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Growth, Research & Development, and Uncertainty: An Empirical Analysis in Finland

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Abstract

Invention and innovation are the most important aspects in the growth and development of a country. Investors come up with innovative ideas that can play a role in the development of technology in the country. The research and development (R&D) sector is very much associated with this, as it comprises researchers who have the ability to think creatively and come up with innovative ideas and designs for firms. It can be stated that countries where the research sector is well-developed and well-maintained have a greater chance to enjoy better economic growth (EG). The core purpose of the current study is to understand the influence of R&D and uncertainties associated with R&D on the EG of Finland. Based on this context, the researcher has gathered data on relative variables in Finland for 29 years and applied a stochastic model. The results obtained show that uncertainty in the research sector has a negative influence on the EG in Finland. The results also indicate the fact that, as uncertainty in the research sector increases, the distribution or allocation of human capital will shift from the research sector to the final goods sector. Moreover, it was also found that uncertainty has a negative impact on welfare. This study has significant implications for the R&D sector in Finland, in the sense that it has the potential to guide the research sector towards improvement through an increase in the number of patents and the establishment of research institutions that can reduce impact of uncertainty.

Keywords: Research and development; Uncertainty; Economic growth; Finland; Final goods; Human capital; Welfare.

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Contents

Contribution of this paper to the literature

The aims of current study is to understand the influence of R&D and uncertainties associated with R&D on the EG of Finland. Based on this context, the researcher has gathered data on relative variables in Finland for 29 years and applied a stochastic model.

1. Introduction

Commonly, the growth of a country is inversely proportional to R&D uncertainty, as a high rate of R&D uncertainty results in a reduction in the rate of economic growth (EG) (Colak, Gungoraydinoglu, & Öztekin, 2018). A high rate of R&D uncertainty also results in deteriorating welfare levels, which affects the decisions of an organization. It may also cause a reduction in the willingness of organizations to invest in R&D (Gu & Wang, 2018). In Finland, there are high levels of certainty in some organizations, which actually ends up hindering R&D and negatively affecting EG. Therefore, it is important to resolve this issue so that the EG of Finland can be increased. Innovative technology and R&D help to increase EG, but R&D can also harm growth if an organization experiences high rates of uncertainty.

A phenomenal effort has been undertaken in the past few decades with regard to the EG of different countries through different perspectives, such as recent research by Tsuboi (2020). Tsuboi evaluated the overall impact and role of natural resources and other activities on economic uncertainty in European countries. In fact, much of the research that has been carried out in previous years has evaluated EG and other indicators. Furthermore, the overall influence of physical capital and infrastructure on EG has also been investigated in particular areas and firms, mainly by applying certain data practices and empirical approaches. However, research has not been conducted on Finland and its overall EG, and no studies have described the direct role of R&D and its impact on a nation's development and EG. Hence, this research paper is unique and significant in terms of understanding the role and impact of R&D on the EG of Finland. In other words, the current research study is justified because no other scholar or academic researcher has explained or evaluated the relationship between uncertainty and the EG of a country.

Based on the above discussion and justification statement, the current study has the following aims:

- The main target of the current paper is to empirically analyze the impact of various R&D efforts on the overall EG of Finland.
- The second objective and purpose of the present research paper is to empirically find the impact of uncertainty on the economic development of Finland.
- Moreover, the given paper also considers the impact of uncertainty factors on the entire EG of Finland, mainly through the stochastic model and R&D.

Moreover, the present research study also contributes to theoretical literature and policy design. The analyst of this research has mainly discussed and considered literature concerning the risks and threats of uncertainty and how they influence the EG of a country. Furthermore, the given paper can also be adopted by several policymakers in Finland to make economic decisions concerning R&D and uncertainty in economic activities, in order to enhance the overall EG and development of a country and region, as well as its sustainability. Furthermore, the results of the present paper have profound theoretical advantages. Theoretically, this paper contributes constructively to the current body of information and data on the above factors and variables, predominantly through an evaluation of the impact of R&D and uncertainty factors on the EG of a nation.

The rest of the paper is organized as follows: Section two presents information on the study's philosophy, approach, data collection methods and techniques, as well as population and sampling techniques; section three presents a descriptive and demographic analysis and interpretation of the data; section four concludes the findings of the paper with a discussion and presentation of the implications and limitations of the paper; and the final section provides significant and beneficial suggestions about the study.

According to Strulik (2017), UGT was mainly developed in light of the failure of the endogenous growth model to express significant empirical regularities and developments in overall growth mechanisms, and to contribute to the momentous rise in uncertainty across regions in two nations (Nielsen, 2016). Unlike earlier growth models and theories that have focused on the modern growth administration, the current theory encapsulates the entire growth process over the course of human existence. According to Kawalec (2020), the demanding part of the differential timing was the transition from allusion stagnation to sustained EG in the emergence of uncertainty across nations and countries. UGT was initially advanced by Oded Galor and his colleagues, who were able to efficiently transition from an epoch of stagnation to an era of continued EG using a single dynamical mechanism (d'Albis, Greulich, & Ponthière, 2018). According to Attar (2020), this theory captures the basic steps and processes of growth, including the Malthusian era that was prevalent throughout the majority of human history. Following the enticement of the Malthusian era, there was an emergence of human R&D as the major and central component of growth mechanism. This formed the origin of the modern technological era of continual EG, as well as the beginning of differing uncertainties across regions over the past few decades (Ross, Fisch, & Varga, 2018; Yoo & Kim, 2019).

Moreover, this theory has proposed that, during the majority of human existence, R&D advancements were mainly offset by population growth as the majority of living standards were near survival levels, according to Madsen and Strulik (2020). Although the strengthening connection between the degree of technological and research progress and the volume and balance of the entire population has gradually improved the extent of R&D, according to Boehlke (2018), improving the significance of knowledge highlights our capability to adapt to a changing technological and R&D environment. This theory also states that the increasing distribution of certain resources towards research has generated a degree of uncertainty and a decline in productivity. This ensures that entire economies will distribute a significant portion of R&D benefits towards increasing income per capita; the alternative goes against the development of population, and paves the way for constant EG (Içer, 2017). This theory further proposed that variations and changes in biological properties as well as institutional and cultural settings have developed a certain pace of change across many regions—predominantly from stagnation towards development. Furthermore, the current theory explores the nexus between the degree of uncertainty in economic

activities and the process of EG (Diebolt & Perrin, 2019). Specifically, it advances the hypothesis that uncertainty factors and forces have a direct role in transforming the global economy from stagnation to growth (García-Quevedo, Pellegrino, & Savona, 2017).

In Finland, R&D is known as research and technological development (R&TD). according to Yüksel (2017), R&TD mainly refers to innovative practices undertaken by central governments and corporations when developing new products and services that have, according to Wang and Wang (2019), a direct impact on the overall EG of the country. R&D constitutes the initial process of developing a potential new advancement. According to Zafar, Shahbaz, Hou, and Sinha (2019), R&D processes differ from region to region, with two initial models of R&D; some R&D establishments are staffed by engineers who are directly tasked with generating modified goods and products, and others are, according to Yazgan and Yalçinkaya (2018), staffed with industrial experts who are tasked with applied research in technological as well as scientific fields, which may support the nation's current and future EG (Freimane & Bāliņa, 2016). According to Recep and ALABAŞ (2017), R&D differs from the huge majority of corporate practices in that it is not expected or intended to acquire quick profit and growth and it typically carries significant risks and an uncertain return on investment (ROI). Saidi and Mongi (2018) have claimed that R&D is important in terms of acquiring significant growth, mainly through advertising new products and services. Empirically, different studies have found a direct nexus between R&D, economic productivity and EG across all nations (Blanco, Gu, & Prieger, 2016); however, this direct nexus is much more significant in high-tech nations than low-tech nations. In studies by Hong (2017) and Dinçer, Yüksel, Adalı, and Aydın (2019), countries with high technological capabilities were found to have more positive effects, while nations with low technological capabilities experienced negative effects. Khairutdinov et al. (2018) have stated that this has resulted in high-tech regions being awarded subsidies on merit, while low-tech countries have typically been given subsidies that depended on name recognition. Moreover, according to Afonso (2016), high-end technological advancements and innovations have been a fundamental dynamic of Finland's EG and industrial enlargement for a long time. Continual support through governmental rules and policies has contributed to a significant variety of support that encourages R&D. As a result, the nation has used innovation, specifically in niche telecommunications, to support its production and service firms to efficiently compete in the global economic arena.

Uncertainty refers to the state of not being certain about a particular situation that may change in a positive or negative way. If the economy of a country is uncertain, this creates a critical situation (Baharumshah, Slesman, & Wohar, 2016). Uncertainty in the economy is often described as an unpredictable economic situation. However, it essentially refers to negative economic events. Uncertainty in the economy of any country involves every individual, whether or not they are actively involved in the economic market. The primary impact of uncertainty is that it creates volatility in inflation rates; in other words, inflation uncertainty. Uncertainty creates a horrible environment for unemployed people and unemployment itself creates a negative effect that every member of society is affected by (Jiang, Juan, & He, 2018). Uncertainty also plays a major role in the devaluation of the currency of the economy, which causes a decline in business and affects the conditions of the economy. Thus, every section of the economy, including government policymakers and all individuals who are directly or indirectly involved in the economy, face a dismal situation. In these circumstances, governments face such crucial situations that they become helpless and they borrow at high interest rates, which means that the projects and schemes the government announces have high rates that are sometimes out of the range of common citizens (Ghosh, 2019). Business workers and owners go through difficult situations that may cause a deadlock, leading to the collapse of many SMEs. This uncertainty in the economy involves many other factors that may cause foreign investors to stop their business activities. This will damage the structure of the government's economic system and policies will be also be affected. Currently, uncertainty in the global economy is affecting the Finnish economy. The Bank of Finland have stated that, in the year 2020, their EG level will slow down, reaching 1.3%. The Finnish economy is facing great challenges and the economic downfall has created a challenging situation for the Finnish economy (Vauhkonen & Packalen, 2018). Housing construction growth has decreased, which has affected a lot of private investment. This study broadly evaluates the issue of economic uncertainty and its effects on the economy of Finland, as well as the relationship between uncertainty and EG. It is a fact that the economy is facing certain uncertain conditions that negatively affect EG, with projects being left incomplete. SMEs have also been badly affected. Investors and businesspeople have suffered, as they have all been negatively impacted by the extent of the EG. Furthermore, public unrest is apparent. Foreign companies feel unable to develop their projects or start new projects and unemployment is causing people to face very serious situations. Economic policies face a challenging situation in terms of developing new options and resources. Based on the literature review, the hypothesis of the current study is: There is a significant relationship between R&D uncertainty and the EG of a country.

2. Methodology

The core purpose of this study is to uncover the influence of R&D and the uncertainties associated with it on the EG of Finland. Based on this, the researcher has, for over 29 years, gathered data on relative variables concerning Finland and applied the methodology that will be discussed in this section. The researcher has developed a stochastic version of a past model developed by Romer (1990). Before explaining the developed version of this model in detail, an important aspect to be discussed is that the overall economy of any country is made up of three sectors. The first sector is the final goods sector, in which different consumer goods are produced using labor forces and capital goods. The second sector of the economy is composed of various capital goods, also referred to as intermediate goods, which are produced using creative ideas and raw material. The last sector of the economy is the R&D sector, which focuses on human capital and its ability to derive new and innovative ideas using human minds. Another thing that must be kept in mind is that the current study uses the context of Finland; therefore, the assumption will be that the population of Finland and their labor force are consistent. Another interesting phenomenon to be considered here is that, when a researcher develops a new kind of capital good, the company who produces it acquires a patent against that design, which provides that company with the exclusive right to produce that design and sell it to the market. This patent provides an advantage for that company, as it means that

there will be no competitor in the market and all profits and revenues will be acquired by that particular company. As a result, the researcher who invented the design gets compensation from the company.

Let us consider a closed economy that contains a significant number of households that are experiencing CRRA, or "Constant Relative Risk Aversion".

$$E\int_0^{\infty} e^{-pt}\frac{C^{1-\phi}-1}{1-\phi}dt$$

In this equation, ϕ shows the relative risk aversion coefficient; E shows the expectation operator and is associated with the information obtained by the households; and 'p' denotes the discount rate that is subjective and related to each household. As discussed earlier, the researcher has considered the population and labor of the country to be constant. An economy has the right to distribute available stocks in different ways. These stocks may be distributed in the output production and new capital production, which have been denoted by H_y and H_a respectively. Cumulatively, the two become H. In this regard, Y is given as:

$$Y = \eta^{\alpha+\beta-1}A^{\alpha+\beta}H_y^{\alpha}L^{\beta}K^{1-\alpha-\beta}$$

In this equation, L is the amount of labor that has been considered to be constant by the researcher. The law of the motion of capital can be demonstrated as:

$$dK = \eta^{\alpha+\beta-1}A^{\alpha+\beta}H_y^{\alpha}L^{\beta}K^{1-\alpha-\beta}dt - Cdt - \delta Kdt$$

In this equation, δ represents the depreciation factor of the capital, K.

The basic equation, in cases of technological progress, is that the law of motion is linked to the total amount of designs produced or developed by researchers or the total amount of knowledge possessed by them. Knowledge, in this regard, is a factor that can be employed by different authors in their research on similar contexts (Bucci, Colapinto, Forster, & La Torre, 2011; Hiraguchi, 2013). This was the essence of the model developed by Romer and, following that model, technological progress will be considered as an endogenous variable in this study. The total amount of designs by researchers, which is represented as 'A', undergoes the Brownian process with the equation presented as follows:

$$dA = \mu H_A A dt + \sigma A dz(t)$$

In this particular equation, μ represents the parameters of the productivity of firms and H_A represents the total amount of labor included in the R&D sector. Similarly, σ is the coefficient linked to technology and dz (t) shows the Brownian motion or process in the aforementioned equation. Importantly, the Brownian process has a normal distribution when being considered for only a limited or finite period of time. As time passes in the given time, the variance associated with this process enhances. However, if a longer run is taken in a similar context, the behavior of the Brownian process will be such that it will eventually reach infinity. This is because of the fact that the Brownian process is nonstationary in nature. In this regard, the equation presented above is not the same as the one presented by the other researchers because of the involvement of control variable H_A. This difference can also be explained on the basis that, in past research, technological progress was taken to be exogenous, whereas it is endogenous in the current study. In the case of such past research, the model would not be able to find out the ways in which the growth rate is associated with technology or technological progress (Tsuboi, 2019). Using this equation, it is possible that the distribution of human capital or the impact of labor on two economic sectors, such as R&D and final goods, can be examined effectively, in accordance with the expected growth rate. In the same means, it is possible to identify the way in which the results of uncertainty affect welfare.

One serious issue that arises with regard to the economy, which is related to utility maximization, is linked to the law of motion and capital. The second issue is the stochastic equation that includes technological functions, and the last issue is the resource limitation presented by $H_y + H_a = H$, which means that the labor force used to develop products and ideas make up the labor force of the whole economy. However, these issues have been effectively resolved through the application of the Hamilton Jacobi-Bellman (HJB) equation. The final form of this equation is given as:

$$\rho J(K,A) = \frac{\phi}{1-\phi}J_K^{\frac{\phi-1}{\phi}} - \frac{1}{1-\phi} - J_K\delta K + (1-\alpha)J_K^{\frac{1}{1-\phi}}\eta^{\frac{\alpha+\beta-1}{1-\alpha}} \times A^{\frac{\beta}{1-\alpha}}L^{\frac{\beta}{1-\alpha}}K^{\frac{1-\alpha-\beta}{1-\alpha}}J_A^{\frac{\alpha}{\alpha-1}}\left(\frac{\alpha}{\mu}\right)^{\frac{\alpha}{1-\alpha}} + \mu J_A AH + \frac{J_{AA}\sigma^2A^2}{2}$$

It must be noted here that the model developed by Romer is complex; therefore, a very careful method must be used in order to reach a solution. The aforementioned model does not provide a viable solution; therefore, an alternative solution must be required. This can be achieved using a theorem, the final form of which is given as:

$$H_A = H - \left(\frac{\alpha L^{\beta}X}{\mu\eta^{1-\alpha-\beta}Y}\right)^{\frac{1}{1-\alpha}}$$

$$H_A = H - \frac{\alpha\left(\rho - \mu H(\alpha+\beta) + \frac{\sigma^2}{2}(\alpha+\beta)(1-\alpha-\beta)\right)}{\mu(1-\alpha)(\alpha+\beta)}$$

3. Analysis

Assuming the constant nature of consumption capital ratio, the possibility that the optimum consumption level and the total amount of ideas are independent from each other is very rare, which is in line with past research. In addition, it has also been found that consumption and uncertainty are also independent of each other, as per the equation of the law of motion of capital. The reason behind this is the absence of uncertainty during different time periods. The final equation of the theorem presented earlier in this study indicates that human capital distribution in the department of R&D is based on different factors, especially uncertainty. In other words, if uncertainty levels with regard to R&D are higher, the firms will feel reluctant to add more human capital in this particular sector, which will ultimately result in a shortage of innovative and creative ideas. Due to this shortage, fewer ideas will be generated and less progress will be made by firms.

In order to find the growth rate, the following equation can be developed:

$$G_a = \frac{\mu\Lambda H - \alpha\left(\rho - \mu H(\alpha+\beta) + \frac{\sigma^2}{2}(\alpha+\beta)(1-\alpha-\beta)\right)}{\Lambda}$$

In this equation, Λ is equal to (1-α)(α+β). It can be noted that technological growth rate is increasing alongside the total amount of human capital. In an economy in which human capital is higher, EG will also be greater. The reason behind this result is that, when human capital is greater, there is a higher chance that human capital will be distributed in the R&D sector of firms, which will lead to new and innovative ideas and more technological progress (Figure 1). As per Figure 1, four responses have been presented in relation to the increased uncertainty in the R&D sector. The first response shows that human capital distribution in the R&D sector will decrease as uncertainty increases, as previously discussed. The next response presents a totally opposite behavior, which states that, when uncertainty in the research sector increases, the distribution of human capital increases in the final goods sector. The next response regarding EG presents the same negative response in terms of the research sector and human capital. In other words, an increase in uncertainty in the research sector leads to a fall in the overall EG. Furthermore, welfare shows a similar negative response to uncertainty.

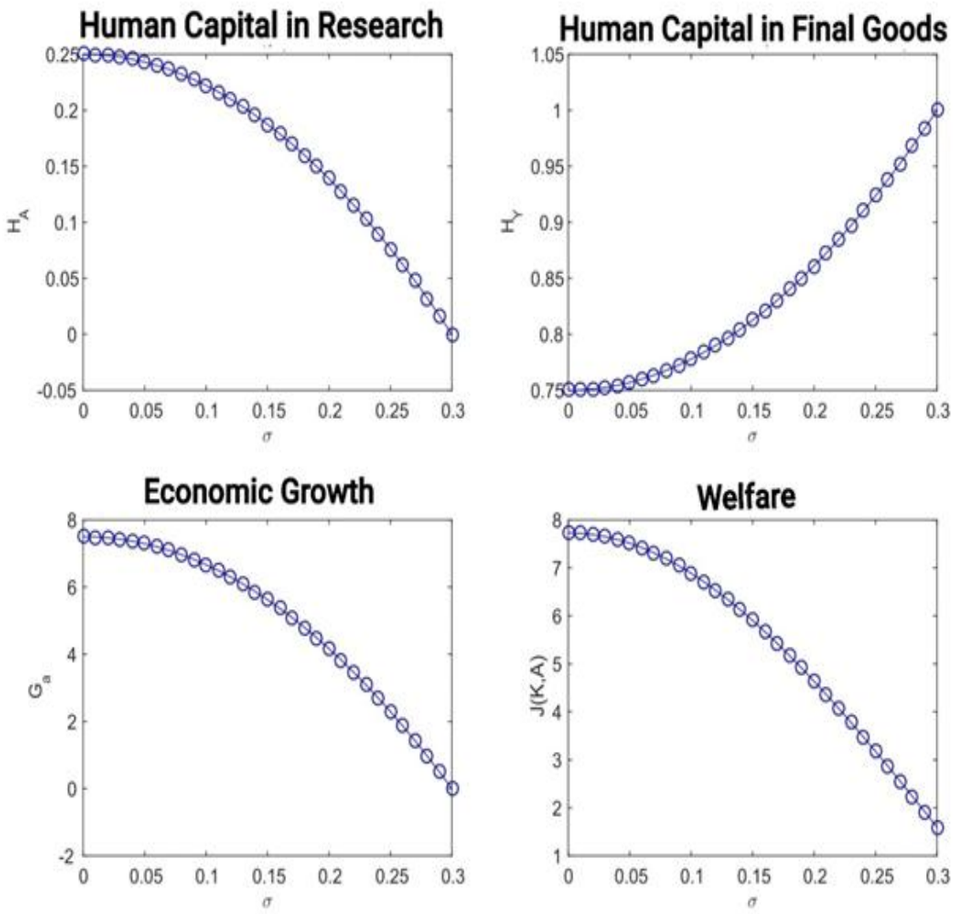

Figure-1. Response to uncertainty in the R&D sector

3.1. Welfare

Welfare was taken as the control variable in the study. As previously discussed in reference to the Figure 1, it shows a negative response to uncertainty in the R&D sector.

$$J(K,A) = \frac{\varrho J(K,A)}{\varrho\sigma}$$

As this uncertainty increases, less human capital is invested in the sector and fewer ideas are generated with regard to new designs and innovations. In this case, the function of welfare increases the total amount of ideas by research sector. It can also be confirmed that, as human capital decreases in this particular sector, there is a reduction in technological growth and the total amount of ideas have reduced their influence on welfare due to increasing uncertainty. In this way, welfare has been included as a control variable in the study and its relationship with uncertainty has been studied.

3.2. Regression Estimation

The results of the regression estimation have been given in Table 1. These results indicate that uncertainty in the research sector has a significant and negative impact on human capital distribution in the same sector. The results also suggest that uncertainty has a positive and significant impact on the final goods sector. On the contrary, in the cases of EG and welfare, the impact of uncertainty is also negative.

Table 1. Regression estimations

Variables	R&D Uncertainty Coefficient	P-value
HC Distribution in R&D Sector	-0.335*	0.0263
HC Distribution in Final Goods Sector	0.264**	0.0022
Economic Growth	-0.174**	0.0041
Welfare	-0.242*	0.0129

4. Discussion and Conclusion

4.1. Discussion

The current study is based on the core purpose of uncovering the influence of R&D and the uncertainties associated with it on the EG of Finland. Based on this context, the researcher gathered data on relevant variables over 29 years and then applied a stochastic model in accordance with similar previous research. The main result of the study has proven that uncertainty in the research sector has a negative influence on EG, which means that, if the uncertainty level in the R&D sector is high, firms will hesitate to add more human capital to this particular sector and, as a result, there will be a shortage of innovative and creative ideas and designs. If this occurs, fewer ideas will be developed and less economic progress will be made by firms. This result is in line with past studies (Kaur & Singh, 2016; Ustabaş & Ersin, 2016). The next result from this study relates to the distribution of human capital in two major sectors of the economy: The R&D sector and the final goods sector. It has been estimated that, as uncertainty increases in the research sector, the distribution or allocation of human capital will shift from the research sector to the final goods sector. In other words, the firms will tend to add more human capital to the final goods sector, as opposed to the research sector, as the former has the ability to provide guaranteed revenue, while the latter is experiencing uncertainty in that regard. This result can be confirmed using past literature (Cetenak & Oransay, 2017; Saito, 2017). Another result of the study is related to the control variable of welfare. Its response to uncertainty is also negative, which means that welfare activities will decrease as uncertainty rises in the research sector. This result is in agreement with studies conducted by other researchers on similar topics (Cadil, Mirosnik, Petkovova, & Mirvald, 2018; Huang, Yang, & Cheng, 2017).

4.2. Conclusion

The results show that uncertainty in the research sector has a negative influence on the EG of Finland. It has also been estimated that, as uncertainty increases in the research sector, the distribution or allocation of human capital will shift from the research sector to the final goods sector. Moreover, welfare's response to uncertainty was also found as negative. These results lead to the conclusion that firms in Finland need to improve their research sector by increasing the number of patents and establishing research institutions that will lead to a reduction in the impact of uncertainty. This will provide room for more human capital in this sector, as well enhancing the EG of Finland in the long-ter.

4.3. Implications and Limitations

The current study is very beneficial for the R&D sector of Finland and other countries, in the sense that it has the potential to guide the improvement of the research sector of a country by increasing the number of patents and establishing research institutions in order to reduce the impact of uncertainty. This will not only provide room for more human capital in this sector, but it will also enhance the EG of Finland in the long-term. Additionally, this study is beneficial for researchers, as they can obtain literature about the stochastic model used in the study and the results obtained. In the future, researchers must conduct this study in countries other than Finland in order to increase the scope of the topic. They can also incorporate other factors associated with different sectors in the country, in order to also understand their perspective. It is recommended that future research uses different quantitative techniques and tools to carry out these estimations in a more reliable way.

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