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Innovation and Productivity: Is Learning by Doing Over?

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Abstract

Labour productivity is one of the key measures of economic performance. It represents the total volume of output produced per unit of labour. This paper examines the influence of business investments in research and development and education on labour productivity using system dynamics modelling. The results reveal that investments in education and training activities generate higher labour productivity growth. The impact of innovations largely depends on their diffusion and adoption that require educated and trained users. The new industrial era makes learning by doing quietly disappear and demand a great flexibility of workers and their ability to rapidly acquire new and master the existing knowledge.

Keywords: Labour productivity, Innovation, Research and development, Education, System dynamics modelling

JEL classification: J24, O30, O52

Introduction

In macroeconomics, labour productivity is one of the most used indicators for dynamic measuring of economic growth, competitiveness and living standard within an economy. Labour productivity is a value that each employed person creates per his or her input. It measures the amount of real gross domestic product (GDP) produced by an hour of labour or by a person during a given reference period. Labour productivity provides general information about the efficiency and quality of human capital in the production process for a given economic and social context (International Labour Organization, 2019).

The most important determinants of labour productivity are physical and human capital and technological change. Physical capital implies the tools, equipment and facilities available to workers to produce goods and services. Human capital represents the accumulated knowledge, skills and expertise that workers possess. Technological change implies a combination of invention (advances in knowledge) and innovation (putting the advancement into a new product or service). If

labour productivity is growing, it can usually be attributed to the growth in one of these determinants. However, if the real gross domestic product is increasing while labour hours remain static, it signals that the labour force has become more productive. Such situations could be observed during economic recessions as workers increase their labour effort to avoid losing their jobs.

After the World War II, between 1950 and 1995, labour productivity throughout Europe grew faster than in the USA (by 3.1% in France, Germany, Belgium, Italy and the Netherlands, while by 2.1% in the USA). The trend reversed later on, as labour productivity in Europe slowed down, while the productivity in the USA rose and even with slowdowns always remained higher than in Europe. Labour productivity growth in the USA averaged 1.1% from 2007 to 2017, while in the EU-15 only 0.6% in the same period, widening the already existing productivity gap. According to the Information Technology and Innovation Foundation (ITIF), this effect is largely attributable to Europe's failure to invest in information and communication technologies which drives labour productivity (Atkinson, 2018).

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The concept of “learning by doing” is based on learning from experiences resulting from one’s own actions (Reese, 2011). Learning takes place through the attempt to solve a problem and it only takes place during activity (Arrow, 1962). The role of experience in increasing productivity has not gone unobserved by scientists. In his work published in 1936, Wright analysed and concluded that the number of labour hours expended in the production of an airframe is a decreasing function of the total number of airframes of the same type previously produced. Furthermore, Lundberg introduced the “Horndal effect” in 1961 that indicates the process of gradual increase in output despite the lack of investments. Lundberg observed that productivity at the Horndal steel works in Sweden increased on average close to 2% per year for a period of 15 years, despite the lack of significant capital investments (Hendel & Spiegel, 2013). In his work on the theme of “learning by doing”, a Nobel prize winner in economic sciences Kenneth Arrow argued that the sustained productivity growth at Horndal could only be attributed to learning from experience (Arrow, 1962). Arrow provided foundational work in endogenous growth theory which holds that investments in human capital, knowledge and innovation are significant contributors to economic growth.

Early researches of the concept of “learning by doing” have mostly been performed in the manufacturing sector and through a progress function determining variation in production costs over the years (Hirsch, 1952; Montgomery, 1943; Wright, 1936). In further studies (Bahk & Gort, 1993; Rapping, 1965; Sheshinski, 1967), learning by doing has been acknowledged as a productivity enhancing factor in the production function. However, learning is not continuous in the production process; it can be depreciated or interrupted. When a technological change occurs in the production, past knowledge and experience can become irrelevant. Knowledge and skills passed to workers can be lost when they leave the job. Therefore, recent studies try to investigate the effects of learning by doing and labour turnover on productivity (Baffoe-Bonnie, 2016; Chiang, 2004; Da Rocha, Pero, & Corseuil, 2019).

This paper contributes to the existing literature in several ways. First, existing studies on labour productivity and innovation relationship, as well as on labour productivity and investments in human capital have largely focused on production function estimation. The purpose of this paper is to challenge and advance these studies by using system dynamics modelling. System dynamics modelling is based on system thinking and enables viewing problems and

human actions as interconnected wholes, taking into account also lagged feedback loops that is difficult to do through traditionally used production functions. It enables understanding the big picture around the problem and predicting its long-term change. A systems approach enables to identify where to focus actions and with what intensity to reach the best desirable results. System dynamics modelling has been widely applied to better understand complex system issues from organisational change to urban and world dynamics, including climate change (Lane & Sterman, 2011; Sterman et al., 2013). This paper presents a dynamic model that may be used to analyse the influence of investments in education and research and development (R&D) on labour productivity and can easily be applied by company managers and decision makers for long-term strategic planning. What often prevents companies from achieving higher performance is not a lack of resources, knowledge or commitment to change, but a lack of meaningful system thinking capability (Sterman, 2002). Therefore, this paper could also serve to students to better understand system dynamics modelling and its application. Second, the model also takes into consideration labour turnover and thus contributes to the recent studies on learning by doing, labour turnover and productivity relationship. Third, a better understanding of the effects of the above relations will make policymakers, managers and company owners aware of the importance of investing in continuous education and innovation and allow them to adjust their mechanisms, improve their employment decisions, provide support and work on key issues that contribute to labour productivity growth. By increasing labour productivity, they will directly contribute to the growth of income per capita and living standard in their countries.

The paper is composed of five chapters. After the introduction, the first chapter gives a brief overview of the relevant literature. The second chapter presents the developed model. The results and discussion are presented in the third chapter. The last chapter summarizes the most important implications.

1 Theoretical background

Labour productivity is directly linked to economic growth, as the latter most frequently occurs when labour productivity increases. With growth in labour productivity, an economy is able to produce more goods and services for the same amount of work. The additional production enables higher consumption of these goods and services.

Labour productivity is important for everyone in an economy: businesses, workers and government.

Increased labour productivity brings businesses higher profit and thus an opportunity for more investments, while for workers it can translate into higher wages, better working conditions, as well as new job positions. For the government, increased labour productivity results in higher tax revenues. The amount of tax revenue received by the government is dependent upon the extent to which productivity grows over a period and paying attention to trends in productivity is therefore vital for policymakers. If productivity grows by less than expected, fiscal deficits could occur, while if it grows by more than expected, there may be fiscal surpluses (Sprague, 2014).

According to the Bureau of Labor Statistics of the United States Department of Labor, workers in the United States business sector worked the same number of hours in 2013 as they had in 1998 (approximately 194 billion labour hours). During that period, the United States population increased by over 40 million people and thousands of new businesses were established. However, the United States businesses managed to produce 42% (\$ 3.5 trillion) more output in 2013 than in 1998 (adjusted for inflation). Such additional output growth must have come from productive sources other than the number of labour hours, i.e. investing in technology, equipment, hiring more high-skilled and experienced workers (Sprague, 2014).

Drawing on the literature, the conceptual framework is composed of two key determinants of labour productivity: innovation, including research and development and education.

1.1 Innovation, research and development and labour productivity

Innovation can be defined as the implementation of creative ideas in order to generate value (Baumgartner, 2009). R&D refers to innovative activities undertaken by companies or governments in developing new or improving existing products or services. R&D is a crucial component of innovation and a key factor in developing new competitive advantages. It directly supports the development of knowledge and technology.

Many studies have already been done on innovation and labour productivity as well as investment in R&D and labour productivity relationship. Many of them reach the conclusion that innovation and investment in R&D do matter. Crépon, Duguet, and Mairesse (1998) gave one of the most influential contributions in recent literature on economics of innovation. They introduced a structural model that explains productivity by innovation output and

innovation output by research investment. By the use of data on innovation output in French manufacturing and econometric methods which correct for selectivity and simultaneity biases, the authors revealed that innovation output rises with research investment and productivity correlates positively with a higher innovation output. Löf and Heshmati (2006) investigated the relationship between innovation and company's performance in the multidimensional sensitivity analysis, showing that the model of Crépon, Duguet and Mairesse can be estimated in a simple framework, applying the instrumental variables approach.

Mohnen and Hall (2013) did a brief survey of the empirical literature on innovation and productivity. In spite of the usual positive relationship between innovation and productivity, in the EU member states high costs of innovation often lead to lower companies' productivity. Moreover, in Central and Eastern European countries, a negative feedback effect from productivity to innovation output has been noticed which could indicate that companies rather improve production of existing products than introduce new products to the market (Hashi & Stojčić, 2013). Crespi and Zuniga (2012) have examined the determinants of technological innovation and its impact on labour productivity across six Latin American countries (Argentina, Chile, Colombia, Costa Rica, Panama and Uruguay). They found out that companies that invest in knowledge are abler to introduce new technological advances and that those that innovate have greater labour productivity.

There are two types of innovation output: product and process innovations. Product innovation is the main driver of labour productivity and the influence of process innovation is rather insignificant (Baumann & Kritikos, 2016; Mairesse & Robin, 2009). However, process innovations are important, as they improve the transformation process (Kemp et al., 2003; Klomp & Van Leeuwen, 2001). Some companies perform both, product and process innovations, especially in manufacturing. Stojčić and Hashi (2014) investigated the influence of product, process and both product and process innovations on productivity across several East and West European countries. The results revealed that there is a positive and statistically significant relationship between process innovations, as well as product and process innovations together, and productivity. Companies tend to be more successful in product innovation if they use customers as a source of information and in process innovation if they use information from suppliers (Griffith et al., 2006).

The econometric results obtained so far indicate the existence of a positive and significant

relationship between R&D and company and labour productivity growth (Solomon et al., 2015; Tsai & Wang, 2004; Wakelin, 2011). Both applied and experimental R&D, as well as R&D from private sources tend to have higher productivity impacts compared to the basic R&D and publicly funded R&D (Coccia, 2011; Solomon et al., 2015). Although many studies have shown positive correlation between investment in R&D and labour productivity, Benavente (2006) analysed the impact of spending on R&D and innovation on labour productivity using data from Chilean companies. He found out that in the short term, productivity is not affected by innovation or by spending on R&D. The explanation for such results he found in the fact that there were no lags between the implementation of innovations and impact on productivity. Similar results were obtained in the study of Erdil, Cilasun, and Eruygur (2013) in which the contribution of R&D expenditures to labour productivity in 22 OECD countries was analysed. The results showed that the initial impact of the growth in the ratio of total R&D expenditure to GDP on labour productivity is negative and insignificant. However, that situation ceases to exist after a period of time and labour productivity starts to rise. In this respect, the policies that favour R&D could help to increase the productivity.

1.2 Education and labour productivity

Human capital is a very important contributor to the productivity growth (Engelbrecht, 1997; Pietrzak & Balcerzak, 2016). Rapid technological change makes many skills obsolete quite quickly, while constantly creating demand for new ones. Even though the willingness to participate in adult learning increases with the worker's socio-economic status and the given level of education (Desjardins, 2015), workers usually struggle to improve their knowledge and skills, especially because of their age, lack of time, will and finance resources. In order to improve their ability to absorb new technologies coming out of R&D and keep pace with the competition, companies often invest in education and training of their workers.

The U.S. National Center on the Educational Quality of the Workforce (EQW) studied the relationship between education and productivity at more than 3100 U.S. workplaces. In a report published in 1995, it showed that, on average, a 10% increase in workforce education level led to an 8.6% gain in total factor productivity, while a 10% rise in physical capital (equipment) increased productivity by just 3.4%. Therefore, the marginal value of

investing in human capital is almost three times greater than the value of investing in machinery (Stewart, 2010). Further studies (Almeida & Carneiro, 2009; Galor & Moav, 2004; Stauvermann & Kumar, 2018) confirmed the importance of investing in human capital. However, according to Durán and Rillaers (2002), investing less in education does not necessarily lead to less growth, as the accumulation of physical and human capital displays some degree of substitutability.

Some recent studies (Afrooz et al., 2010; Benos & Karagiannis, 2016; Maciulyte-Sniukiene & Matuzeviciute, 2018; Tabari & Reza, 2012) have shown that human capital in terms of education has a positive impact on labour productivity growth. Human capital is composed of general and company-specific knowledge. General knowledge is acquired during schooling, while company-specific knowledge is acquired through worker's on-the-job experience, training or through specialised courses. High rate of turnover (loss of experienced workers) has negative effects on learning and labour productivity (Chiang, 2004; Da Rocha, Pero, & Corseuil, 2019). With the high turnover, companies lose company-specific human capital and it becomes harder to convert “doing” into “learning”. General human capital is easy to compensate by employing new workers, but only by retaining experienced workers can companies convert their “doing” into “learning” (Chiang, 2004).

Bartel (1995) studied the relationship between on-the-job training and worker productivity and found that training has a positive and significant effect on job performance, thereby confirming the relationship between training and productivity. It is particularly important that companies increase their investments in on-the-job training and learning by doing of workers with secondary school diploma (Yunus, Said, & Hook, 2014). The skills acquired through training should be applicable across all possible departments in the organization to engage the workplace and increase productivity.

Although most of the countries have increased efforts in adult learning, the share of adults who participated in education programs and courses for certain European countries was in the range between 24.2% (Italy) and 66.7% (Denmark) in 2012. The Nordic countries, more precisely, Denmark (66.7%), Sweden (65.9%), Finland (65.4%), Netherlands (64.9%) and Norway (64.7%) registered the highest rates of adult participation in education activities (Desjardins, 2015). Despite their high level of economic development, the Nordic countries have a strong record of public policy that aims to promote adult learning, target various barriers to

value of labour productivity. The latter is expressed as labour productivity per hour worked, as it provides a better picture of productivity developments in the economy than labour productivity per person employed (it eliminates differences in the full time/part time composition of the workforce).

In order to determine the value of labour productivity per hour worked, some variables have been taken into consideration based on the literature overview and data availability, such as business expenditure on research and development (BERD), business expenditure on education, adult participation in learning and total number of workers. Worker, skilled worker and value added (company's profit) are stocks, while new workers, worker leaving, education, skilled worker leaving, income and cost of education and R&D are flows in this model. The cloud represents a stock outside the model boundary. It serves as the acknowledgement that the observed system is connected in some way to another system.

3 Results and discussion

The goal of the model presented in Fig. 1 is to enable company owners and decision managers to see the impact that various policies and changes may have on labour productivity in the company. The above model has been tested on the German economy, using secondary data from the Eurostat database for the year 2016. The German economy has been chosen, as it is one of the most developed economies in Europe and is often used as a role model for many other European countries. In order to simplify the visualisation and calculations, some

basic assumptions for the model are defined: the hypothesized company has 100 unskilled workers, each month the company employs two new unskilled workers, one newly employed unskilled worker leaves the company each month (e.g. he or she did not fit in the company, did not like the job, etc.) and every two months one skilled worker leaves the company (e.g. for a better paid or more challenging job position in another company, moving to another place for family matters, etc.). According to Eurostat data (Eurostat, 2019), in 2016 business expenditure on R&D was at 1.99% of the German GDP, while business expenditure on education and training was at 7% of the German GDP and adult participation rate in education and training was 56.4% (employed persons). The simulation is set for a period of ten years.

Fig. 2 shows a simulation of labour productivity for the hypothesized company based on the above mentioned data and model assumptions.

The model shows that labour productivity increases by over 60% after ten years. It firstly grows rapidly and then slows down as the time passes. Fig. 3 reveals that it starts to slow down after 43 months, i.e. when the number of unskilled and skilled workers meet in the company. After 43 months, there are approximately 122 employed workers left in the company, of which 61 are unskilled and 61 skilled workers.

System dynamics is a useful tool for long-term, strategic modelling and simulation. Figs. 2 and 3 show a simulation of labour productivity, the number of unskilled and skilled workers as well as the number of total workers for a period of 120 months

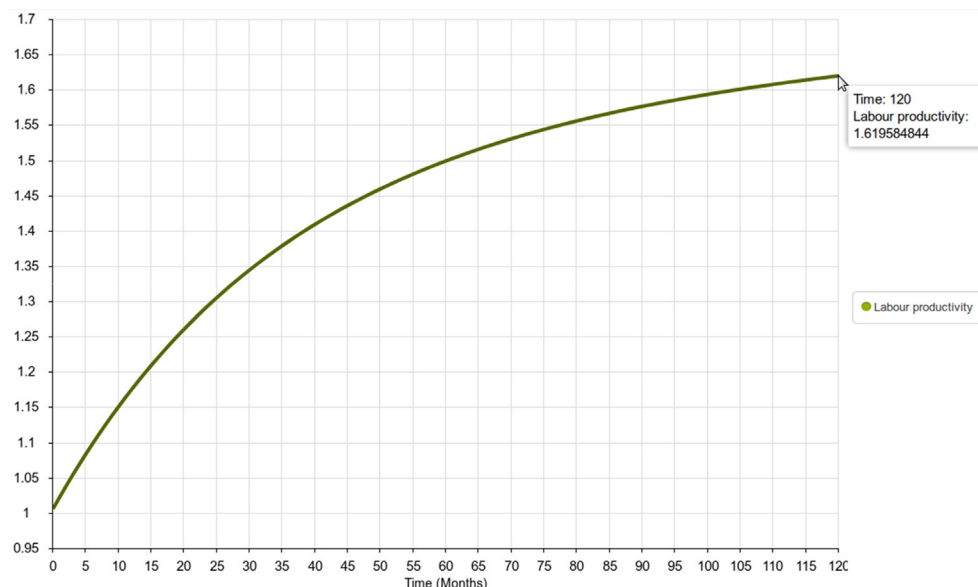


Fig. 2. Simulation of labour productivity for hypothesized company for 120 months. Source: author's simulation.

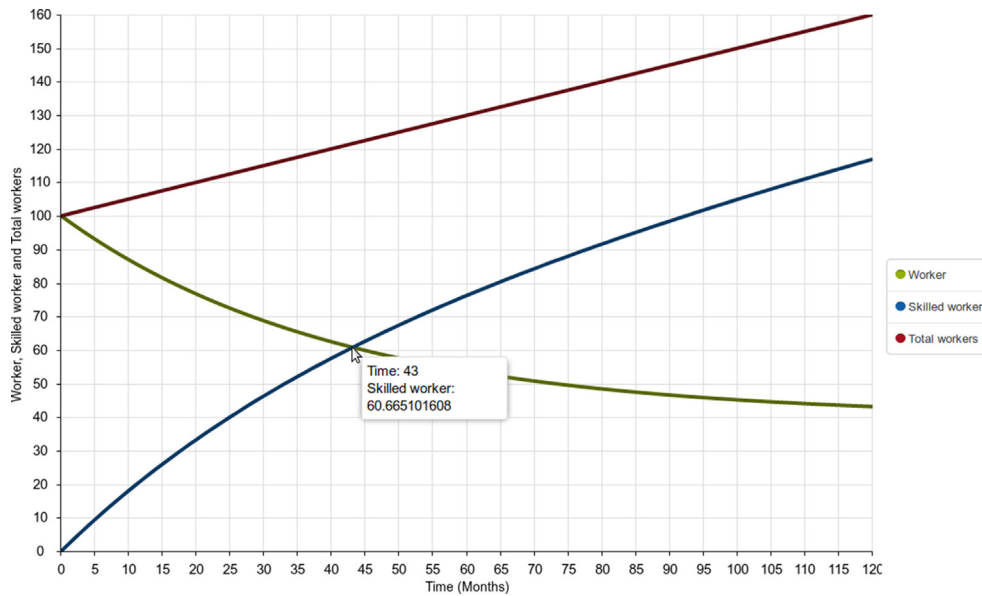


Fig. 3. Simulation of unskilled workers, skilled workers and total number of workers in the hypothesized company for 120 months. Source: author's simulation.

in a hypothesized German company. Company owners and decision makers are often interested in improving labour productivity. Changes in processes can be expensive and it is therefore better for decision makers to simulate the effects of new policies before applying them in reality in order to avoid unintended consequences.

The presented model can easily be used by company managers to analyse various investment scenarios in similar real-world companies and serve as a decision support tool for long-term strategic planning. Many companies find themselves in a situation where they do not know whether it is more convenient to increase the investment in R&D or education and training activities of their workers in order to improve labour productivity and company profit. The model presented in this paper could help companies to find the right answer through building “what-if” scenarios. Assuming that the company decides to increase its labour productivity by increasing the expenditure on R&D, e.g. decides to invest two times more (4% instead of 1.99% of the German GDP), labour productivity would not increase significantly.

Fig. 4 shows that increasing the investment in R&D did not contribute to the significant growth in labour productivity (62.56% vs. 61.96% after ten years). According to this simulation model, the investment in R&D does not have significant influence on labour productivity. Such a result differs from the majority of researches done in the past and presented in the literature overview, but is in line with the results obtained by Benavente (2006) and Erdil et al. (2013).

Adoption of new technologies and introduction of new production processes require time and effort that usually lead to the insignificant labour productivity growth, especially in the short run (Ahn, 1999). Investment in R&D does not directly increase workers' knowledge and skills. Highly educated and skilled workers usually already work in R&D, but other workers in the company need time to acquire new knowledge and improve their performance. It is important to invest in workers' education to teach them how to use new developments (e.g. development of new software does not increase labour productivity, if workers do not learn how to use it).

In the new era of rapid information exchange, learning by doing has become obsolete, as it is time-consuming. Therefore, companies should improve workers' knowledge and skills by investing in education and training activities. Fig. 5 shows a simulation model of labour productivity when the company decides to invest in education and training of its workers (in this case, it decides to invest twice as much, i.e. 14% instead of 7% of the German GDP).

The increase of investment in education and training leads to the growth in labour productivity (67% after ten years). This simulation model proves that there is a positive impact of business investment in education and training on labour productivity and such results are in line with the researches done in the past. However, by using this simulation model the company can design better operating policies and guide effective changes, e.g. it can plan investments in education and training activities. At the beginning of the investment labour productivity growth is faster, as

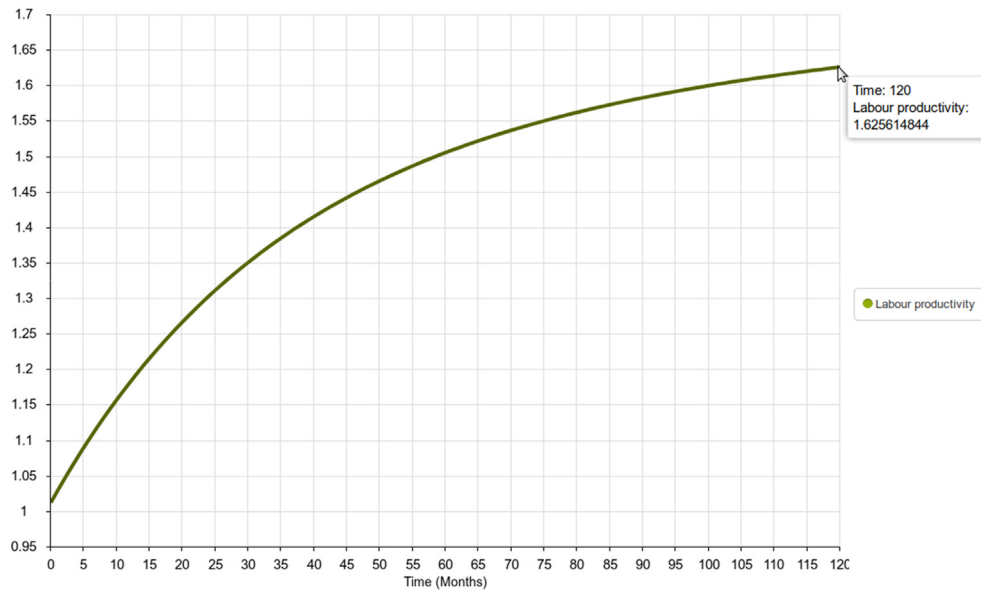


Fig. 4. Simulation of labour productivity for the hypothesized company for 120 months when it doubles its expenditure on R&D (4% instead of 1.99% of the German GDP). Source: author's simulation.

workers acquire new knowledge and skills through education and training activities. Therefore, the company can increase its investment in education and training in the first years and decrease it when there will be more skilled workers than unskilled workers in the company. Fig. 6 reveals that with doubling the investment in education and training, the company will need less time to reach the moment when it has the same number of unskilled and skilled workers (32 months instead of 43).

Companies should not only increase their expenditures on education and training, but also

motivate their workers to participate in such activities. Without participation in education and training activities, workers will need more time to acquire new knowledge and skills. In the case of the hypothesized company presented in this paper, if the adult participation rate in education and training activities was halved (28.2% instead of 56.4% employed persons), it would take the company more than 10 years to equalize the number of unskilled and skilled workers.

System dynamics modelling is not an intervention, but rather a useful tool for analysing the structure and

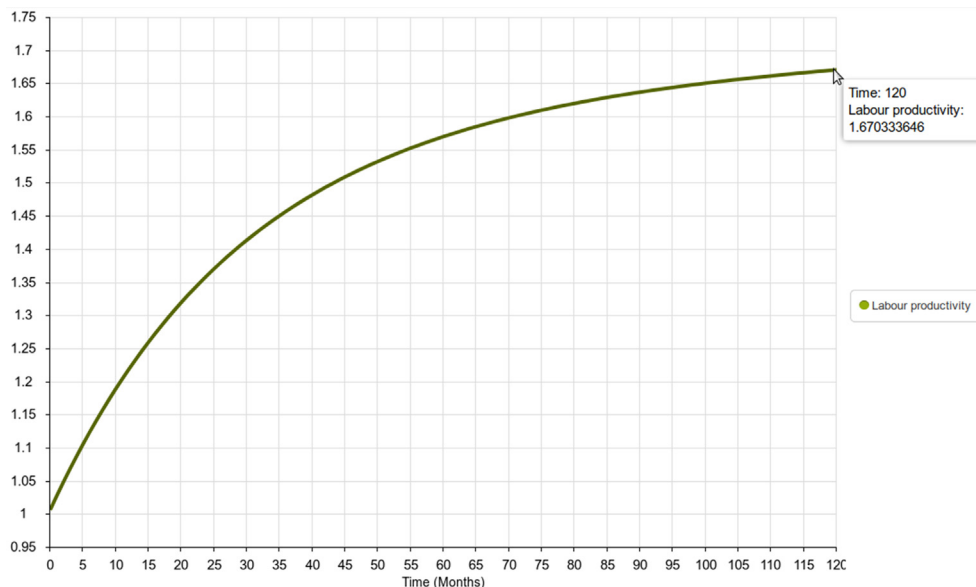


Fig. 5. Simulation of labour productivity for the hypothesized company for 120 months when it doubles its expenditure on education and training (14% instead of 7% of the German GDP). Source: author's simulation.

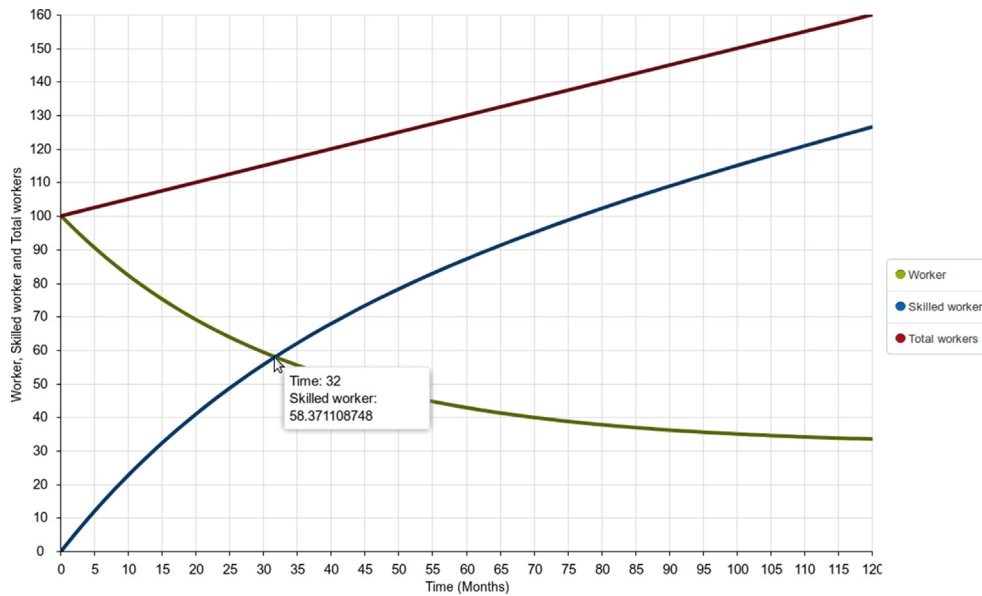


Fig. 6. Simulation of unskilled workers, skilled workers and total number of workers in the hypothesized company for 120 months when it invests two times more in education and training (14% instead of 7% of the German GDP). Source: author's simulation.

behaviour of a complex system with nonlinear links and for designing efficient policies. The model presented in this paper highlights the importance of learning and investing in education and training activities in order to improve labour productivity. Learning by doing is time-consuming and expensive nowadays, especially in high tech and other industries that require rapid technological changes (Ahn, 1999). Although learning by doing is applied in many companies, active research and learning is a dominant driver of technological change (Jamasb, 2006). Adoption of new technologies requires time and effort and therefore tends to restrict labour productivity growth temporarily. Innovation and R&D can be seen as a prolonged learning process on experience and problem solving, as learning advances are embodied in new technological developments that could improve labour productivity in the long run (Baffoe-Bonnie, 2016). Learning interacts with technology to improve labour productivity, reduces company's costs of production and increases profit. Thus, companies should increase the investment in professional training and encourage their workers to actively participate in education and training activities in order to keep pace with new developments and to apply new knowledge and skills in their everyday work tasks. By increasing the levels of engagement and creating a favourable working environment, companies will prevent high turnover rates that harm labour productivity and affect their development plans. Companies are less likely to fire trained workers, as education and training costs can be high. In addition, company-specific knowledge acquired through worker training cannot

be applicable in other companies and could positively influence worker wage and their decision to stay in the same company (Konings & Vanormelingen, 2015).

4 Conclusion

Labour productivity is a fundamental factor in determining how fast the economy and the average standard of living grow. Existing studies on labour productivity have largely focused on the production function estimation. This paper advances those studies by presenting a system dynamic model. The use of system dynamics represents an untraditional approach in modelling labour productivity. The main advantage of the presented model is that it enables viewing problems and actions as interconnected wholes and takes into account lagged feedback loops. As such, it can easily be applied by company owners and decision makers in long-term strategic planning and labour productivity improvement.

The purpose of this paper is to examine the influence of investments in R&D and education on labour productivity using system dynamics modelling. Therefore, this paper represents a contribution to the studies dealing with these relationships and to the system dynamics application. The existing literature mostly shows the importance of innovation and R&D in raising labour productivity and emphasizes that companies should adopt innovations as quickly as possible. However, this study reveals that business expenditure on education and training as well as adult participation in such activities have stronger influence on the labour productivity growth. The findings provide further evidence on the importance of absorbing

new knowledge generated by R&D. The impact of innovations on the labour productivity growth depends largely on their diffusion and adoption which can mostly be done by education and training activities.

In the era of Industry 4.0, the flexibility of workers and their ability to acquire new knowledge have become the most desirable characteristics. Large and rapid flow of every day information requires constant updating in order to keep pace with the competition. New technologies have become more complex and require specific training for their users. Hence, learning by doing is not sufficient anymore, as it is time consuming.

According to this study, adult participation in education and training activities has become one of the main drivers that boost labour productivity. Education should be universally available, as the higher the average level of education in an economy, the higher the accumulated human capital and the higher the labour productivity. It is important that companies and policymakers encourage and support adult participation in education and training activities, because low productivity growth is correlated not just with low wages and low competitiveness but also low government revenues. Reduced government revenues, among other things, have as a consequence fewer funds for productivity enhancing expenditures in the areas such as innovation, R&D, education, and therefore decrease labour productivity and living standard over time. Policy interventions can include supporting educational institutions, creating and supporting training programs, supporting specialised online portals for teaching, etc.

The presented model can easily be adjusted to each company and extended by adding variables, stocks and flows to analyse additional problems and actions. However, there is no model that will perfectly represent the reality and some limitations should be taken into consideration. Labour turnover is not always easy to predict and it affects productivity. Workers that leave or join the company will differently affect productivity, depending on their level of education and performance.

The simulation model developed in this study is limited to just one country and uses the average data for one year. Further research on a larger sample using bigger datasets should be done in the future to confirm the obtained results. The data regarding business expenditures on R&D and education and training are aggregated data for companies of all sizes. Thus, it would be interesting to see in further studies, whether the same results would be achieved in case that the developed model used data only for micro or large companies.

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Appendix: Model equation list

Simulation settings	<ul style="list-style-type: none"> • Time Start: 0 • Time Length: 120 • Time Step: 1 • Time Units: Months
Model variables	
Adult participation in learning	<ul style="list-style-type: none"> • Value: 0.564
BERD	<ul style="list-style-type: none"> • Value: 0.0199
Business exp. on education	<ul style="list-style-type: none"> • Value: 0.07
Labour productivity	<ul style="list-style-type: none"> • Value: $([Worker]+1.84*[Skilled\ worker])/([Worker]+[Skilled\ worker])+0.3*[BERD]$
Total workers	<ul style="list-style-type: none"> • Value: $[Skilled\ worker]+[Worker]$
Model stocks	
Skilled worker	<ul style="list-style-type: none"> • Initial Value: 0
Value added	<ul style="list-style-type: none"> • Initial Value: 100
Worker	<ul style="list-style-type: none"> • Initial Value: 100
Model flows	
Cost of education and R&D	<ul style="list-style-type: none"> • Rate: $[Value\ added]*([Business\ exp.\ on\ education]+[BERD])$ • Alpha: Value added • Omega: <i>None</i> • Positive Only: Yes
Education	<ul style="list-style-type: none"> • Rate: $0.4/12*[Adult\ participation\ in\ learning]*[Worker]+10*[Business\ exp.\ on\ education]*([Adult\ participation\ in\ learning]*[Worker]/18+(1-[Adult\ participation\ in\ learning]*[Worker])/24)$ • Alpha: Worker • Omega: Skilled worker • Positive Only: Yes
Income	<ul style="list-style-type: none"> • Rate: $[Labour\ productivity]*100-[Value\ added]$ • Alpha: <i>None</i> • Omega: Value added • Positive Only: Yes
New workers	<ul style="list-style-type: none"> • Rate: 2 • Alpha: <i>None</i> • Omega: Worker • Positive Only: Yes
Skilled worker leaving	<ul style="list-style-type: none"> • Rate: 0.5 • Alpha: Skilled worker • Omega: <i>None</i> • Positive Only: Yes
Worker leaving	<ul style="list-style-type: none"> • Rate: 1 • Alpha: Worker • Omega: <i>None</i> • Positive Only: Yes
