	-13.335*	-18.773***	-13.552***
Model-3	-8.742***	-14.114*	-19.775***	-14.812***
Model-4	-9.423***	-15.221**	-20.574***	-15.339***

4.5. Complementarity between Knowledge Spillover and Quality Adjusted Human Capital

The purpose of this research is to employ empirical techniques to confirm the existence of interactions between knowledge spillover and quality-adjusted human capital as drivers of total factor productivity. Table 7 presents empirical results showing a favorable correlation between quality-adjusted human capital and total factor productivity across all income groups. The findings suggests that quality adjusted human capital positive effects total factor productivity after controlling for initial GDP, domestic R&D capital stock, inflation rate and investment. There is a need to explain the favorable and statistically significant coefficient of HCQ, which can be stated as follows: Labor with developed human capital adds more to productivity. Put differently, Human capital is one of the crucial factors in determining the pace of economic growth through its effects on total factor productivity and technological diffusion.

Furthermore, the stock of people with secondary and primary education as a significant determinant of economic growth. As a result, there may not be direct and sufficient effects of basic education on advanced research and development (R&D), but it is crucial to enable population to increase it absorptive capacities in order to enhance the quality of human capital and contribute to growth. In line with the findings of Arrow (1962), Romer (1990), our findings suggest that economies with high levels of adjusted human capital are more likely to be on a high productivity trend.

Additional, Knowledge spillover interacts with the quality of human capital term in the model as well. Knowledge spillover is hypothesized to be more beneficial to nations with higher levels of human capital. Knowledge spillover and HCQ are tested for compatibility in Table 7. Since the IMPKS*HCQ interaction term is positive and statistically significant, it may be inferred that countries that have higher HCQ gain a greater number of benefits from knowledge spillover. (This confirms our hypothesis that countries that have a high quality of life are more likely to gain from the knowledge spillover) This may be owing to the premise that nations with workers that have skill full and a higher education level are more likely to embrace advance technologies and, as a result, are able to gain more from the knowledge spillover. It appears that higher quality of life only benefits the knowledge spillover-driven productivity relationship in upper income nations, as the interaction term between knowledge spillover and quality of human capital was statistically significant only for those countries. More educated entrepreneurs in a technically sophisticated economy mean new manufacturing methods can be implemented more quickly, which in turn accelerates the spread of new technologies. In a more technically advanced economy, the rate of return to learning (the benefit of further schooling) rises. The results of Table 7 also suggest that domestic R&D capital stock and inflation rate negatively affect total factor productivity of sample countries.

Table 7: Knowledge Spillover, Quality Adjusted Human Capital and Total Factor Productivity

Variables	Full Sample		High Income Group		Middle Income group		Lower-Income Group	
	Without Interaction	With Interaction	Without Interaction	With Interaction	Without Interaction	With Interaction	Without Interaction	With Interaction
Core Variable								
IMPKS ***Imports Spillover***	0.090 (0.00)	-0.104 (0.00)	0.053 (0.03)	0.064 (0.00)	0.033 (0.16)	0.039 (0.21)	0.074 (0.00)	0.088 (0.00)
Control Variables								
Yo ***Transitional Convergence***	-0.922 (0.00)	-0.922 (0.00)	-0.345 (0.04)	-0.346 (0.00)	-0.071 (0.00)	-0.062 (0.18)	-0.754 (0.00)	-0.755 (0.00)
R&D ***Domestic R&D stock***	-0.098 (0.00)	-0.098 (0.00)	-0.065 (0.04)	-0.068 (0.00)	0.009 (0.18)	-0.010 (0.16)	-1.556 (0.03)	-1.547 (0.00)
MES ***Macroeconomic stability***	-1.334 (0.00)	-1.334 (0.03)	0.077 (0.00)	0.077 (0.00)	0.045 (0.21)	0.045 (0.16)	0.049 (0.00)	0.049 (0.00)
INV ***Investment (in % of GDP)***	0.017 (0.00)	0.017 (0.00)	0.211 (0.00)	0.214 (0.00)	0.019 (0.25)	0.022 (0.29)	0.053 (0.00)	0.039 (0.00)
Variables of interest								
HCQ	1.324 (0.00)	0.013 (0.00)	1.546 (0.06)	-1.887 (0.00)	1.103 (0.03)	-1.232 (0.00)	2.032 (0.04)	-2.996 (0.00)
Interaction Term								
IMPKS*HCQ	---	0.0451 (0.00)	---	0.0342 (0.00)	---	0.232 (0.15)	---	0.767 (0.27)
Number of Countries	24	24	05	05	08	08	11	11

4.5.1. Assessment of the Marginal Effect (QAHC)

Because this is something that is pertinent to us, we are interested in finding out what degree of quality of life causes a shift in the link between knowledge spillover and production. As a result, we start by calculating the partial derivative of the dependent variable (TFP) with respect to the knowledge spillover (IMPKS), and then we integrate the interaction component (from column 2 of 7). Given the level of human capital existing in the receiving economy, it is possible to make an estimate of the marginal impact that IMPKS will have on TFP.

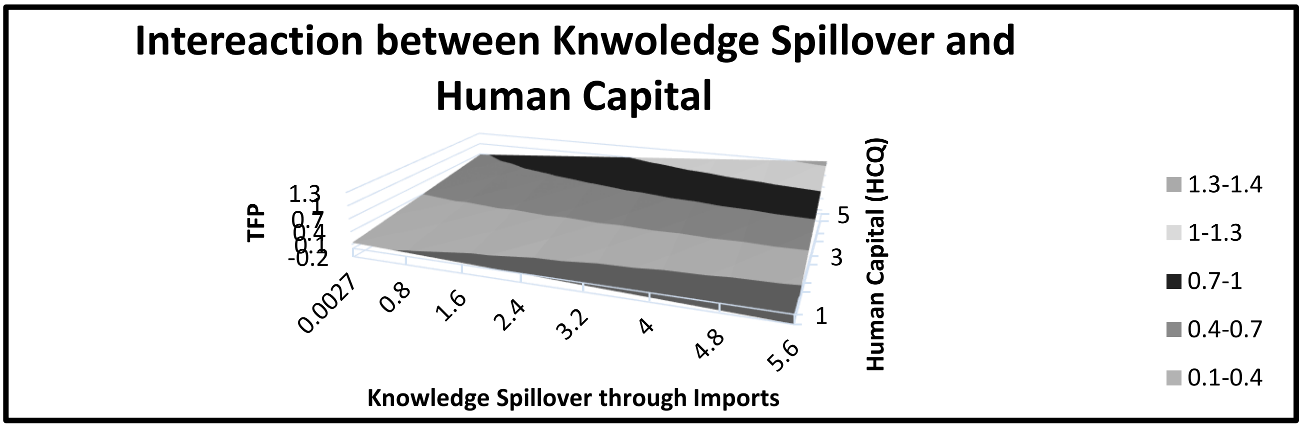
$$dTFP/dIMPKS = -0.104 + 0.0451 * HCQ \quad (17)$$

When QAHC is at 2.172, (17), a little adjustment in knowledge spillover will not affect total factor productivity. Knowledge spillover, on the other hand, has a positive impact on production at levels of QAHC that are maintained over a particular threshold. Only ten of the twenty-four nations included in the study met or exceeded the QAHC criteria. A number of nations, including Argentina, China, Hong Kong, Japan, Korea, Malaysia, Malta, Peru, Romania, and Singapore, have surpassed the minimum level of HC that was required in 1996.

4.5.2 Threshold level of complementarities (HCQ)

The effect that quality of life has on the connection between knowledge spillover and total factor production is seen in Figure 1.

Figure 1: Interactions between Knowledge Spillover and Human Capital



This demonstrates how the dissemination of knowledge and improvements in quality of life work effectively together. Total factor productivity is shown to be higher in countries with a high quality of life (as measured by quality-adjusted human capital) and a high degree of knowledge spillover in Figure 1. On the other hand, economies with little knowledge spillover and a poor standard of living tend to have low total factor productivity. As a result, poor quality of life has a negative effect on productivity in the country's groups. As long as HCQ is at its highest level, knowledge spillover has a positive effect on total factor productivity.

4.6. Complementarity between Knowledge Spillover and Economic Freedom

We discovered in Table 8 statistically significant and favorable effects for all group of countries when looking at economic freedom. This finding is consistent with the hypothesis that more economically free nations will see more rapid growth. Economic freedom is described as the absence of state interference in the form of fundamental reforms to ensure continued economic stability in the face of shifting world economic perspectives. Economic freedom also improves a nation's ability to compete, withstand disruptions, and adapt, as well as its employment outlook. Capital and labour sectors, finance, commodities, investment possibilities and foreign direct investment, company markets and entrepreneurialism, and even the legislative environment are all improved by economic freedom, which in turn boosts productivity. Advances in economic freedom are correlated with higher levels of total factor productivity.

Table 8: Knowledge Spillover, Economic Freedom and Total Factor productivity

	Full Sample		**High Income Group**		**Middle Income group**		**Lower-Income Group**	
	Without Interaction	**With Interaction**	**Without Interaction**	**With Interaction**	**Without Interaction**	**With Interaction**	**Without Interaction**	**With Interaction**
IMPKS *Imports Spillover*	0.219 (0.18)	-0.1314 (0.00)	0.021 (0.13)	-0.372 (0.04)	0.037 (0.32)	-0.119 (0.21)	0.069 (0.03)	-1.199 (0.00)
Control Variables								
Yo *Transitional Convergence*	-0.681 (0.20)	-0.675 (0.08)	-0.310 (0.21)	-0.321 (0.04)	-0.104 (0.32)	-0.101 (0.12)	-0.681 (0.00)	-0.643 (0.00)
R&D *Domestic R&D stock*	-2.174 (0.31)	-2.122 (0.00)	-0.112 (0.21)	-0.123 (0.21)	-0.176 (0.17)	-0.179 (0.18	-1.721 (0.03)	-1.721 (0.00)
MES *Macroeconomic stability*	1.348 (0.19)	1.240 (0.03)	0.031 (0.00)	0.702 (0.03)	0.019 (0.35)	0.032 (0.28)	-0.011 (0.22)	0.033 (0.00)
INV *Investment (in % of GDP)*	0.327 (0.17)	0.306 (0.04)	0.181 (0.18)	0.172 (0.00)	0.191 (0.03)	0.179 (0.00)	0.316 (0.04)	0.312 (0.00)
Variable of interest								
EFI	1.163 (0.21)	0.075 (0.00)	4.012 (0.32)	-0.401 (0.00)	1.564 (0.21)	-0.266 (0.18)	0.310 (0.02)	-0.208 (0.00)
Interactive Terms								
IMPKS*EFI		0.0123 (0.00)	---	0.082 (0.03)	---	0.032 (0.21)	---	0.124 (0.32)
Number of Countries	24	24	05	05	08	08	11	11

Further, Knowledge spillover's interactive term with economic liberty is built into the model. Knowledge spillover is hypothesized to be more beneficial to economically free nations in this study. Knowledge spillover and economic liberty are compared in Table 8. Greater economic freedom is inferred to have a positive impact on the knowledge spillover-driven productivity nexus given that the coefficient of the cross term is positive. The fact that the IMPKS*EF interaction term in the model is both favorable and statistically significant lends credence to the idea that economies that enjoy a larger degree of economic liberty have more benefits as a result of knowledge spillover. The diffusion of knowledge has a significant bearing on economic freedom, but this is only the case for countries with high per capita wealth. This suggests that economic freedom boosts the productivity nexus generated by knowledge spillover, primarily in high-income group. One of the most basic markers of economic independence is the freedom to start and operate a business without intervention from the state. The most common obstacles to the free exercise of entrepreneurial activity are onerous and unnecessary laws.

Regulated businesses may struggle to compete in the market because of the added expense of manufacturing imposed by government policies. There is no required minimum capital and the process of starting a business in high income countries (such as Singapore, Korea, Japan, Hong Kong and Malta) only takes around a day and a half and entails two procedures. Getting a company license in certain other economies in middle income and low income groups (such as India, Pakistan, Algeria, Nigeria, Peru and Argentina) can take months or even years, and requires frequent travel to government offices and frequent interactions with officious and even corrupt bureaucrats. As Technological progress is a critical reason for the long-run increase in TFP due to its crucial role in virtually all economic sectors.

In addition to attracting knowledge spillover and foreign technology, host countries must exhibit specific quality and absorptive capacities in order to absorb foreign-generated technology and information. In addition, the same holds true for economic freedom, as nations with adequate economic freedom are able to absorb and assimilate knowledge spillover and new technologies supplied through numerous routes. When the economic climate is liberated and there are less restraints, firms are more likely to undertake risky investment initiatives and bring innovative ideas and technology. Similarly, it encourages domestic firms to use foreign technology for the domestic market. The outcomes validate the findings of Erdem and Tugcu (2012).

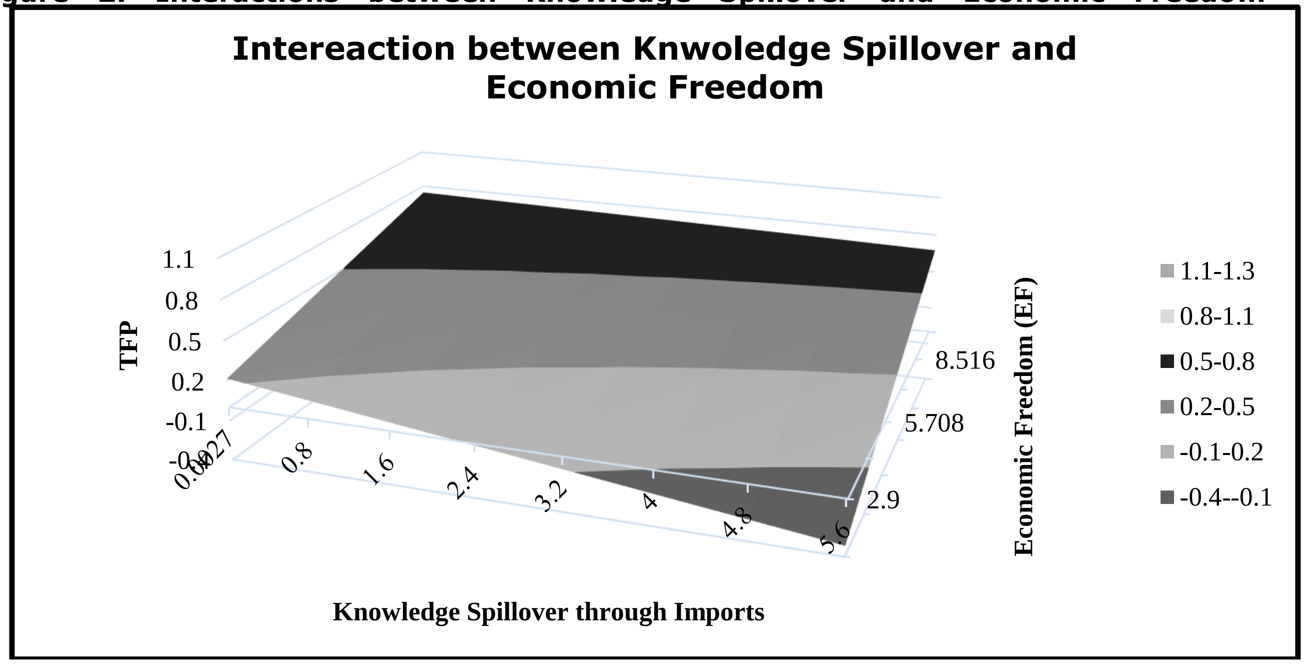
4.6.1. Assessment of the Marginal Effect (EF) and Threshold level of complementarities (EF)

$$dTFP/dIMPKS = -0.734 + 0.024 * EFI$$

When EFI is at 6.5711, a little adjustment in knowledge spillover will not affect total factor productivity. Knowledge spillover, on the other hand, has a positive impact on production at levels where EFI is maintained above a specific threshold. Only nine of the twenty-four countries included in the study met the required level of economic independence. The threshold level of economic independence was breached in 1996 by a number of nations, including Argentina, Hong Kong, Japan, Korea, Malaysia, Malta, Peru, Singapore, and South Africa, among others.

In addition, Figure 2 demonstrates how IMPKS and TFP complement one another in their respective roles. Because of this picture, we are able to draw two highly interesting inferences about the situation. The total factor productivity (TFP) was often higher in nations that had both high levels of IMPKS and greater economic freedom. Increases in knowledge spillover have a positive effect on total factor productivity, with the exception of economies that have the least amount of economic freedom, as seen in figure 2. As a result, there is compelling evidence that total factor productivity (TFP) has improved as a direct result of increased economic freedom.

Figure 2: Interactions between Knowledge Spillover and Economic Freedom



5. Conclusion and Policy Recommendations

In conclusion, this research article has employed the robust econometric technique of CSARDL (Cross-Sectionally Augmented Autoregressive Distributed Lag) to analyze the relationship between knowledge spillover, productivity differences, and the role of quality of life across countries. The findings of this study have shed light on the crucial role that quality of life indicators play in driving knowledge spillover effects and influencing productivity levels. The results of the CSARDL analysis have demonstrated the existence of complementarities between quality of life indicators and knowledge spillover, indicating that countries with more quality of life indicators such as (developed human capital and more economic freedom) get more benefitted from knowledge spillover in terms of productivity as compared to those countries that lack these opportunities. Furthermore, the study has identified specific quality of life indicators that have a more substantial impact on knowledge spillover effects and productivity disparities.

Based on our findings, the policy implications from this study suggests that, fostering a culture of lifelong learning and strengthening the educational system can increase human capital and promote knowledge spillover, which has important policy implications. All citizens should be able to participate in high-quality educational opportunities, such as job-specific training and ongoing education. To guarantee that all citizens have access to quality medical care that is both inexpensive and accessible, governments should place a high priority on healthcare system investment. This has the potential to boost happiness, cut down on absenteeism, and increase output. If policymakers are serious about promoting domestic and international knowledge spillover, they must put a premium on physical infrastructure investments. Knowledge exchange and collaboration can only flourish when people feel safe talking to each other. Policies that foster community, lessen economic disparity, and guarantee everyone a fair shot in life should be given high priority by governments. This has the potential to make the economy more accessible and productive for all. Knowledge creation and distribution can be aided when collaboration between universities, businesses, and research facilities is encouraged. Further, Cross-border cooperation and partnerships play a significant role in knowledge spillover, and governments should encourage policies that incentivize R&D activities, foster collaboration, and facilitate the transfer of technology and information across borders. Joint research projects, exchange programmes, and knowledge-sharing platforms are all examples of international cooperation that policymakers can encourage. This has the potential to increase the sharing of best practices and the global dissemination of knowledge. These policy suggestions can help policymakers foster an atmosphere conducive to knowledge sharing and increased output. Economies can work towards a more equitable distribution of benefits from economic activity by emphasizing enhancements to the quality of life for their populations.

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Appendices

Table A1: Classification of Countries as per Income and Growth Performance

Income Group	List of Countries (59 Countries)			
List of OECD Countries[1] (35 countries)	Australia Austria Belgium Canada Chile Columbia Czech Rep. Denmark Estonia Finland	France Germany Greece Hungary Iceland Ireland Israel Italy Latvia Lithuania	Luxembourg Mexico Netherlands New Zealand Norway Poland Portugal Slovakia Rep. Slovenia	Spain Sweden Switzerland Turkey United Kingdom United States
Non-OECD High Income Countries (HIC) (05 countries)	Hong Kong Republic of Korea	Japan Malta	Singapore	
Non-OECD Middle Income Countries (MIC) (08 countries)	Argentina Botswana Brazil	China Malaysia Romania	South Africa Venezuela	
Non-OECD Low Income Countries (LIC) (11 countries)	Algeria Bangladesh Egypt	India Indonesia Iran	Nigeria Pakistan Peru	Philippines Thailand

Source: World Bank (2021)

Table A2: OECD Technology intensity classification

High-technology industries	Medium-high-technology industries
Aircraft and spacecraft	Electrical machinery and apparatus, n.e.c.
Pharmaceuticals	Motor vehicles, trailers and semi-trailers
Office, accounting and computing machinery	Chemicals excluding pharmaceuticals
Radio, TV and communciations equipment	Railroad equipment and transport equipment
Medical, precision and optical instruments	Machinery and equipment
Medium-low-technology industries	Low-technology industries
Building and repairing of ships and boats	Manufacturing, Recycling
Rubber and plastics products	Wood, pulp, paper, paper products, printing & publishing
Coke, refined petroleum products & nuclear fuel	Food products, beverages and tobacco
Other non- metallic mineral products	Textiles, textile products, leather and footwear
Basic metals and fabricated metal products	

Source: http://www.oecd.org/science/inno/48350231.pdf

Only medium-high and high-tech industries used in the analysis for international trade.

[1] Responsible for vast majority of international knowledge transfer