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EXAMINING THE LINK BETWEEN INNOVATION, PRODUCTIVITY AND GROWTH: A GLOBAL VIEW

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Abstract

Innovation has long been recognized as one of the key elements of economic progress, though some say that its direct relation to the concept of economic growth remains rather controversial. Productivity growth is the key economic indicator of innovation, non-the-less. Growth theory assumes that changes in real output are result of technological shocks within the economy. Using ARIMA modelling techniques and Beveridge-Nelson univariate decomposition this paper estimates the impact of technological shocks on GDP, GDP per capita and labour productivity (long-term) growth of OECDs' most developed countries. The study explores the global effects of the 'third industrial revolution' for 25 OECD countries over 1950-2013 periods. The impact of innovations on growth differs in intensity and time among the countries. Measured impact of technological innovation on growth is significant, and it is expected to become even more significant in the future. Economic growth is riding on the technological innovation wave but for how long and how far it is uncertain if the 'Great Decoupling' problem is to abound. Positive impact of technological innovation on growth and welfare is seriously risked by the high divergence and inequality arising from the Great decoupling problem.

Keywords: computer and information technology, productivity and growth, ARIMA models, Beveridge-Nelson decomposition, OECD countries

JEL Classification: O30, O32, O33, O37, O38

Introduction

Long recognized as a driver of development and prosperity, technological innovation became an essential factor in displacing existing economic structures by laying down fundamentals for new economic forces and opportunities. From Karl Marx to Joseph Schumpeter, scholars have long noted the role that technological development plays in economic progress and wealth accumulation. Both, Marx and Schumpeter, concluded that the dynamics of technological improvement is what enables capitalism to revolutionize itself (Schumpeter, 1947, p. 411). Economic development and growth turns on harnessing human creativity across the entire spectrum of innovation through productivity; from the creation of new technologies and new firms to new and improved processes, increased

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labour productivity, more efficient manufacturing and production systems, and increasing effectiveness in the delivery of services (CGI, 2011, p. 9). Namely, progress depends on new standards of economic efficiency i.e. productivity growth. An increase in productivity can come from changing methods or increasing resources or, for some time from both. For the number of years economists were sceptical regarding effects of computer and information technology on aggregate productivity and economic growth, however, new studies have found that the surge of productivity (especially in the USA in the 1990s) has been largely the result of the adoption of new technologies (Edwards, 2001, p. 3). The computer equipment manufacturing industry comprised only 0.30% of USA value added in the period 1960-2007, but has generated 2.70% of economic growth and 25.0% of productivity growth (Jorgenson et al., 2010, p. 2). The so-called 'New Economy' associated with advances in computer, information and communication technology is often related to transformation of economies from industrial to information societies. However, some state that the advances made by using these new industries are far from the benefits associated with the two industrial revolutions. Up until the end of the 1980s economists had trouble to distinguish actual benefits from such technologies. The potential of computer, information and communication prospect, however, was made clear in the 1990s (Šimurina and Tolić, 2008, p. 18).

Growth theory assumes that changes in real output are result of technological shocks within the economy. These shocks embodied in technological innovations have a permanent effect on real gross domestic product (GDP) growth, raising the standard of living over the time as the economy moves to an improved equilibrium point (Falatoon and Safarzadeh, 2006). This paper analyzes the impact of significant technological innovations within computer and information technology over the last 60 years on the real GDP, GDPpc and labour productivity growth of OECD countries by using the time series data for the period 1950-2013. Data are collected from the Conference Board *Total Economy Database*. Following the methodology used by Falatoon and Safarzadeh (2006) we apply ARIMA models in order to generate appropriate forecast functions. Beveridge-Nelson (1981) univariate decomposition was used to decompose variable into the sum of a random walk plus drift and stationary components. Since the outbreak of 'path breaking' innovations such as the steam engine, spinning machine, railroads, electricity, auto industry, aerospace, computer and information technology we are analyzing the concept of technological growth. In the perspective of time, these innovations have been raising real GDP from one steady-state equilibrium level as they converged to a new and higher steady-state level (Falatoon and Safarzadeh, 2006, p. 241). The growth rate is then stabilized until a new wave of innovation has changed existing *status-quo* state. Linking long-term economic growth with technological progress is deeply embedded in the main message of the Solow-inspired growth models, which treat technological change as exogenous and even more so in the endogenous growth models (Mokyr, 2005, p. 4).

Following Neo-Classical growth models and pioneering work of Solow (1956; 1957) we would conclude that technological change, in a Solow's words, is indeed expressed in relatively large 'residual factor' (Dosi, Freeman and Fabiani, 1994, p. 3). But until recently, little progress was made in the formal modelling of technical development itself. As Gancia and Zilibott (2009, p. 2) point out, despite the obvious importance of technology in explaining modern growth, quantifying the exact contribution of technical progress is not really simple, considering that technological development is hard to observe and measure directly. New-Growth theory (Romer, 1986; Grossman and Helpman, 1991; Aghion and

Howitt, 1992) does attempt to incorporate some measures of technological innovation; however, it also provides some limitations on the ways the technology is represented (Dosi, Freeman and Fabiani, 1994, pp. 3-4). Furthermore, since innovative activity and technological progress have a positive effect on productivity growth, it means that Schumpeterian growth hypothesis which predicts that productivity growth is driven by the levels of research intensity in the economy, in fact, holds (Rajabrata, 2011, p. 16). Following endogenous technological approach some second-generation Schumpeterian growth models were developed (Aghion and Howitt, 1998; Howitt, 1999; Peretto and Smulders, 2002; Ha and Howitt, 2007).

As we already pointed out, technological improvement is an economic phenomenon which is hard to observe, measure and quantify. Process of linking technological progress and economic growth triggered research patterns into independent modelling of these variables which are then intertwined in profound composite indicators. These composite indicators can be classified in three categories: (1) those used for measuring an aspect individually (analyzing own component factors), (2) analyzing two related aspects linked using components of both variables and (3) indicators created to analyze development with the inclusion of other components (such as technological innovations, socio-economic status etc.). The use of composite indicators in general provides a mechanism for modelling nation's development in some relevant features such as composite technological innovation (Shanmuganathan, 2008, p. 2708). However, even these composite indicators are surrounded with controversies giving the fact that indicator weights could be manipulated. We can conclude that empirical irregularities could obstruct theoretical setting of a research. This is the reason why many economists rely on theoretically inclined macroeconomic modelling.

Advances in computer and information (plus communication) technology often referred as ICT sector is regularly labelled as 'third industrial revolution'. Though there is no compelling evidence that these technological improvements constitute the next industrial revolution, its full potential is being revealed and materialised in the lower prices of information technology, reduction in the cost of capital, rapid productivity growth and significant improvement in organisational techniques[†]. From new innovations like software, robotics, biotechnology and nanotechnology to improvements in manufacturing systems and processes, technology makes economies and societies more efficient and productive. Getting back to *Solow's paradox* – we see computers everywhere but in productivity statistics – it is quite the obvious why many economists were sceptical about the productivity reach of the computer and information technologies. Most of the scepticism rose mainly from inadequate method in measuring technological contributions. Another problem is that most of the aggregate research on computer and information technology vs. economic performance use categories such as 'computer using' and 'computer producing' industries. A limitation of such research evolves from the fact that they do not specify the exact mechanism through which investment in computer and information technology affects productivity and growth. Perhaps the most important insight from these micro studies is that investments in technology do not have a large 'direct' effect on productivity. Their impact is indirect and is mostly related to change in other aspects of the productive process. Investment in information technology plays the role of a

[†] There are also negative effects: irrational exuberance and accumulation of intangible assets, widening wage inequality (capital-skill complementarities vs. skill biased technological change).

facilitator that allows other innovations to take place (Edwards, 2001, pp. 3-4). Again, this also explains why our study converges to more economy-wide implications i.e. to macroeconomic approach. Ultimately, computer and information technology was an important element of growth dynamics of the most of the developed countries in last few decades. Furthermore, computer derived technology became also an important element in explaining cross-country income differences. Considering that innovation is the fundamental force underlying long-run GDP growth, Ježić (2012), Pivčević and Garbin Praničević (2012), Aralica and Botrić (2013), Bildirici and Kayikci (2012) we can conclude that it can also explain why some countries have been so much more productive than the others (Tomić, 2012, p. 1293). Next section will provide us some insight into the reason why developed countries are developed and why many other countries are only participants in the ‘catching-up’ process.

The paper is organized as follows. Section 2, after the introduction, discusses the theoretical background and reviews the literature. Section 3 reviews used methodology and data. Section 4 evaluates empirical results on the growth and welfare effects of technological shocks. Section 5 provides some concluding remarks.

1. Data and methodological framework

To test effects of technological progress on growth and productivity of selected countries we have applied methodology used by Falatoon and Safarzadeh (2006). Their approach is based on Neo-Classical growth models of Solow (1956) and Swan (1956) who assume that real GDP per unit of labour is a function of capital per unit of labour and technology:

$$Y / N = f(A, K / N) \quad (1)$$

where Y is real GDP, N is labour unit, K is capital input, and A is technological development. Since growth theory assumes that in equilibrium real GDP of unit of labour grows at the rate of technological growth, it means that with technological innovation of A , at the so-called steady-state, real GDP will grow at the rate of innovation growth (\dot{A}). If we consider technological innovations as supply shocks which have a permanent effect on the trend of GDP, a decomposition of such variable on its permanent and irregular components could reveal impact of technological development on the growth rate of real GDP between two ‘path breaking’ innovations. As to ensure appropriate decomposition of the deviations of the real GDP growth from its long-run growth into its deviations due to demand shocks and technological development within time, Falatoon and Safarzadeh based their modelling on the equation:

$$\dot{Y}_t = \dot{A}_t + \dot{N}_t \quad (2)$$

so that the trait represents the rate of change of the respective variable. If \dot{Y}_t^* and \dot{N}_t^* represent potential values, equation (2) can be reformulated to interpret both, deviation of real GDP growth from its long run and growth rate of potential real GDP per unit of growth for effective labour so we get:

$$\begin{aligned} (\dot{Y}_t^* - \dot{Y}_t) &= \alpha \left[\dot{Y}_t^* - (\dot{A}_t + \dot{N}_t^*) \right] \\ (\dot{N}_t^* - \dot{N}_t) &= (1 - \alpha) \left[\dot{Y}_t^* - (\dot{A}_t + \dot{N}_t^*) \right] \end{aligned} \quad (3)$$

Equations (1) and (2) should be interpreted as follows; an increase in the growth rate of technological improvement depending on the value of α will accelerate the rate of real GDP while positively impacting on the rate of growth of real output, but with the time passing by, the excess output gap will become smaller so the result of the technology shock will eventually fade away, pushing the rate of growth to its long-rung potential (Falatoon and Safarzadeh, 2006, pp. 242-44)

Before proceeding with the ARIMA modelling, series were tested for possible long memory presence as in Škare and Stjepanović (2013). A battery of non-parametric Robinson and Lobato (1998), Lo (1991), modified R/S, Giraitis et al. (2003) V/S test, semi-parametric Geweke and Porter-Hudak (1983), Moulines and Soulier (1999), Robinson (1995a, 1995b) tests were used to test series integration. Also a parametric ARFIMA(p,d,q) model is used to test for the presence of fractional integration in the series. Test results (not displayed here) for all used battery of tests (non-parametric, semi-parametric and parametric) show that the innovation – growth model for selected OECD economies can be modeled as ARIMA(p,d,q).

In order to evaluate the permanent trend in the growth and productivity variables we have to extract conditional expectation of the limiting value of the forecast function derived from ARIMA models, similar to the above mentioned authors. An ARIMA model is appropriate for this kind of study since it predicts a value in response time series as a linear combination of its own past values, past errors (shock or innovations) and current and past values of other time series. Besides, ARIMA procedure provides a comprehensive set of tools for univariate time series model identification, parameter estimation and forecasting, and in that way it offers high flexibility. To identify appropriate ARIMA models we have to recognize its elements p , d and q . Lags of the differenced series in the forecasting equation are called auto-regressive terms (p), lags of the forecast errors are called moving average terms (q), and a time series which needs to be differenced to be made stationary is said to be an integrated version (d) of a stationary series. Based on those elements we can estimate proper ARIMA model. ARIMA models are a useful tool for relatively short term study. Their flexibility and adaptive behaviour contribute to their good short-term forecasting. In the literature on trend/cycle decomposition, Beveridge and Nelson (BN) method was recognized as a model based method for decomposing a univariate or multivariate time series into permanent and transitory components. Beveridge and Nelson (1981) showed how to decompose ARIMA (p,I,q) i.e. proposed a definition of the permanent component of an $I(1)$ time series y_t with drift μ as the limiting forecast as horizon goes to infinity, adjusted for the mean rate of growth over the forecast horizon,

$$TD_t + BN_t = \lim_{h \rightarrow \infty} y_{t+h|t} - \delta h \tag{4}$$

where TD_t represents deterministic trend. The stochastic part of the permanent component (7), BN_t is referred as the BN trend. The implied cycle (C) at the time t is then

$$C_t = y_t - TD_t - BN_t \tag{5}$$

so Beveridge and Nelson suggested that if Δy_t has Wold representation $\Delta y_t = \delta + \psi^*(L)\varepsilon_t$ then BN_t follows a pure random walk without drift (Morley et al., 2003):

$$BN_t = BN_{t-1} + \psi^*(1)\varepsilon_t \tag{6}$$

To conclude, the long-horizon conditional forecast used to calculate the BN trend corresponds to an estimate of the permanent component of an integrated time series. This forecast will be different at each period as additional information becomes available.

Data on growth and productivity variables (real GDP, real GDPpc, real labour productivity (LP) per person and per hour) for 25 OECD countries were collected from the Conference Board *Total Economy Database* for the period 1950-2013. Variables are converted to 2013 price level with 2005 EKS PPPs in order to obtain real category. Data span is chosen based on the assumption that commercial usage of computer and subsequent technologies started immediately after the II World War. Country selection was based on the fact that these countries have grown over the past century probably faster than during any previous time in history. But also, Japan and USA have been exchanging on the first and second place of the annual list of countries with most inventions for a long time, only Germany and lately South Korea obstructing that order sometimes. Hence, the importance of computer and information improvements has been an important part of their growth and development. Likewise, Falatoon and Safarzadeh (2006), we also divided the sample periods into sub-periods based on the major technological improvements in computer and subsequent industries over the last 60 years, with classification being selected by the *rule-of-thumb*. In order to evaluate trend perspective, we estimated growth rates for all the variables and all sub-periods. To estimate adequate ARIMA models we performed logarithmic transformation on the variables and tested the presence of a unit root. For this purpose we used Augmented Dickey Fuller test (1979), Phillips-Perron test (1988) and Kwiatkowski-Phillips-Schmidt-Shin test (1992). Generally (though with some exceptions), all tests confirmed the presence of unit root for all the variables and all the countries in a whole and its sub-periods. Graphical displays of the observed variables also suggest that they are not stationary in levels. In conclusion, variables reveal a non-stationary behaviour. This means that we have to apply an appropriate degree of integration before we run ARIMA models.

When we know all the characteristics of our variables, we can estimate ARIMA models for all the countries. Due to several facts (small sample, loss of degrees of freedom, similar results in the entire period and when divided into sub-periods), ARIMA models were estimated for the whole period and then divided into its sub-periods (as growth rates). The model selection was based on Schwartz Bayesian Criterion being the most restrictive one. In recent years, the efficiency and reliability of automatic identification procedures, based mostly on information criteria, has strongly decreased the importance of so-called tentative identification. For each model, we checked for serial correlation in residuals. For most of the countries Autoregressive Conditional Heteroscedasticity (ARCH) tests indicated no problem of autocorrelation and there were no problems of normality in residuals. Since all the variables had to be differenced in order to obtain stationarity, and we wanted to gain some flexibility in moving average terms so we can filter out the noise and more accurately estimate local mean, ARIMA (1,1,1) models were estimated for most of the countries. To correct possible deviations, different ARIMA processes of orders p and q were introduced as well[‡]. Dummy variables were introduced in order to correct possible parameter

[‡] For example, if the errors of the random walk model are autocorrelated, the problem can be fixed by adding one lag of the dependent variable to the prediction equation. Then we get a first order autoregressive AR(1) model with one order of nonseasonal differencing and a constant term i.e. ARIMA (1,1,0) model with constant. Another strategy for correcting autocorrelated errors in a random walk model is suggested by the simple exponential smoothing model, so we get ARIMA

problems. The permanent trend in the variable (as a measure of economic prosperity result of technological development) was presented as the conditional expectation of the limiting value of the forecast function derived from the obtained ARIMA models. For each sub-period growth rates were calculated so that the economic prosperity impact of innovation could be measured as a geometric mean of the permanent trend component of the decomposed series for that sub-period. Display of the results by the country can be found in the Appendix (see table 1)[§].

2. The importance of computer and information technology: empirical evaluation

Invention leads to innovation leading in turn to further invention with a solution to more and more complex problems. This is probably the best way to describe the manner in which computer and information technology helped in the creation of economic prosperity and well-being, especially in developed nations. Computer and subsequent technologies improved technical innovation potential, as the capacity to develop and advance further. Following the latest edition of the Global Creativity Index (GCI) that addresses the challenges of future development, by shifting the dialogue from a narrow focus on competitiveness and growth to a broader focus on creativity and prosperity, we found OECD countries highly rated. On the Global Technology Map (CGI, 2011, p. 6) Japan takes second place, ranking fourth in R&D investment, third in researchers, and second in innovation. Japanese companies have not only consistently pushed the technology envelope; they have followed through, building reliable, subsequent generations of products, from high quality cars to flat panel displays. The United States ranks third, finishing sixth in R&D investment and seventh in researchers, but solidly in the first place for innovation. With its infrastructure for entrepreneurial venture capital finance in Silicon Valley and elsewhere, the United States has seen a long list of high-tech start-ups turn into global giants, including Microsoft, Apple, Google and Yahoo. Again, we have to acknowledge that Japan and USA have been exchanging on the first and second place of the annual list of countries with most inventions for a long time, with Germany being always in the top behind these two economic giants. On CGI tables for 2011, Germany holds 9th place in technology index, 8th in R&D investment and 7th in innovation. In all three categories South Korea, Sweden, Finland, Denmark, Norway, Switzerland, Canada and New Zealand hold respective places.

OECD countries have grown over the past half century (except during the First and Second Industrial Revolution) probably faster than in the other historic times. Our results strongly confirm such statement. The average growth rate of real output has been fairly similar across countries, albeit we find some differences. Maximum value corresponds to Japan and South Korea, whereas the minimum value corresponds to the Netherlands and Belgium. During the observed period, inclined by the commercial usage of computer and subsequent businesses, average GDP growth was well over 3,0% and average GDPpc growth above 2%. After the II World War, Japan had an incredible growth path (in average GDP growth 4.80%, GDPpc growth 4,06%) whereat Computer and information related

(0,1,1) with/or without a constant. In practice, parsimony (i.e. few parameters) should be a crucial property of ARIMA models. In such manner our estimations were limited to maximum AR(2) or MA(2) modelling.

[§] For detailed insight into data analysis, tests and results please contact the author.

industries contributed the most to the positive co-movements of other economic indicators (aggregate income effect, investment, research and development, employment etc.). Therefore, Japan had benefited the most from these businesses. Interestingly, Computer and subsequent industries had a stronger long-term impact effect on the European economies, than on, for example, the USA economy (Tomić, 2011, p. 1296). However, if we want to assess the total impact of that business, beside macroeconomic indicators we would need to observe the correlation between the profit rates, wage rates, levels of labour productivity etc., i.e. correlation between some microeconomic indicators, either cross-sectionally or over time. So we also evaluated the effects of the increase in the labour productivity over the observed period (which was followed by the fall in hours engaged in the production process). Labour productivity increase per person and per hour was ranging from 1.68% to 1.87% in the USA, from 3.80% to 4.11% in Japan and from 2.61% to 3.54% in Germany. Australia, New Zealand, Canada, Switzerland and Netherland had the lowest increase in the labour productivity, while Japan, Korea and Ireland show the best performance, with an average productivity growth exceeding 4.00%. We cannot ignore the fact that there has been a slowdown in growth and productivity since 1970s due to a decrease in the rate of technological development. The proximate reason for the decline in the rate of technological development can be found in a decline in fertility of R&D and limited reach of technological improvements in the service sector (Blanchard, 2003).

Our econometric results suggest that the technological development of main innovation industries was the highest contributing part of the long-run growth of GDP and GDPpc, as well of labour productivity in the observed period. We have to be very careful in interpretations since the results do not represent contribution factor, but rather an approximation of the aggregate growth in the observed variables which came of general technological improvements. Historical evidence suggests robust correlation between the capabilities of innovating and export shares, per capita income and rates of growth. Hence, data suggest that sources of economic growth have changed in the 20th century, increasing even more the importance of technological and organizational improvement compared to the accumulation of so-called tangible assets (Dosi, Freeman and Fabiani, 1994, p. 22). In the 19th, business with the highest absolute and relative contribution to the output growth of selected countries was a Railroad industry; however, Oil industry also showed a remarkable influence on GDP and GDPpc growth in that period (Tomić, 2011, pp. 1296-7).

The business that gave the highest relative contribution to the average output growth in the 20th century was the Computer industry with an average GDP growth rate of 3.51%, average GDPpc growth of 2.09%, LP per person growth of 2.15% and LP per hour of 2.45% for the USA (estimated by technological improvements), meaning that technological growth of that industry was, in fact, entirely integrated in an improved standard of living. This was even more so true for Germany (average GDP growth rate of 5.62%, average GDPpc growth of 4.99%, LP per person growth of 4.52% and LP per hour of 5.55%) and especially Japan (average GDP growth rate of 8.62%, average GDPpc growth of 7.54%, LP per person growth of 6.95% and LP per hour of 6.64%). The trend is similar in other OECD countries. Subsequent industries, closely related to the Computer Industry, likewise showed a significant impact. This is especially true for South Korea, which witnessed strongest technologically boosted growth in the second period (Silicon Chips industry) from 1970s till mid 1980s (average GDP growth rate of 6,82%, average GDPpc growth of 5.42%, LP per person growth of 4.46% and LP per hour of 4.83%). South Korea successfully transformed its economy from low income to middle income level, and its

production structure entails substantial technological sophistication. If we look at the USA (Silicon Valley) Finland and Ireland (average GDP growth rate of 3.72%, average GDPpc growth of 2.93%, LP per person growth of 3.14% and LP per hour of 3.77%) we can see what immense influence the development of ICT had on economic growth of those countries. Strong ICT sector involves young, healthy and dynamic companies, increase of employment, presence of entrepreneurial talents and technological expertise, export expansion etc., everything that is of high importance for contemporary, but also for a future development. In the creation of Silicon Valley were included many planned ICT communities, clusters and hi-tech parks, whereas some stages of development was government sponsored. Finnish ICT equipment industry cluster was the cornerstone of ICT manufacturing in Finland and ICT clusters drove the industry of Ireland during the 1990s. But, once more we can notice the slowdown in growth and productivity across all countries in the second and third period, meaning that the rise of the service sector (ICT industries) lead to a fall in contribution of technological improvement. Nevertheless, growth rates remained relatively high. To summarize the effects of technological improvements: for most of the countries more than 80% of real output and productivity can be explained by technological progress.

We can conclude that technological development by all main contributing (computer and following) industries assured permanent welfare effect that generated political, social, cultural and economic power of those countries worldwide. As such, technological development has a universal character which constitutes long-term fundament for economic development and growth (see table 1 in the appendix).

Conclusions

Before going on to the conclusion, let's review the importance of macroeconomic modelling of economic growth by citing Robert. M. Solow (1957, p. 312): *'In this day of rationally designed econometric studies and super-input-output tables, it takes something more than the usual 'willing suspension of disbelief' to talk seriously of the aggregate production function. But the aggregate production function is only a little less legitimate concept than, say, the aggregate consumption function, and for some kinds of long-run macro-models it is almost indispensable as the latter is for the short-run. As long as we insist on practicing macro-economics we shall need aggregate relationships.* Our study is not a 'fancy econometric work' but a simple endeavour pointed towards clarification of some growth related questions.

Indicators that show the connection between technological progress and economic growth can easily be manipulated and misinterpreted by economists who want to confirm their theories of hypothesis. This paper implemented widely used Solow's model in order to assess the growth effect theory of technological innovations in computer and subsequent industries. We have to accentuate that our study was not focused on confirming the hypothesis of Schumpeterian growth models or hypothesis of global convergence of income but on appreciation of the dynamics of technological change and its impact on the contingency of growth and development patterns of developed countries. Therein, we showed that the technological development in the observed period was, in fact, entirely incorporated in the improved living standard of selected countries, having in such manner vast welfare effect which determined future growth.

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Appendix

Table no. 1: Estimated ARIMA(p,d,q) models impact of innovation on growth

Periods	Industry ¹⁾	1	2	3	4	5	6	7	8
USA									
1950 - 1972	Computer	3.86	2.35	2.30	2.56	3.51	2.09	2.15	2.45
1973 - 1989	Silicon Chips	3.19	2.19	1.11	1.32	3.20	2.23	1.14	1.33
1990 - 2013	Information	2.46	1.41	1.63	1.72	2.45	1.49	1.64	1.70
Average		3.17	1.98	1.68	1.87	3.06	1.93	1.64	1.83
ARIMA estimations²⁾									
lnGDP ARIMA (1,1,2)	const	0.03***	phi 1	-0.80***	theta 1	0.97***	theta 2	0.23*	
	ARCH (1)	p = 0.91		Normality		p = 0.81			
lnGDPpc ARIMA (1,1,2)	const	0.02***	phi 1	0.89***	theta 1	-0.84***	theta 2	-0.16	
	ARCH (1)	p = 0.22		Normality		p = 0.49			
lnLP_person ARIMA (1,1,1)	const	0.02***	phi 1	0.82***	theta 1	-0.72***	/	/	
	ARCH (1)	p = 0.53		Normality		p = 0.32			
lnLP_hour ARIMA (1,1,1)	const	0.02***	phi 1	0.90***	theta 1	-0.75***	/	/	
	ARCH (1)	p = 0.13		Normality		p = 0.40			
JAPAN									
1950 - 1972	Computer	9.35	8.14	7.53	7.31	8.62	7.54	6.95	6.64
1973 - 1989	Silicon Chips	3.91	3.07	2.87	3.31	3.82	3.00	2.93	3.41
1990 - 2013	Information	1.13	0.99	1.01	1.71	1.05	0.92	0.96	1.69
Average		4.80	4.06	3.80	4.11	4.50	3.82	3.61	3.91
ARIMA estimations²⁾									
lnGDP ARIMA (1,1,1)	const	0.05**	phi 1	0.95***	theta 1	-0.55***	/	/	
	ARCH (1)	p = 0.66		Normality		p = 0.00			
lnGDPpc ARIMA (1,1,1)	const	0.04**	phi 1	0.94***	theta 1	-0.53***	/	/	
	ARCH (1)	p = 0.61		Normality		p = 0.00			
lnLP_person ARIMA (1,1,1)	const	0.04**	phi 1	0.93***	theta 1	-0.52***	/	/	
	ARCH (1)	p = 0.61		Normality		p = 0.00			

Periods	Industry ¹⁾	1	2	3	4	5	6	7	8
lnLP_hour ARIMA (1,1,1)	const	0.04***		phi 1	0.89***	theta 1	-0.29*	/	/
	<i>ARCH (1)</i>		$p = 0.06$			<i>Normality</i>		$p = 0.01$	
	GERMANY								
1950 - 1972	Computer	6.04	5.36	4.79	5.92	5.62	4.99	4.52	5.55
1973 - 1989	Silicon Chips	2.16	2.18	1.97	3.03	2.04	2.09	1.91	2.93
1990 - 2013	Information	1.53	1.37	1.08	1.67	1.58	1.41	1.07	1.70
Average		3.24	2.97	2.61	3.54	3.08	2.83	2.50	3.40
ARIMA estimations ²⁾									
lnGDP ARIMA (1,1,1)	const	0.04*		phi 1	0.98***	theta 1	-0.74***	/	/
	<i>ARCH (1)</i>		$p = 0.32$			<i>Normality</i>		$p = 0.26$	
	lnGDPpc ARIMA (1,1,1)	const	0.04***		phi 1	0.98***	theta 1	-0.76***	/
<i>ARCH (1)</i>		$p = 0.31$			<i>Normality</i>		$p = 0.42$		
lnLP_person ARIMA (1,1,1)		const	0.03		phi 1	0.98***	theta 1	-0.74***	D '09 ³⁾
	<i>ARCH (1)</i>		$p = 0.96$			<i>Normality</i>		$p = 0.06$	
	lnLP_hour ARIMA (1,1,1)	const	0.04		phi 1	0.99***	theta 1	-0.67***	/
<i>ARCH (1)</i>		$p = 0.54$			<i>Normality</i>		$p = 0.23$		
AUSTRALIA									
1950 - 1972	Computer	5.00	2.89	2.48	3.15	4.81	2.74	2.40	3.06
1973 - 1989	Silicon Chips	3.36	1.94	1.45	1.56	3.17	1.79	1.47	1.64
1990 - 2013	Information	3.25	2.02	1.49	1.68	3.26	2.03	1.43	1.58
Average		3.87	2.28	1.81	2.13	3.75	2.19	1.77	2.09
ARIMA estimations ²⁾									
lnGDP ARIMA (1,1,1)	const	0.04***		phi 1	-0.47**	theta 1	0.79***	/	/
	<i>ARCH (1)</i>		$p = 0.02$			<i>Normality</i>		$p = 0.62$	
	lnGDPpc ARIMA (1,1,1)	const	0.02***		phi 1	-0.55***	theta 1	0.82***	/
<i>ARCH (1)</i>		$p = 0.72$			<i>Normality</i>		$p = 0.32$		
lnLP_person ARIMA (1,1,1)		const	0.02***		phi 1	-0.40	theta 1	0.55**	/
	<i>ARCH (1)</i>		$p = 0.53$			<i>Normality</i>		$p = 0.32$	
	lnLP_hour ARIMA (2,1,2)	const	0.02***		phi 1	-1.23***	phi 2	-0.99***	theta 1
theta 2		0.99***	/	/	/	/	/	/	/
<i>ARCH (1)</i>		$p = 0.44$			<i>Normality</i>		$p = 0.86$		
AUSTRIA									
1950 - 1972	Computer	4.65	4.15	4.89	5.45	4.18	3.80	4.60	5.09
1973 - 1989	Silicon Chips	2.56	2.49	1.88	2.60	2.59	2.43	1.75	2.48
1990 - 2013	Information	2.11	1.79	1.28	1.97	2.18	1.86	1.32	2.00
Average		3.10	2.81	2.68	3.34	2.98	2.70	2.56	3.19
ARIMA estimations ²⁾									
lnGDP ARIMA (0,1,1)	const	0.03***	/	/	/	theta 1	0.35***	/	/
	<i>ARCH (1)</i>		$p = 0.70$			<i>Normality</i>		$p = 0.06$	
	lnGDPpc ARIMA (1,1,1)	const	0.03***		phi 1	0.96***	theta 1	-0.83***	/
<i>ARCH (1)</i>		$p = 0.40$			<i>Normality</i>		$p = 0.04$		
lnLP_person ARIMA (1,1,1)		const	0.02**		phi 1	0.94***	theta 1	-0.65***	/
	<i>ARCH (1)</i>		$p = 0.84$			<i>Normality</i>		$p = 0.23$	
	lnLP_hour ARIMA (1,1,1)	const	0.03***		phi 1	0.94***	theta 1	-0.66***	/
<i>ARCH (1)</i>		$p = 0.33$			<i>Normality</i>		$p = 0.37$		
BELGIUM									
1950 - 1972	Computer	4.00	3.49	3.52	4.52	3.68	3.20	3.24	4.15
1973 - 1989	Silicon Chips	2.37	2.23	2.26	2.94	2.33	2.22	2.30	2.98
1990 - 2013	Information	1.70	1.49	0.94	1.13	1.76	1.54	0.94	1.11
Average		2.69	2.40	2.24	2.86	2.59	2.32	2.16	2.75
ARIMA estimations ²⁾									
lnGDP ARIMA (1,1,1)	const	0.02***		phi 1	0.87***	theta 1	-0.66***	/	/
	<i>ARCH (1)</i>		$p = 0.92$			<i>Normality</i>		$p = 0.10$	

Periods	Industry ¹⁾	1	2	3	4	5	6	7	8
lnGDPpc ARIMA (1,1,1)	const	0.02***		phi 1	0.86***	theta 1	-0.67***	/	/
	ARCH (1)				$p = 0.92$		Normality		$p = 0.15$
lnLP_person ARIMA (1,1,1)	const	0.02*		phi 1	0.96***	theta 1	-0.75***	/	/
	ARCH (1)				$p = 0.04$		Normality		$p = 0.85$
lnLP_hour ARIMA (1,1,1)	const	0.02*		phi 1	0.95***	theta 1	-0.64***	/	/
	ARCH (1)				$p = 0.97$		Normality		$p = 0.47$
CANADA									
1950 - 1972	Computer	4.69	2.83	2.11	2.68	4.47	2.51	2.00	2.55
1973 - 1989	Silicon Chips	3.50	2.26	0.84	1.17	3.55	2.37	0.91	1.23
1990 - 2013	Information	2.24	1.25	0.92	1.13	2.17	1.17	0.90	1.11
Average		3.48	2.11	1.29	1.66	3.40	2.02	1.27	1.63
ARIMA estimations ²⁾									
lnGDP ARIMA (1,1,0)	const	0.03***		phi 1	0.40***	/	/	/	/
	ARCH (1)				$p = 0.96$		Normality		$p = 0.07$
lnGDPpc ARIMA (1,1,0)	const	0.02***		phi 1	0.38***	theta 1	-0.83***	/	/
	ARCH (1)				$p = 0.96$		Normality		$p = 0.09$
lnLP_person ARIMA (0,1,1)	const	0.01**		/	/	theta 1	0.39***	/	/
	ARCH (1)				$p = 0.10$		Normality		$p = 0.69$
lnLP_hour ARIMA (1,1,0)	const	0.01***		phi 1	0.40***	/	/	/	/
	ARCH (1)				$p = 0.28$		Normality		$p = 0.15$
DENMARK									
1950 - 1972	Computer	4.26	3.59	2.88	3.89	3.89	3.27	2.67	3.48
1973 - 1989	Silicon Chips	1.94	1.78	1.56	2.50	2.10	1.94	1.63	2.64
1990 - 2013	Information	1.43	1.10	1.27	1.57	1.32	0.99	1.21	1.50
Average		2.55	2.15	1.90	2.65	2.44	2.07	1.84	2.54
ARIMA estimations ²⁾									
lnGDP ARIMA (1,1,1)	const	0.03**		phi 1	0.96***	theta 1	-0.81***	/	/
	ARCH (1)				$p = 0.55$		Normality		$p = 0.08$
lnGDPpc ARIMA (1,1,1)	const	0.02**		phi 1	0.96***	theta 1	-0.84***	/	/
	ARCH (1)				$p = 0.64$		Normality		$p = 0.07$
lnLP_person ARIMA (1,1,1)	const	0.02***		phi 1	0.96***	theta 1	-0.87***	/	/
	ARCH (1)				$p = 0.03$		Normality		$p = 0.20$
lnLP_hour ARIMA (1,1,1)	const	0.03***		phi 1	0.97***	theta 1	-0.85***	/	/
	ARCH (1)				$p = 0.95$		Normality		$p = 0.17$
FINLAND									
1950 - 1972	Computer	4.57	4.08	4.31	4.71	3.94	3.50	3.87	4.22
1973 - 1989	Silicon Chips	3.29	2.89	2.77	3.19	3.35	2.94	2.77	3.17
1990 - 2013	Information	1.67	1.42	1.63	1.97	1.64	1.38	1.65	1.98
Average		3.18	2.79	2.90	3.29	2.97	2.61	2.77	3.12
ARIMA estimations ²⁾									
lnGDP ARIMA (0,1,1)	const	0.03***	/	/	/	theta 1	0.75***	D '09 ³⁾	-0.05***
	ARCH (1)						Normality		$p = 0.11$
lnGDPpc ARIMA (0,1,1)	const	0.03***	/	/	/	theta 1	0.76***	D '09 ³⁾	-0.05***
	ARCH (1)						Normality		$p = 0.04$
lnLP_person ARIMA (1,1,1)	const	0.03***		phi 1	0.90***	theta 1	-0.67**	D '09 ³⁾	-0.05***
	ARCH (1)				$p = 0.18$		Normality		$p = 0.01$
lnLP_hour ARIMA (1,1,1)	const	0.03***		phi 1	0.91***	theta 1	-0.71***	/	/
	ARCH (1)				$p = 0.14$		Normality		$p = 0.00$
FRANCE									
1950 - 1972	Computer	5.03	3.99	4.56	5.26	4.78	3.82	4.36	4.94
1973 - 1989	Silicon Chips	2.58	2.04	2.11	3.03	2.43	1.93	2.05	2.99
1990 - 2013	Information	1.48	0.94	0.92	1.38	1.54	0.98	0.92	1.41
Average		3.03	2.32	2.53	3.22	2.92	2.25	2.44	3.11

Periods	Industry ¹⁾	1	2	3	4	5	6	7	8
ARIMA estimations²⁾									
lnGDP ARIMA (1,1,1)	const	0.03**	phi 1	0.95***	theta 1	-0.66***	/	/	/
	<i>ARCH (1)</i>		$p = 0.46$		<i>Normality</i>		$p = 0.08$		
lnGDPpc ARIMA (1,1,1)	const	0.02**	phi 1	0.96***	theta 1	-0.72***	/	/	/
	<i>ARCH (1)</i>		$p = 0.54$		<i>Normality</i>		$p = 0.06$		
lnLP_person ARIMA (1,1,1)	const	0.02*	phi 1	0.97***	theta 1	-0.66***	/	/	/
	<i>ARCH (1)</i>		$p = 0.05$		<i>Normality</i>		$p = 0.06$		
lnLP_hour ARIMA (1,1,1)	const	0.03**	phi 1	0.97***	theta 1	-0.70***	/	/	/
	<i>ARCH (1)</i>		$p = 0.87$		<i>Normality</i>		$p = 0.36$		
GREECE									
1950 - 1972	Computer	6.73	6.10	7.04	7.46	5.92	5.36	6.21	6.57
1973 - 1989	Silicon Chips	2.58	1.85	1.68	2.40	2.78	2.09	1.85	2.71
1990 - 2013	Information	1.05	0.75	1.07	1.24	0.93	0.62	1.15	1.20
Average		3.45	2.90	3.26	3.70	3.21	2.69	3.07	3.49
ARIMA estimations²⁾									
lnGDP ARIMA (1,1,0)	const	0.03**	phi 1	0.76***	/	/	D '74 ³⁾	-0.04***	/
	<i>ARCH (1)</i>		$p = 0.13$		<i>Normality</i>		$p = 0.50$		
lnGDPpc ARIMA (1,1,0)	const	0.02*	phi 1	0.75***	/	/	D '74 ³⁾	-0.04***	/
	<i>ARCH (1)</i>		$p = 0.22$		<i>Normality</i>		$p = 0.48$		
lnLP_person ARIMA (1,1,0)	const	0.03***	phi 1	0.63***	/	/	D '74 ³⁾	-0.05***	/
	<i>ARCH (1)</i>		$p = 0.51$		<i>Normality</i>		$p = 0.96$		
lnLP_hour ARIMA (1,1,0)	const	0.03***	phi 1	0.60***	/	/	D '74 ³⁾	-0.04***	/
	<i>ARCH (1)</i>		$p = 0.51$		<i>Normality</i>		$p = 0.75$		
ICELAND									
1950 - 1972	Computer	4.70	3.11	3.04	3.96	4.29	2.85	2.77	3.47
1973 - 1989	Silicon Chips	4.14	2.99	1.95	2.66	3.89	2.72	1.92	2.67
1990 - 2013	Information	2.26	1.32	1.30	1.68	2.19	1.30	1.33	1.78
Average		3.70	2.47	2.10	2.77	3.45	2.29	2.01	2.64
ARIMA estimations²⁾									
lnGDP ARIMA (2,1,1)	const	0.04***	phi 1	0.98***	phi 2	-0.40**	theta 1	-0.46	/
	<i>ARCH (1)</i>		$p = 0.75$		<i>Normality</i>		$p = 0.44$		
lnGDPpc ARIMA (2,1,1)	const	0.02***	phi 1	1.01***	phi 2	-0.44***	theta 1	-0.52	/
	<i>ARCH (1)</i>		$p = 0.82$		<i>Normality</i>		$p = 0.20$		
lnLP_person ARIMA (2,1,1)	const	0.02***	phi 1	0.96***	phi 2	-0.28**	theta 1	-0.69*	/
	<i>ARCH (1)</i>		$p = 0.82$		<i>Normality</i>		$p = 0.91$		
lnLP_hour ARIMA (2,1,2)	const	0.03***	phi 1	-0.69***	phi 2	-0.67***	theta 1	1.04***	/
	theta 2	1.00***	/	/	/	/	/	/	/
	<i>ARCH (1)</i>		$p = 0.51$		<i>Normality</i>		$p = 0.97$		
IRELAND									
1950 - 1972	Computer	3.47	3.21	3.88	4.35	2.96	2.80	3.33	3.75
1973 - 1989	Silicon Chips	3.84	2.93	3.50	4.08	3.80	2.84	3.53	4.13
1990 - 2013	Information	4.57	3.24	2.46	3.37	4.40	3.14	2.56	3.42
Average		3.96	3.13	3.28	3.93	3.72	2.93	3.14	3.77
ARIMA estimations²⁾									
lnGDP ARIMA (1,1,0)	const	0.04***	phi 1	0.61***	/	/	/	/	/
	<i>ARCH (1)</i>		$p = 0.06$		<i>Normality</i>		$p = 0.40$		
lnGDPpc ARIMA (1,1,0)	const	0.03***	phi 1	0.62***	/	/	/	/	/
	<i>ARCH (1)</i>		$p = 0.08$		<i>Normality</i>		$p = 0.49$		
lnLP_person ARIMA (1,1,1)	const	0.03***	phi 1	-0.56*	theta 1	0.77***	/	/	/
	<i>ARCH (1)</i>		$p = 0.01$		<i>Normality</i>		$p = 0.80$		
lnLP_hour ARIMA (1,1,1)	const	0.04***	phi 1	-0.80***	theta 1	0.98***	/	/	/
	<i>ARCH (1)</i>		$p = 0.81$		<i>Normality</i>		$p = 0.44$		

Periods	Industry ¹⁾	1	2	3	4	5	6	7	8
ITALY									
1950 - 1972	Computer	3.47	4.37	5.27	5.80	2.96	4.20	4.99	5.47
1973 - 1989	Silicon Chips	3.84	2.76	2.33	2.64	3.80	2.60	2.25	2.47
1990 - 2013	Information	4.57	0.45	0.39	0.68	4.40	0.44	0.34	0.70
Average		3.96	2.53	2.67	3.04	3.72	2.41	2.53	2.88
ARIMA estimations ²⁾									
lnGDP ARIMA (1,1,0)	const	0.04***	phi 1	0.61***	/	/	/	/	/
	ARCH (1)			$p = 0.06$	Normality		$p = 0.40$		
lnGDPpc ARIMA (1,1,1)	const	0.02	phi 1	0.98***	theta 1	-0.77***	/	/	/
	ARCH (1)			$p = 0.42$	Normality		$p = 0.05$		
lnLP_person ARIMA (1,1,1)	const	0.03	phi 1	0.97***	theta 1	-0.70***	/	/	/
	ARCH (1)			$p = 0.21$	Normality		$p = 0.29$		
lnLP_hour ARIMA (1,1,1)	const	0.03	phi 1	0.97***	theta 1	-0.68***	/	/	/
	ARCH (1)			$p = 0.56$	Normality		$p = 0.15$		
SOUTH KOREA									
1950 - 1972	Computer	7.96	5.49	4.95	4.49	7.18	4.94	4.64	4.13
1973 - 1989	Silicon Chips	8.72	7.21	5.42	5.81	8.31	6.91	5.22	5.50
1990 - 2013	Information	5.21	4.58	3.65	4.88	4.97	4.41	3.52	4.87
Average		7.30	5.76	4.67	5.06	6.82	5.42	4.46	4.83
ARIMA estimations ²⁾									
lnGDP ARIMA (1,1,1)	const	0.06***	phi 1	0.91***	theta 1	-0.74***	/	/	/
	ARCH (1)			$p = 0.99$	Normality		$p = 0.01$		
lnGDPpc ARIMA (1,1,1)	const	0.05***	phi 1	0.80***	theta 1	-0.66**	/	/	/
	ARCH (1)			$p = 0.93$	Normality		$p = 0.01$		
lnLP_person ARIMA (1,1,1)	const	0.04***	phi 1	0.93***	theta 1	-0.85***	/	/	/
	ARCH (1)			$p = 0.66$	Normality		$p = 0.15$		
lnLP_hour ARIMA (2,1,2)	const	0.05***	phi 1	1.28***	phi 2	-0.73***	theta 1	-1.51***	
	theta 2	1.00***	/	/	/	/	/	/	
	ARCH (1)			$p = 0.16$	Normality of		$p = 0.21$		
LUXEMBOURG									
1950 - 1972	Computer	3.45	2.69	2.61	3.65	3.03	2.37	2.43	3.37
1973 - 1989	Silicon Chips	3.47	2.95	2.29	2.98	3.23	2.69	2.13	2.83
1990 - 2013	Information	3.35	2.03	0.17	0.71	3.49	2.23	0.27	0.79
Average		3.42	2.55	1.69	2.45	3.25	2.43	1.61	2.33
ARIMA estimations ²⁾									
lnGDP ARIMA (1,1,1)	const	0.03***	phi 1	-0.63***	theta 1	0.84***	/	/	/
	ARCH (1)			$p = 0.54$	Normality		$p = 0.09$		
lnGDPpc ARIMA (1,1,1)	const	0.03***	phi 1	-0.67***	theta 1	0.87***	/	/	/
	ARCH (1)			$p = 0.62$	Normality		$p = 0.05$		
lnLP_person ARIMA (1,1,1)	const	0.02***	phi 1	-0.76***	theta 1	-1.00***	/	/	/
	ARCH (1)			$p = 0.41$	Normality		$p = 0.18$		
lnLP_hour ARIMA (1,1,1)	const	0.02***	phi 1	-0.69***	theta 1	1.00***	/	/	/
	ARCH (1)			$p = 0.65$	Normality		$p = 0.20$		
THE NETHERLANDS									
1950 - 1972	Computer	4.74	3.43	3.25	4.13	4.49	3.27	3.10	3.97
1973 - 1989	Silicon Chips	2.32	1.67	1.35	2.53	2.15	1.52	1.32	2.41
1990 - 2013	Information	2.01	1.49	0.82	1.00	2.10	1.60	0.85	1.05
Average		3.02	2.20	1.81	2.55	2.91	2.13	1.76	2.48
ARIMA estimations ²⁾									
lnGDP ARIMA (1,1,0)	const	0.03***	phi 1	0.41***	/	/	/	/	/
	ARCH (1)			$p = 0.34$	Normality		$p = 0.08$		
lnGDPpc ARIMA (1,1,0)	const	0.02***	phi 1	0.32***	/	/	/	/	/
	ARCH (1)			$p = 0.54$	Normality		$p = 0.14$		

Periods	Industry ¹⁾	1	2	3	4	5	6	7	8
lnLP_person ARIMA (1,1,1)		const	0.02**	phi 1	0.95*	theta 1	-0.80***	/	/
		<i>ARCH (1)</i>		$p = 0.07$		<i>Normality</i>		$p = 0.23$	
lnLP_hour ARIMA (1,1,1)		const	0.02**	phi 1	0.95***	theta 1	-0.72***	/	/
		<i>ARCH (1)</i>		$p = 0.03$		<i>Normality</i>		$p = 0.37$	
NORWAY									
1950 - 1972	Computer	3.81	3.03	3.27	4.18	3.52	2.81	3.09	3.86
1973 - 1989	Silicon Chips	3.47	3.03	2.17	3.16	3.48	3.05	2.01	3.04
1990 - 2013	Information	2.53	2.06	1.39	1.67	2.47	2.01	1.47	1.71
Average		3.27	2.71	2.28	3.00	3.16	2.62	2.19	2.87
ARIMA estimations ²⁾									
lnGDP ARIMA (1,1,0)		const	0.03***	phi 1	0.49***	/	/	/	/
		<i>ARCH (1)</i>		$p = 0.12$		<i>Normality</i>		$p = 0.26$	
lnGDPpc ARIMA (1,1,0)		const	0.03***	phi 1	0.46***	/	/	/	/
		<i>ARCH (1)</i>		$p = 0.17$		<i>Normality</i>		$p = 0.19$	
lnLP_person ARIMA (1,1,1)		const	0.02***	phi 1	0.54*	/	/	/	/
		<i>ARCH (1)</i>		$p = 0.86$		<i>Normality</i>		$p = 0.70$	
lnLP_hour ARIMA (1,1,1)		const	0.03***	phi 1	0.87***	theta 1	-0.50*	/	/
		<i>ARCH (1)</i>		$p = 0.18$		<i>Normality of</i>		$p = 0.63$	
NEW ZEALAND									
1950 - 1972	Computer	3.42	1.63	1.52	2.13	3.11	1.41	1.26	1.83
1973 - 1989	Silicon Chips	1.78	0.93	0.97	1.20	1.85	1.07	0.94	1.15
1990 - 2013	Information	2.61	1.51	0.94	1.07	2.47	1.42	1.08	1.29
Average		2.60	1.36	1.15	1.47	2.47	1.30	1.09	1.42
ARIMA estimations ²⁾									
lnGDP ARIMA (2,1,2)		const	0.03***	phi 1	1.14***	phi 2	-0.86***	theta 1	-1.14***
		theta 2	1.00***	/	/	/	/	/	/
<i>ARCH (1)</i>		$p = 0.91$		<i>Normality</i>		$p = 0.01$			
lnGDPpc ARIMA (1,1,1)		const	0.01***	phi 1	0.83***	theta 1	-1.00***	D '67-8	-0.02*
		<i>ARCH (1)</i>		$p = 0.09$		<i>Normality</i>		$p = 0.39$	
lnLP_person ARIMA (1,1,1)		const	0.01***	phi 1	0.69***	theta 1	-1.00***	/	/
		<i>ARCH (1)</i>		$p = 0.87$		<i>Normality</i>		$p = 0.07$	
lnLP_hour ARIMA (1,1,1)		const	0.01***	phi 1	0.83***	theta 1	-1.00***	D '67 ³⁾	-0.04**
		<i>ARCH (1)</i>		$p = 0.78$		<i>Normality</i>		$p = 0.08$	
PORTUGAL									
1950 - 1972	Computer	5.63	5.48	5.36	6.00	5.13	4.80	4.63	5.19
1973 - 1989	Silicon Chips	3.54	2.92	1.87	2.47	3.50	3.01	2.03	2.63
1990 - 2013	Information	1.40	1.05	1.40	1.55	1.41	1.17	1.43	1.56
Average		3.52	3.15	2.88	3.34	3.35	2.99	2.70	3.13
ARIMA estimations ²⁾									
lnGDP ARIMA (1,1,0)		const	0.03***	phi 1	0.55***	/	/	D '75-6	-0.05***
		<i>ARCH (1)</i>		$p = 0.96$		<i>Normality</i>		$p = 0.05$	
lnGDPpc ARIMA (0,1,1)		const	0.03***	/	/	theta 1	0.66***	/	/
		<i>ARCH (1)</i>		$p = 0.08$		<i>Normality</i>		$p = 0.49$	
lnLP_person ARIMA (0,1,1)		const	0.03***	/	/	theta 1	0.70***	/	/
		<i>ARCH (1)</i>		$p = 0.34$		<i>Normality</i>		$p = 0.01$	
lnLP_hour ARIMA (0,1,1)		const	0.03***	/	/	theta 1	0.71***	/	/
		<i>ARCH (1)</i>		$p = 0.38$		<i>Normality</i>		$p = 0.01$	
SPAIN									
1950 - 1972	Computer	6.20	0.58	5.59	5.61	5.59	0.62	5.01	5.02
1973 - 1989	Silicon Chips	3.70	0.12	3.58	4.53	3.64	-0.01	3.71	4.59
1990 - 2013	Information	2.16	1.09	1.06	1.23	2.21	1.07	1.07	1.29
Average		4.02	0.60	3.41	3.79	3.81	0.56	3.26	3.63

Periods	Industry ¹⁾	1	2	3	4	5	6	7	8
ARIMA estimations²⁾									
lnGDP ARIMA (1,1,1)	const	0.04***	phi 1	0.37**	theta 1	0.64***	/	/	/
	ARCH (1)			$p = 0.13$	Normality			$p = 0.01$	
lnGDPpc ARIMA (1,1,1)	const	0.01	phi 1	0.71***	theta 1	0.38**	D '09-1	-0.03***	
	ARCH (1)			$p = 0.62$	Normality			$p = 0.05$	
lnLP_person ARIMA (1,1,0)	const	0.03***	phi 1	0.77***	/	/	/	/	/
	ARCH (1)			$p = 0.97$	Normality			$p = 0.00$	
lnLP_hour ARIMA (1,1,0)	const	0.03***	phi 1	0.77***	/	/	/	/	/
	ARCH (1)			$p = 0.97$	Normality			$p = 0.00$	
SWITZERLAND									
1950 - 1972	Computer	4.27	2.83	2.87	3.16	4.05	2.70	2.78	2.99
1973 - 1989	Silicon Chips	1.29	0.97	0.64	1.39	1.13	0.84	0.57	1.32
1990 - 2013	Information	1.50	0.80	0.56	0.80	1.55	0.87	0.59	0.87
Average		2.36	1.53	1.36	1.78	2.24	1.47	1.32	1.73
ARIMA estimations²⁾									
lnGDP ARIMA (1,1,0)	const	0.02***	phi 1	0.43***	/	/	/	/	/
	ARCH (1)			$p = 0.93$	Normality			$p = 0.00$	
lnGDPpc ARIMA (1,1,0)	const	0.02***	phi 1	0.28**	/	/	/	/	/
	ARCH (1)			$p = 0.98$	Normality			$p = 0.01$	
lnLP_person ARIMA (1,1,0)	const	0.02***	phi 1	0.28**	/	/	/	/	/
	ARCH (1)			$p = 0.98$	Normality			$p = 0.10$	
lnLP_hour ARIMA (1,1,0)	const	0.02***	phi 1	0.28**	/	/	/	/	/
	ARCH (1)			$p = 0.52$	Normality of			$p = 0.14$	
SWEDEN									
1950 - 1972	Computer	4.01	3.37	3.21	4.24	3.82	3.21	3.06	3.95
1973 - 1989	Silicon Chips	1.86	1.57	0.94	1.28	1.81	1.55	0.95	1.31
1990 - 2013	Information	2.04	1.76	1.87	1.81	1.98	1.69	1.87	1.79
Average		2.64	2.23	2.00	2.44	2.54	2.15	1.96	2.35
ARIMA estimations²⁾									
lnGDP ARIMA (1,1,0)	const	0.03***	phi 1	0.42***	/	/	D '09 ³⁾	-0.04***	
	ARCH (1)			$p = 0.00$	Normality			$p = 0.17$	
lnGDPpc ARIMA (1,1,0)	const	0.02***	phi 1	0.40***	/	/	D '09 ³⁾	-0.04***	
	ARCH (1)			$p = 0.00$	Normality			$p = 0.17$	
lnLP_person ARIMA (1,1,0)	const	0.02***	phi 1	0.40***	/	/	/	/	/
	ARCH (1)			$p = 0.08$	Normality			$p = 0.22$	
lnLP_hour ARIMA (1,1,0)	const	0.02***	phi 1	0.58***	/	/	/	/	/
	ARCH (1)			$p = 0.45$	Normality			$p = 0.23$	
TURKEY									
1950 - 1972	Computer	5.35	2.81	4.45	5.28	4.85	2.53	4.14	4.89
1973 - 1989	Silicon Chips	4.71	2.32	2.99	3.61	4.90	2.58	3.30	3.95
1990 - 2013	Information	4.14	2.53	2.67	2.69	3.92	2.35	2.38	2.44
Average		4.73	2.55	3.37	3.86	4.56	2.49	3.27	3.76
ARIMA estimations²⁾									
lnGDP ARIMA (1,1,1)	const	0.05***	phi 1	0.78*	theta 1	-0.85**	/	/	/
	ARCH (1)			$p = 0.43$	Normality			$p = 0.00$	
lnGDPpc ARIMA (1,1,1)	const	0.03***	phi 1	0.79***	theta 1	-1.00***	/	/	/
	ARCH (1)			$p = 0.45$	Normality			$p = 0.01$	
lnLP_person ARIMA (2,1,2)	const	0.03***	phi 1	-0.20*	phi 2	-0.92***	theta 1	0.11	
	theta 2	1.00***	/	/	/	/	/	/	/
lnLP_hour ARIMA (2,1,2)	const	0.04***	phi 1	0.36***	phi 2	-0.83***	theta 1	-0.39***	
	theta 2	1.00***	/	/	/	/	/	/	/
	ARCH (1)			$p = 0.98$	Normality of			$p = 0.03$	

Periods	Industry ¹⁾	1	2	3	4	5	6	7	8
UNITED KINGDOM									
1950 - 1972	Computer	2.65	2.10	2.63	3.32	2.36	1.87	2.42	3.07
1973 - 1989	Silicon Chips	2.36	2.22	1.85	2.50	2.43	2.30	1.99	2.56
1990 - 2013	Information	2.08	1.64	1.64	1.92	1.99	1.56	1.51	1.82
Average		2.36	1.99	2.04	2.58	2.26	1.91	1.97	2.49
ARIMA estimations ²⁾									
lnGDP ARIMA (0,1,1)	const	0.02***	/	/	theta 1	0.57***	/	/	/
	ARCH (1)		$p = 0.05$		Normality		$p = 0.00$		
lnGDPpc ARIMA (1,1,0)	const	0.02***	phi 1	0.36***	/	/	/	/	/
	ARCH (1)		$p = 0.08$		Normality		$p = 0.01$		
lnLP_person ARIMA (1,1,0)	const	0.02***	phi 1	0.32**	/	/	/	/	/
	ARCH (1)		$p = 0.13$		Normality		$p = 0.00$		
lnLP_hour ARIMA (1,1,0)	const	0.03***	phi 1	0.44***	/	/	/	/	/
	ARCH (1)		$p = 0.99$		Normality		$p = 0.08$		

Source: Authors' own calculation.

Notes: (1) GDP growth, (2) GDPpc growth, (3) LP per person, (4) LP per hour, (5) GDP growth due to technological progress, (6) GDPpc growth due to technological progress, (7) LP per person growth due to technological progress, (8) LP per hour growth due to technological progress

¹⁾ average growth rates per industry; possible slight differences in aggregation due to a rounding-up problem

²⁾ estimated coefficients; ***, **, * denotes 1%, 5% and 10% significance levels respectively

³⁾ dummy variables

⁴⁾ Estimation periods for USA, JAP, GER, FRA and NLD starts from 1950; for SUI and TUR from 1955, for AUS, AUT, BEL, CAN, DEN, FIN, GRE, ISL, IRL, ITA, NOR, NZL, POR, SPA SWE and UK from 1956, for LUX from 1958 and for KOR from 1960.