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Contribution of Knowledge Economy and Agglomeration Economies to Economic Growth in OECD Countries

KHOMIAKOVA Tatiana*

Abstract

This paper assesses the contribution of knowledge economy and agglomeration economies to GDP growth per worker in 30 OECD countries at the innovation-driven period from 1992 to 2005. The various proxies for knowledge economy and agglomeration economies - business expenditures on research and development as a percentage of value added in industry (innovation pillar); number of mobile phones per 1,000 workers (information communication technology pillar); tertiary education attainment (human capital pillar); trade to GDP ratio (economic regime pillar); market capitalization (institutions pillar); concentration of GDP in top 10% of regions (agglomeration economies pillar) - exhibited positive statistically significant effects on economic growth. It is the growth in various proxies of knowledge and agglomeration economies that is highly correlated with output growth per worker. Finally, comparison of results from the earlier period 1992–1998 regression and from the later period 1999–2005 regression provided evidence of a structural shift between the earlier period and the later period. The cross-section regression has also been performed for two combined periods, 60 observations, for results robustness check.

1. Introduction

At the modern innovation-driven stage of economic development, the economic growth prospects and global competitiveness of high-income Organization for Economic Cooperation and Development (OECD) economies is dependent on ability to create and shift to new technologies and science-based learning.

Economic growth can be attained in several ways, such as by increasing the amount and types of labor and capital used in production, as well as by improving two of the biggest components of total factor productivity (TFP) - technology growth and efficiency. The estimated GDP per worker equation confirms the earlier findings that capital and TFP are relatively large and significant in explaining growth in OECD countries. For example, Growth Accounting concludes that with 1.22 annual average growth in percentage points, TFP contributes 43% to GDP growth in OECD countries over the period

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1995–2005. Consequently, the remaining part of GDP growth can be explained by the increase in inputs of labour (26%), ICT-capital (17%) and non-ICT capital (14%) (OECD, 2006 b: 23). This paper will focus on the key drivers of growth of GDP per worker in OECD countries, namely capital and total factor productivity.

TFP growth is achieved by growth and development of knowledge and agglomeration economies. Therefore, the article examines the key determinants of economic growth in the 30 OECD member states at the current innovation-driven stage of development. The analysis and respective applied methodology is in line with the knowledge assessment methodology (KAM) of the World Bank (World Bank 2007: http://www.worldbank.org/kam), and accounts for unique properties of OECD countries. OECD countries have the highest scores in cross-country comparisons of the aggregate knowledge economy index and four pillars: innovation, information communications technologies, human capital, economic regime and institutions (KAM framework). The experience of OECD countries may be used for knowledge application - being the core of development process - in developing countries. As knowledge is one of the key sources of growth and competitiveness in global economy, OECD countries are the main concern of this article and best choice for cross-country growth regressions.

The choice of OECD countries is prompted by differences in the growth performance of OECD countries during 1990s (Table 1). This difference in performance is in contrast with the "thirty glorious years" after World War II, when the trend was many countries' per capita incomes to catch up with American levels (OECD 2004:3). Stronger growth in the major seven countries in the second half of the 1990s was due to capital deepening (investment in information and communications technology) and more rapid multi-factor productivity growth.[1] Between 1995 and 2005, multi-factor productivity growth was an important source of GDP growth in Ireland, Finland, Greece and the United States. By contrast, multi-factor productivity growth was very low or negative in Austria, Denmark, Italy, the Netherlands and Spain (OECD 2006 b: 22).

The second prominent point is the share of technology and knowledge-based industries (37% average for OECD countries) in total gross value added.[2] The share of technology and knowledge-based industries[3] varied from the lowest 23.8% in Greece to the highest 47.8% in Ireland in 2002. In turn, this achievement has been driven by investment in knowledge (sum of expenditure on R&D, total higher education, and software), that amounted to 5.2% of GDP in the OECD area in 2002 (OECD Factbook 2006).

The key assets of economic growth (Pillar I-IV) tend to be localized in a small number of regions within the country. In 2001, 54% of the total patents recorded in OECD member countries came from only 10% of regions, and over 64% of the highly educated population live in urban regions (OECD 2005: 16). In recent years, regional development issues have returned to the policy agenda of many OECD countries. Higher integration driven by institutional processes (e.g. European Union, WTO) and economic trends (i.e. globalization) is eroding national borders and creating competition along regional lines in the world market. At the same time, the persistence of significant regional disparities challenges countries' capacity to promote economic growth while ensuring social cohesion (OECD 2005: 15).

Given that various proxies of knowledge and agglomeration economies constitute total factor productivity term in our estimating equation, knowledge economy and agglomeration impacts are important in the growth performance of the 30 OECD members from 1992 to 2005, and analysis of economic growth respectively. Taking into account the specifics of OECD countries (like knowledge industries prevailing in the economic structure, Table 1 column 6), the new set of knowledge and agglomeration economies variables (discussed in Section 4 below) were tested and analyzed.

Specifically, we pose and test the following three research hypotheses:

H1. Four pillars of knowledge economy represent key drivers of economic growth in OECD countries in the period 1992–2005. Moreover, the higher concentration of economic activity (agglomeration economies) tends to result in higher growth of GDP.

H2. It is the growth / changes in various proxies of knowledge and agglomeration economies that influence economic growth.

H3. There was a structural shift between the earlier period 1992–1998 and the later period 1999–2005.

The paper is organized as follows: the subsequent section provides literature review on sources of economic growth. The third section introduces methodology, in three parts: econometric model in section 3.1; estimated production function with total factor productivity (TFP) components in section 3.2; and data in section 3.3. The fourth section provides the results of cross-section regressions with GDP per worker growth as dependent variable in the following format. The first sub-section deals with the principal regression (1992–2005) results and robustness check results from regression with 2 combined periods (1992–1998 and 1999–2005) and 60 observations respectively. The individual contribution of each of 4 pillars of knowledge economy (independent variables) to economic growth is explained.

The sub-section 5.2 tests for structural change by comparing the results of the earlier period (1992–1998) with the results of the later period 1999–2005. Finally, sub-section 5.3 focuses on contribution of knowledge and agglomeration economies to GDP growth per worker in 1995–2004, given that data-set on region-wise GDP is constrained by the shorter time period 1995 – 2004. Finally, summary and conclusions can be found in section 5.

2. Literature Review

This section is devoted to empirical studies on knowledge economy and agglomeration impacts in order to highlight the existing knowledge and the scope for future research, including focus of this

Table 1. Real GDP Growth and Indicators of Knowledge Economy in OECD

		Compound GDP Growth per Worker			Knowledge Economy			
1	2	3	4	5	6	7	8	9
		1992–2005	1992–1998	1999 2005	Share of knowledge industries, 2002, %	Investment in knowledge, 2002	BERD as % of value added in industry, 1992–2005	ICT investment in non-residential fixed capital formation,%
1	Australia	2.22	3.16	1.19	36.70	4.12	1.04	20.64
2	Austria	1.41	1.28	1.31	34.30	3.30	1.84	12.86
3	Belgium	1.17	1.09	1.39	41.60	3.70	1.88	19.56
4	Canada	1.93	2.28	1.32	34.70	4.70	1.42	17.64
5	Czech Republic	2.67	1.95	3.68			0.96	
6	Denmark	2.48	3.21	1.93	37.40	5.50	2.22	18.74
7	Finland	2.66	3.35	2.15	37.30	6.10	2.88	23.10
8	France	1.24	1.10	1.21	39.80	3.60	2.06	14.63
9	Germany	1.12	1.14	0.91	42.80	3.80	2.31	14.96
10	Greece	1.70	0.00	3.38	23.80		0.19	11.17
11	Hungary	4.17	4.33	4.43	36.30		0.48	
12	Iceland	2.26	2.25	2.38	32.60		1.56	
13	Ireland	3.77	4.73	2.42	47.80	2.40	1.13	8.46
14	Italy	1.14	1.87	0.39	34.60		0.75	15.29
15	Japan	1.09	0.34	2.00		5.00	2.81	12.51
16	Korea, Rep.	3.62	2.94	3.56	39.50	5.90	2.54	16.32
17	Luxembourg	3.05	3.36	2.46	45.50		1.96	
18	Mexico	0.51	−0.43	1.06	29.10		0.16	
19	Netherlands	0.74	1.20	0.04	38.90	3.80	1.49	15.19
20	New Zealand	1.75	1.77	1.27	30.20	2.80	0.44	17.48
21	Norway	1.97	2.77	1.22	29.30		1.35	9.98
22	Poland	4.67	6.06	3.38			0.34	
23	Portugal	0.91	1.62	−0.13	32.00	2.80	0.28	11.97
24	Slovak Republic	3.54	3.92	3.73			0.64	
25	Spain	1.15	1.15	0.86	30.10	2.80	0.65	13.20
26	Sweden	2.47	2.74	1.98	42.10	6.70	4.26	23.96
27	Switzerland	0.45	0.34	0.54	42.50		2.82	
28	Turkey	2.26	2.82	3.31			0.19	
29	United Kingdom	2.49	3.12	1.93	40.70	3.60	1.77	20.49
30	United States	1.98	2.18	1.60	43.10	6.60	2.64	26.64

Source: Columns 3–5 “Real GDP growth” rates, WDI (2007).
Column 6 “Share of value-added by technology and knowledge-based industries in total gross value added, 2002 (percentages)”. OECD Science, Technology and Industry Scoreboard 2005, p 204
Column 7 “Investment in knowledge (sum of expenditure on R&D, on total higher education and on software), 2002”. OECD Factbook 2006
Column 8 “Business Expenditures on Research and Development (BERD) as a percentage of value added in industry, 1990–2004”. OECD Main Science and Technology Database
Column 9. Shares of ICT investment as a percentage of total non-residential fixed capital formation, OECD Factbook 2006

paper.

The term "knowledge-based economy" was coined by the OECD and defined as an economy which is "directly based on the production, distribution and use of knowledge and information" ("Knowledge-Based Economy," OECD, 1996).

The most outstanding results of the growth-related research with regression techniques are highlighted below. The first group of research encompasses a wide range of determinants of economic growth (Barro (1997), Bosworth and Collins (2003), Chen and Dahlman (World Bank, 2004), "The New Economy: Beyond the Hype" (OECD, 2001), "Understanding Economic Growth" (OECD, 2004).

Great efforts have been devoted to huge statistical analyses on economic growth running millions of regressions (see for example Barro, 1997 and Sala-i-Marin, 1997).

Bosworth and Collins (2003) examined three issues: (1) the relative importance of capital accumulation and TFP in raising income per capita; (2) the significance of improvements in the quantity and quality of education; and (3) the sources of the sharp differences in growth performance in the period before and after 1980 (little insight except for China and India). In regression called "education attainment, quality and economic growth", human capital variables are considered both in the level (initial level of average years of schooling) and growth (growth in human capital per worker) forms. In regressions called "growth on initial conditions, external shocks and policy", there is also a combination of independent variables in absolute numbers (life expectancy, institutional quality) and growth rates (change in inflation, change in term of trade). Therefore, in research by Bosworth and Collins (2003) some variables are analyzed in the level form, and some variables are taken in the growth rate form while scrutiny of their impact on economic growth.

Chen and Dahlman (World Bank, 2004) studied aspects of knowledge for a group of 92 countries for the period 1960–2004 in the following order: human capital, innovation, information technology, institutions. However, the inclusion of the overall health of the economy and quality of institutions rendered the estimated coefficients of many human capital and information technology variables statistically insignificant. As a result, nowadays the KAM website ranking of knowledge economy variables is led by economic performance, economic regime and governance indicators (Group1), followed by innovation system (Group 2), education, gender (Group 3), Information Communication Technology (Group 4). Thus, the study by Chen and Dahlman (2004) concluded that it is the level of knowledge variables that is responsible for economic growth.

The existing empirical findings on correlations between knowledge economy variables and growth are summarized in the conclusions of the OECD growth project "The New Economy: Beyond the Hype" (OECD, 2001). The study provided insight on correlation between individual performance indicators partially in the level form (share of ICT manufacturing in business value added, administrative burdens on start-ups; employee tenure) and partially in change / growth form (change in average intensity of business R&D, change in PC intensity per 100 inhabitants) and MFP growth (not GDP growth).

The second group of research focuses on the pillars of knowledge economy or agglomeration economies. For instance, Lederman and Maloney (2003), Guellecand van Pottelsberghe (OECD, 2001) and Khan (2005) scrutinized innovation; Colecchia and Schreyer (2001), Pilat and Lee (2001), Jorgenson and Stiroh (2000), Oliner and Sichel (2000), Whelan (2000), and Schreyer (2000) examined ICT; Nicoletti et al. (2003), Conway et al. (2005), Nicoletti and Scarpetta (2003) investigated institutions; OECD (2004) and Sachs and Warner (1995) stressed the importance of market capitalization and economic openness respectively.

Following OECD's "Regions at A Glance" series (2005, 2007), the hypothesis of agglomeration contribution to economic growth has emerged. Economically dense areas will have higher agglomeration economies, leading to larger increasing returns and thus faster growth (Eraydin et al., 2003).

Therefore, the above-mentioned studies underlie the theoretical framework of the present paper in the following way:

1) Bosworth and Collins (2003) incited the trial of GDP per worker as the dependent variable in the econometric model design. The importance of GDP per person employed is also clarified in OECD (2003).

2) The structure of the 4 pillars of knowledge economy followed the KAM methodology of World Bank and Chen and Dahlman (2004).

In addition, the choice of independent variables as proxies of knowledge and agglomeration economies was facilitated by "The New Economy: Beyond the Hype" (2001), "Understanding Economic Growth" (2004), OECD Factbook 2007, and studies on individual pillars of knowledge economy and agglomeration economies.

Initially, we tried to examine whether the level and/or growth rate of knowledge and agglomeration economies variables have influence on GDP per worker growth. As mentioned above, our main hypothesis and analysis below state that growth rate of knowledge and agglomeration economies is crucial for economic growth.

3. Methodology

3.1 Econometric Model

The traditional economy-wide aggregate production function postulates that:'

(1) $Y=AF(K,L)$, where Y is the level of aggregate output, K is the level of the capital stock, L is the size of the labor force, A is total factor productivity.

In accordance with the Cobb-Douglas specification, equation (1) takes the form:

(2) $Y=AK^{\alpha_k}L^{\alpha_l}$, where α_k is the elasticity of output to capital, α_l is the elasticity of output to

labor.

Having taken natural logarithms and partial derivatives from the both sides of equation (2) results in:

(3) $\triangle Y/Y = \alpha_k \triangle K/K + \alpha_l \triangle L/L + \triangle A/A$,

where the left hand side is the growth rate of aggregate output, i.e economic growth. The right-hand side shows that there are three sources of economic growth: growth in the amount of capital (the contribution of capital), growth in the amount of labor (the contribution of labor) and growth in total factor productivity (TFP).

Sometimes researchers identify the economic strengths of the country by comparing GDP per capita, which divides the total size of the country's economic output by size of the population. Study by Barro (2004) and publications on developing countries consider GDP per capita - with intention to show the welfare impact on all people, or not very reliable character of labor statistics in developing countries - being the main reasons. By contrast, this paper considers GDP per worker[4)] primarily due to the fact that labor force contributes to GDP growth, rather than non-working population. In addition, high quality data on labor force are available for OECD countries.

From this perspective, it is of practical importance to look at the per worker specification of Equation (3). From equation (2), with the additional assumption of constant returns to scale ($\alpha_k + \alpha_l = 1$), it can be seen that:

(4) $\triangle(Y/L)/(Y/L) = \alpha_k \triangle(K/L)/(K/L) + \triangle A/A$,

where growth rate of per worker GDP is dependent on the growth rate of capital per worker (capital deepening) and the growth rate of total factor productivity.

3.2. Estimated Production Function with Total Factor Productivity Components

In accordance with the above-mentioned knowledge economy framework of the World Bank, total factor productivity (TFP) is affected by the 4 pillars: 1) domestic innovation and technology adaptation, 2) information and communication technology (ICT), 3) human capital; 4) institutional and economic regime. On the top of that, TFP is spurred by various types of externalities, namely inter-region and inter-firm. The mechanism is that externalities foster both localized economic growth, growth among more geographically dispersed regions, and consequently, economy-wide economic growth. Therefore, TFP term of the estimating equation should account for agglomeration effects. The externality increases with the agglomeration.

Based on the above evidence from the literature, a closer look at performance of OECD countries, and characteristic features of recent development, the aggregate production function should have the following specification:

(5) Y=A (R&D, ICT, HC, IER, Agg).F(K,L), where R&D represents domestic innovation and technology adaptation; ICT represents country's information and communication infrastructure; HC -

human capital; IER - institutional and economic regime of the economy; Agg - agglomeration.

The research objective and following discussion focuses on demonstrating empirical evidence that the knowledge economy and agglomeration economies variables are significant determinants of economic growth (via their effects on the growth rate of TFP). It has been shown in equation (1) above that the growth rate of total factor productivity is one of the three key sources of economic growth. In order to test the hypotheses of the impact of knowledge economy and agglomeration economies variables on the growth rate of real GDP, the growth rate of TFP (in equation 4) is replaced with the proxies of knowledge economy and agglomeration variables (from equation 5). Finally, the estimating per worker specification takes the form of:

(6) $\triangle(Y/L)/(Y/L)=\alpha_k\triangle(K/L)/(K/L)+\beta_{R\&D}R\&D+\beta_{ICT}ICT+\beta_{HC}HC+\beta_{IER}IER+\beta_{Agg}Agg+\varepsilon$

where β_i is the estimated coefficient of the knowledge and agglomeration economies variable *i*.

3.3. Data

For the purpose of this paper the key variables are calculated as follows. As to the labor force, the variable accounted for all people who supply labor for the production of goods and services (both the employed and the unemployed)[5] during the specified periods. These data are used for estimation of GDP per worker and capital stock per worker.

In order to avoid biased estimates, the compound annual growth rate (denoted CAGR) was calculated for GDP per worker. The growth rate for the whole period 1992–2005 was obtained, and then converted to annual growth rate. The same approach was undertaken for sub-periods 1992–1998 and 1999–2005.

The perpetual inventory method (Young 1995) was applied for construction of the country specific capital stock on the basis of gross investment data (gross fixed capital formation). At the next stage, the compound annual growth rate (denoted CAGR) was calculated for capital stock per worker.

For this research, the methodology of Bosworth and Collins (2003) was applied for construction of the initial income variable-the ratio of a specific country's GDP per capita in 1991 to that of the U.S. in 1991 (to prevent endogeneity and causality effects for study period 1992–2005), both measured in PPP, 2000 international dollars. The income variables in 1998 and 1994 were chosen for periods (1999–2005) and (1995–2004 with agglomeration effects) respectively.

The knowledge economy variables[6] actually used in regressions are presented below. First, R&D is a term covering three activities: basic research, applied research, and experimental development. The business sector continues to be the major source of financing of domestic R&D - it accounted for almost 62% of funding in OECD countries in 2003. The business sector's role in R&D funding differs sharply across the three main OECD regions. It funds almost three-quarters of R&D in Japan and 63% in the US, but only 55% in the European Union (OECD 2005).

Business expenditures on research and development as a percentage of value added in industry

(BERD) form were chosen to reflect innovation and technology adoption (Pillar I). BERD variable (Item I.1 in Regression Results Table) represented annual average percentage share of BERD in value added in industry. BERD was the only one independent variable taken in the ratio form, because it was not possible to compute compound annual growth rate or simple difference growth rate, as time series data were not available for several countries. Data source is OECD Science, Technology and R&D database.

The alternative regression with a different proxy for Innovation Pillar I tested the impact of USPTO patents (patents registered at United States Patent and Trademark Office) on economic growth. The variable is constructed as the simple first difference (denoted Δ) between number of USPTO patents per 1,000 workers at the end of study period (2005) minus number of USPTO patents per 1,000 workers at the beginning of study period (1992) (Item I.2 in all Regression Results Tables). The data for two sub-periods 1992–1998 and 1999–2005 are constructed according to the end and beginning of each study period.

Second, the impact of ICT (Pillar II) on economic growth was investigated by means of the simple first difference (denoted Δ) between number of mobile phones per 1,000 workers at the end of study period (2005) and number of mobile phones per 1,000 workers at the beginning of the study period (1992) (Item II.1 in all Regression Results Tables).

Third, contribution of human capital (Pillar III) to economic growth is monitored via tertiary education attainment for age group 25–64 years as a percentage of population of that age group. The first simple difference (denoted Δ) between share (percent) of population in age group 25–64 years with tertiary education in 2005 and share (percent) of population in age group 25–64 years with tertiary education in 1992 was constructed (Item III.1 in all Regression Results Tables).

Fourth, the influence of economic regime (Pillar IV) on economic growth is monitored via trade to GDP ratio. The first simple difference (denoted Δ) between trade to GDP ratio in percent in 1992 is subtracted from trade to GDP ratio in percent in 2005 (Item IV.1 in all Regression Results Tables).

The financial system plays a crucial role in the growth process because it is a key to the provision of funding for capital accumulation and the diffusion of new technologies. As a result, market capitalization is selected as a proxy of the institutions pillar (Pillar IV) of the knowledge economy. Financial stock market capitalization (the value of listed shares), serves as an indicator (though imperfect) of the ease with which funds can be raised on the equity market. The time series data on market capitalization of listed companies (current US$) were adjusted using GDP deflator. Next, the compound annual growth rate (CAGR) of market capitalization for period 1992–2005 and two sub-periods was computed (Item IV.2 in all Regression Results Tables).

The agglomeration economies variable (Pillar V) was calculated based on region-wise GDP statistics. It represents the simple first difference (denoted Δ) between concentration of GDP in top 10% regions (10% of regions from the total number of regions in the country at territorial level 3

(NUTS 3)) in year 2004 (Graph 1) and concentration GDP in top 10% regions in year 1995 (Agglomeration).

Summarizing data used in regressions, GDP per worker, capital stock, and market capitalization are calculated based on compound annual growth rate (CAGR) formula. But for the majority of independent variables - patents (USPTO) per 1,000 workers, mobile phones per 1,000 workers, tertiary education, agglomeration economies - simple first differences are evaluated as these provided better fits. The use of simple difference allows us to identify the short-term effect of the above independent variables on economic growth.

In regard to sources of original data, all macroeconomic variables (GDP, gross fixed capital formation and labor) are from World Development Indicators (WDI 2007) database, while knowledge economy variables are from OECD databases (BERD, USPTO patents, tertiary education,) as well as WDI (mobile phones, foreign trade, market capitalization), and agglomeration economy variable is from Eurostat and national accounts.

The estimation procedure is as follows. The above data are tested as respective dependent (GDP growth per worker) and independent variables, resulting in each country, among 30 OECD member states, having at most one observation in the cross-section regression. The overall study period spans the period from year 1992 to 2005. The study period is divided into 2 sub-periods, namely from 1992 to 1998 and from 1999 to 2005 in order to monitor the possible structural changes. In addition, the regression with 60 observations is shown for robustness check.

The applied estimation technique is Ordinary Least Squares (OLS). The regressions are estimated with White robust standard errors to account for the possibility of heteroskedasticity.

4. Regression Results

This section presents the results of selected regressions in which various indicators of the knowledge and agglomeration economies are applied to explain economic growth.

4.1 GDP Growth per Worker, Period 1992-2005

First of all, the results of principal regression for period 1992-2005 and regression with combined two periods (1992-1998 and 1999-2005), 60 observations are highlighted in Table 2.

All regressions in Table 2 include the compound annual growth rate of capital stock per worker as an independent variable. The estimated coefficients of this variable have the theoretically expected signs and are always statistically significant (Table 2). A one percentage point increase in compound annual growth rate of capital stock per worker is associated with 0.38 percentage point increase in compound annual growth rate of GDP per worker (Table 2, Regression 1).

The highly significant negative estimated coefficient of the initial GDP per worker variable is

Table 2. Dependent Variable: GDP Growth per Worker. Period: 1992–2005

	Principal regression. Period 1992–2005, 30 observations[1]						Regression with combined 2 periods 1992–1998 and 1999–2005, 60 obs.		
	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5	Reg Alternative R&D	Reg 3C[2]	Reg 4C[2]	Reg 5C[2]
K/L (CAGR)	0.3841*** (6.8063)	0.3559*** (8.1650)	0.3384*** (8.4267)	0.3251*** (7.9150)	0.3130*** (6.7179)	0.2732*** (6.0242)	0.3784*** (6.2663)	0.3702*** (6.1955)	0.3300*** (6.4072)
Initial GDP Per Worker 1991/1998	−1.2484* (−1.7782)	−2.1729*** (−3.6992)	−2.6553*** (−5.9145)	−2.5497*** (−5.6974)	−2.5488*** (−5.5807)	−2.3010*** (−4.8184)	−2.0447*** (−3.6284)	−1.9942*** (−3.9911)	−2.3408*** (−4.6187)
I.1 BERD (%)	0.4015*** (2.9843)	0.5312*** (3.5582)	0.5095*** (5.0244)	0.4686*** (4.1784)	0.4528*** (3.8708)		0.3875*** (2.9270)	0.3734*** (2.7944)	0.3789*** (3.2074)
I.2. patent/USPTO/ (Δ)						3.2829*** (4.1762)			
II.1. Mobile Phones (Δ)		0.0008*** (2.9996)	0.0009*** (4.6572)	0.0007*** (3.0964)	0.0006*** (2.8138)	0.0006** (2.3549)	0.0004 (1.5574)	0.0003 (1.2386)	0.0004** (1.9450)
III.1. Tertiary Education (Δ=%-%)			0.0617* (2.0090)	0.0554* (1.8412)	0.0538* (1.7569)	0.0477 (1.5119)	0.0311 (0.6644)	0.0271 (0.5947)	0.0444 (0.9366)
IV.1. Foreign Trade (Δ=%-%)				0.0076** (2.0730)	0.0083** (2.1499)	0.0134** (2.6384)		0.0225*** (2.9184)	0.0171** (2.0782)
IV.2. Market Capitalization (CAGR)					0.0046 (0.5347)	0.0082 (0.8722)			0.0162** (2.2834)
Constant	1.0979* (1.9521)	0.2668 (0.6044)	−0.0224 (−0.0533)	0.3006 (0.6594)	0.3583 (0.7827)	0.5873 (1.0815)	1.2924** (2.4494)	1.1390** (2.2175)	1.2205*** (2.5211)
R Squared	0.7276	0.8094	0.8467	0.8595	0.8611	0.8390	0.5938	0.6491	0.6837
Observation	29	29	29	29	29	29	59	59	59

*, **, *** denotes significance at the 90,95 and 99 percent confidence level respectively
Robust standard errors obtained using White's correction for heteroskedasticity
[1] BERD data are not available for Luxemburg in the first study period 1992–1998, resulting in total 29 observations.
[2] C means regression with combined two periods, 60 observations. Regressions 1C and 2C are omitted due to space limitations.

seen in all regressions for estimation of equation (6). This result with negative coefficient coincides with the theory of conditional convergence that countries that had lower per worker GDP in 1991 tend to have higher economic growth rates relative to countries with higher rates of per worker GDP in 1991.

Regression 1 in Table 2 is run with three independent variables - capital, initial level of GDP per worker and business expenditures on research and development as a percentage of value added in industry (BERD). Regressions 2, 3, 4, 5 incorporate other knowledge economy variables one by one. Therefore, Regression 5 represents the most complete specification in case of principal regression, and Regression 5C represents the most complete specification in case of regression with two combined periods.

Now we turn to the actual statistical results for knowledge economy variables. Firstly, from principal Regression 1 for 1992 – 2005 (Table 2) it can be seen that the estimated coefficient of BERD variable is positive and highly statistically significant. The results indicate that BERD (taken alone just with capital, and initial GDP per worker as control variables) lead to the following relationship: one percentage point increase in business expenditures on research and development as a percentage of value added in industry increases compound annual economic growth rate by 0.38 percentage points (Table 2, Regression 1).

When we include ICT variable and human capital variable - to reduce the possibility of biases resulting from omitted variables - in the principal Regression 3 (Table 2), the coefficient of BERD is equal to 0.5095 and highly statistically significant. The simultaneous incorporation of institutions and economic regime in Regression 5 produces BERD coefficient of 0.4528. It is possible to finally conclude that one percentage increase in business expenditures on research and development as a percentage of value added in industry (BERD) tends to be associated with 0.45 percentage point increase in compound annual growth rate of GDP per worker (Table 2, principal Regression 5).

The results of robustness check from the regression with combined 2 periods 1992–1998 and 1999–2005, 60 observations are very similar to results of the principal regression 1992–2005, with BERD coefficient of 0.40 (Regression 1) in the former case, and 0.37 (Regression 1C) in the latter case. For the complete specification in Regression 5, BERD coefficient is highly statistically significant, and regression results leads to the following inference. A one percentage point rise in business expenditures on research and development as a percentage of value added in industry (BERD) tends to be associated with 0.38 percentage point increase in compound annual growth rate of GDP per worker (Table 2, Regression 7, 60 observations).

Therefore, results of principal regression and regression with 60 observations are very consistent.

The previous Chen and Dahlman study (2004) found that the research and development pillar lost its statistical significance upon inclusion of economic regime and institutions. In contrast, the present empirical analysis highlights the importance of the innovation pillar to economic growth in OECD countries. We demonstrated that the level of innovation variable (BERD as a percentage of value added in industry) is significant for economic growth in OECD countries. Unfortunately, it is not feasible to test the importance of growth in innovation variable for GDP growth per worker due to BERD data limitations. However, application of an alternative proxy for the innovation variable provides statistical evidence of the importance of growth in innovation variable to GDP growth per worker. For instance, our results from principal regression 1992–2005 suggest the following. According to the coefficient value of 3.2829 (Table 2, Regression Alternative R&D) and the regression sample mean of 0.0967, a doubling (100% increase) of USPTO patents tends to lead to 0.3176 percentage point increase in compound annual growth rate of GDP per worker. Thus, 10% increase in USPTO patents is associated with 0.03 percentage point increase in compound annual growth rate of GDP per worker.

Secondly, the role of information and communication technology infrastructure for economic growth is examined. The obtained results are highly statistically significant. The principal regression results allow the following inference, given that the regression mean value is 1,844 (being the first difference between the number of mobile phones per 1,000 workers year 2005 minus number of mobile phones per 1,000 workers in 1992). In Regression 2 (Table 2), when the number of mobile phones per 1,000 workers is doubled, the estimated coefficient suggests that annual compound growth rate of GDP per worker will increase by 1.48 percentage points. Thus, 10 percent increase in number of telephones per 1,000 workers will be correlated with 0.15 percentage point increase in compound annual growth rate of GDP per worker.

In period 1992–2005, the estimation coefficient is equal to 0.0006 in complete specification (Table 2, principal Regression 5) and 0.0004 in regression with 2 combined periods, 60 observations (Table 2, Regression 5C, 60 observations). Finally, in accordance with complete specification for principal regression, when ICT infrastructure, measured by the difference of mobile phones per 1,000 workers, is increased by 10 percent, compound annual growth rate of GDP per worker tends to increase by 0.11percentage points.

Thirdly, the importance of human capital to economic growth in OECD countries was scrutinized starting from Regression 3. It was hypothesized that growth (simple difference between 2005 and 1992) in share of the population that has attained qualifications at the tertiary level is a key indicator of how countries are adapted to benefit from technological and scientific progress. Reference to the complete specification of equation 6 (Table 2, principal Regression 5) shows the positive and statistically significant coefficient and allows me to make the next inference. When tertiary education attainment for age group 25–64 years as a percentage of population of that age group is increased by one percentage point, it will accelerate compound annual growth rate of GDP per worker by 0.05 percentage points. In accordance with Regression 5 C, 60 observations, when tertiary education attainment for age group 25–64 years as a percentage of population of that age group is increased by one percentage point, it will accelerate compound annual growth rate of GDP per worker by 0.04 percentage points. Therefore, results of principal regression and regression with two combined periods are statistically significant and consistent with each other.

Fourthly, the complete specification of equation (6) (Table 2, Principal Regression 5) produced trade openness variable coefficient with the theoretically expected positive sign and significant at 95% confidence level. Therefore, it may be argued that one percentage point improvement in difference in trade to GDP ratio between 2005 and 1992 is associated with 0.01 percentage point increase in compound annual growth rate of output per worker. At the same time, the respective regression for two combined periods 1992–1998 and 1999–2005, (Regression 5C, 60 observations) indicates that one percentage point improvement in difference in trade openness will lead to 0.02 percentage point increase in compound annual growth rate of GDP per worker.

Finally, the results of the empirical analysis point to a robust link between stock market capitalization (compound annual growth rate of the value of listed shares) and economic growth. Thus, a one percentage point rise in compound annual growth rate of the value of listed shares will lead to 0.005 percentage point increase in compound annual growth rate of GDP per worker (Table 2, principal Regression 5). This coefficient has the expected positive sign, but is not statistically significant. According to regression with combined two periods, the estimating coefficient is statistically significant and suggests that one percentage point increase in compound annual growth rate of the value of listed shares will boost compound annual growth rate of output per worker by 0.02 percentage points (Regression 7, 60 observations).

4.2 GDP Growth per Worker: Comparison of Period 1992–1998 and Period 1999–2005

We have also run regression for the earlier 1990–1997 and later 1998–2004 periods separately (Table 3). This approach is aimed at discovery of the structural change between the early half and later half of the study period by means of differences in the estimating coefficients.

The results of the earlier period reveal that a one percentage point increase in compound annual growth rate of capital stock is associated with 0.38 percentage point increase in compound annual growth rate of GDP per worker in 1992–1998 (Table 3, Regression 5). The results of the later period suggests that a one percentage point increase in compound annual growth rate of capital stock is responsible for 0.36 percentage point increase in compound annual growth rate of GDP per worker in 1999–2005 (Table 3, Regression 5L). It might be inferred that capital stock reduced its contribution to GDP per worker growth from the earlier to the later period, while, respectively, total factor productivity components (four pillars of knowledge economy and agglomeration economies) enlarged their contribution to GDP per worker growth.

In respect to knowledge economy variables, the regression results for period 1992–1998 and 1999–2005 reveal that the coefficient of BERD increased from 0.37 in the earlier period (Table 3, Regression 5) to 0.42 in the later period (Table 3, Regression 5L). Therefore, innovation pillar of knowledge economy got more weight in determining economic growth in OECD countries in the recent period 1999–2005. In the later period, a one percentage point increase in business expenditures on research and development as a share of gross value added in industry is correlated with 0.42 percentage point increase in compound annual growth rate of GDP per worker (Table 3, Regression 5L).

By contrast, the coefficient of mobile phones lessened from 0.0016 in the earlier period 1992–1998 (Table 3, Regression 5) to 0.0006 in the later period 1999–2005 (Table 3, Regression 5L). Based on the estimating coefficient (Table 3, Regression 5) and regression sample mean from resulting difference of 457 mobile phones per 1,000 workers), 10 percent increase in number of mobile telephones per 1,000 workers is associated with 0.07 percentage point increase in compound annual GDP growth per worker in earlier period 1992–1998.

Consequently, based on the estimating coefficient (Table 3, Regression 5L) and regression sample mean from resulting difference of 1,107 mobile phones per 1,000 workers), 10 percent increase in number of mobile telephones per 1,000 workers is associated with 0.07 percentage point increase in compound annual GDP growth per worker in later period 1999–2005. Therefore, the impact of growth in mobile phones per 1,000 workers is only slightly higher[7] in the earlier period 1992–1998 in comparison with the later period 1999–2005. The possible explanation for ICT variable influence decline might be the increased role of other factors, like BERD, in period 1999–2005. An additional possible reason might be the spread of internet, but internet variable did not show statistically significant outcomes. It is well-known that investment and diffusion of ICT was high in the 1990s. It still takes time to build networks through which ICT can lift TFP. Thus, internet and computers will show up much more clearly in the productivity statistics in the nearest future.

The coefficient of tertiary education increased in the later period in comparison with the earlier period. As to the earlier period 1992–1998, one percentage point increase in the share of people at age 25–64 with the tertiary education is correlated with 0.12 percentage point increase in compound annual growth rate of GDP per worker (Table 3, Regression 5). Perhaps most important, one percentage point increase in the share of people at age 25–64 with the tertiary education is correlated with 0.13 percentage point increase in compound annual growth rate of GDP per worker (Table 3, Regression 5 L).

As to trade openness, the variable has the expected positive sign, but not statistically significant neither in the earlier period 1992–1998, nor in the later period 1999–2005 in the complete specification (Table 3, Regression 5 and 5L respectively).[8] However, when foreign trade is taken alone with capital and initial level of GDP, foreign trade has the statistically significant coefficient (at 99% confidence level) of 0.04 in period 1999–2005. One reason for the sharp reduction in statistical significance of the estimated coefficient of foreign trade - on the inclusion of all four pillars of

Table 3. Dependent Variable: GDP Growth per Worker. Period: 1992–1998 and 1999–2005

	Period 1992–1998					Period 1999–2005			
	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5	Reg 3L[1]	Reg 4L[1]	Reg 5L[1]	Reg Independent role 1[2]
K/L (CAGR)	0.4385*** (5.3520)	0.4428*** (5.8745)	0.4404*** (5.6167)	0.4365*** (5.4639)	0.3758*** (5.0485)	0.2841*** (4.0046)	0.3074*** (3.6412)	0.3586*** (4.0748)	0.3919*** (4.5779)
Initial GDP Per worker 1991/1998	−1.1326 (−1.3472)	−1.7736** (−2.5224)	−2.0644** (−2.5591)	−1.8849** (−2.1678)	−2.5428*** (−2.9862)	−3.4024*** (−5.1774)	−3.1292*** (−4.7319)	−3.1391*** (−4.6530)	−2.7765*** (−5.5911)
I.1 BERD (%)	0.5515*** (2.6416)	0.4218** (2.0634)	0.3642* (1.9682)	0.3734* (1.8817)	0.3738* (1.9531)	0.5868*** (3.4359)	0.4677** (2.6222)	0.4248** (2.1078)	0.2833** (2.1760)
II.1. Mobile Phones (Δ)		0.0019** (2.7832)	0.0020*** (2.9859)	0.0020*** (2.8119)	0.0016** (2.5535)	0.0014*** (4.8013)	0.0009* (1.9278)	0.0006 (1.0798)	
III.1. Tertiary Education (Δ = %-%)			0.1002 (1.5371)	0.0779 (1.1841)	0.1241* (1.8053)	0.1189** (2.1589)	0.1016* (1.6930)	0.1344** (2.0286)	0.1198* (1.7158)
IV.1. Foreign trade(Δ =%-%)				0.0107 (0.9768)	0.0053 (0.4526)		0.0172 (1.1448)	0.0297 (1.6845)	0.0447*** (5.2410)
IV.2. Market Capitalization (CAGR)				0.0155* (1.8816)				−0.0259 (−1.4709)	−0.0310* (−1.9513)
Constant	0.7291 (0.9090)	0.4850 (0.7419)	0.4203 (0.5774)	0.2505 (0.3059)	0.7512 (0.9097)	0.3917 (0.5752)	0.7997 (1.2257)	0.8715 (1.4143)	1.3873*** (3.0596)
R Squared	0.6796	0.7366	0.7574	0.7679	0.7989	0.6665	0.6790	0.7068	0.6953
Observation	29	29	29	29	29	30	30	30	30

*,**,*** denotes significance at the 90,95 and 99 percent confidence level respectively
Robust standard errors obtained using White's correction for heteroskedasticity
[1] L means regression for later period 1999–2005. Regressions 1L and 2L are omitted due to space limitations.
[2] In period 1999–2005, "Regression Independent Role 1" is focused on coefficient of foreign trade (Pillar IV.1) in the absence of mobile phones (Pillar II) due to substantial multicollinearity between two variables.

knowledge economy - could be because of the substantial multicollinearity between foreign trade (Pillar IV.1) and mobile phones (Pillar II) (correlation coefficient of 0.60 in the correlation matrix for period 1999–2005). Consequently in the absence of mobile phones (Pillar II), "Regression Independent Role 1" demonstrates the positive and statistically significant coefficient of foreign trade.

Growth in the value of listed shares variable has the expected positive sign and was statistically significant in period 1992–1998. Therefore, one percentage point increase in compound annual growth rate of financial stock market capitalization (the value of listed shares) is associated with 0.02 percentage point increase in compound annual growth rate of GDP per worker in the earlier period

1992–1998 (Table 3, Regression 5). Unfortunately, growth in the value of listed shares variable has an unexpected negative sign in the later period 1999–2005.[9] When market capitalization variable is taken alone just with capital and initial level of GDP, the estimated coefficient of market capitalization has the expected positive sign in period 1999–2005. This result, where controlling for all four pillars of knowledge economy together, eliminates independent roles of each regressor of interest, and is consistent with other studies (Chen and Dahlman, 2004). Similar to the foreign trade variable, there might be a problem of multicollinearity. This problem shows up only during the separate estimation of the shorter sub-periods 1992–1998 and 1999–2005, probably because the simple difference of variable is too small in comparison with the larger period 1992–2005.

The results reveal the diminishing impact of capital as well as ICT pillar (II), while the growing impact of innovation pillar (I), human capital pillar (III) and trade as an integral part of institutions and economic regime pillar (IV) on economic growth in the later period 1999–2005 in comparison with the earlier period 1992–1998.

4.3 Regression with Agglomeration, Period 1995–2004

Another striking feature of OECD development in recent years is that GDP is unevenly distributed among regions within countries (Graph 1).

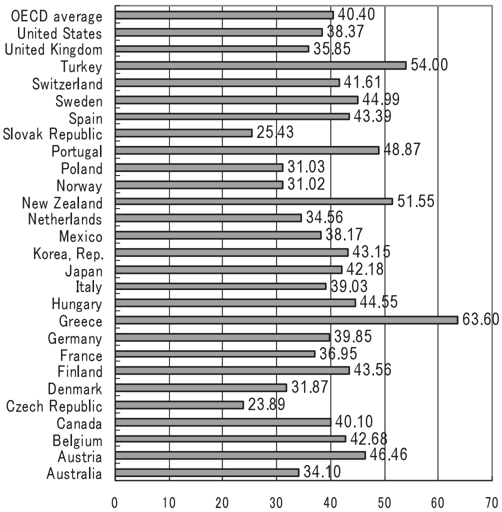
On average, almost 40% of national GDP in OECD member countries in 2004 was produced in only 10% of regions. This study is focused on GDP at territorial level 3 (like European NUTS 3) and accounts for the top 10% of regions from the total number of regions in each country. Given that data on regional GDP in OECD countries is only available since 1995, the regressions with agglomeration effects span the period 1995–2004.

GDP is particularly concentrated in a small number of regions in Greece and New Zealand, where 10% of regions account for more than half of national GDP. In Portugal, Austria, Sweden, Hungary, Finland, Spain, Korea, Belgium, Japan, Switzerland, Canada (in descending order) the top 10% of regions are responsible for more than 40% of national GDP. The territorial distribution of GDP is more dispersed in Slovakia and the Czech Republic, where the 10% of regions with the highest share in national GDP contribute just one-quarter of the national total. During this period concentration of GDP further increased in 20 countries and decreased in 7 countries.

When we account for effects of agglomeration economies on the top of capital, initial GDP per worker in 1994, knowledge economy variables, the results for period 1995–2004 can be interpreted as follows. A rise of one percentage point in agglomeration economies (analyzed as simple difference of concentration of GDP in top 10% of regions in 2004 minus concentration of GDP in top 10% of regions in 1995) conduces to 0.10 percentage point increase in compound annual economic growth per worker (Table 4, Regression 7 Agg).

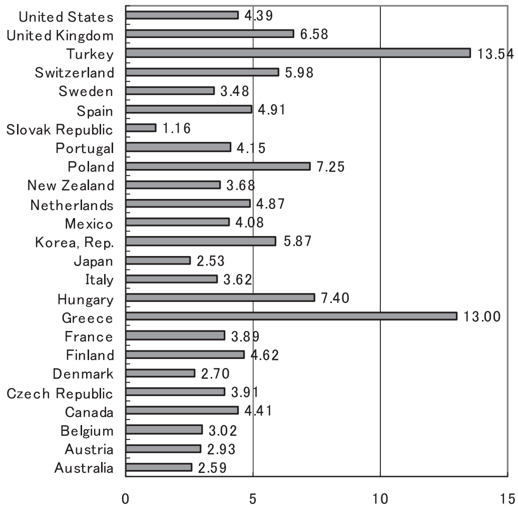
The present research also revealed that the differences in growth rates among regions within the

Graph 1. GDP Share of the Top 10% of Regions with the Highest Concentration of GDP, 2004



Source: Author's calculations based on National Statistics Accounts

Graph 2. Variation in GDP Growth Rates among Regions within Countries 1995–2004



Source: Author's calculations based on National Statistics Accounts

same country (Graph 2) are even larger than cross-country growth differences. One of the largest differences in growth rates among regions is observed in Turkey (13.54%) and Greece (13%), while the smallest was in Slovak Republic (1.16%) and Japan (2.53%) for period 1996–2004.[10] This difference in growth rates suggests that national performance is driven by the dynamism of a limited number of regions. The growth tends to be higher in countries where economic activity is highly concentrated (capital regions, etc) than in those where it is more dispersed.

5. Conclusion

The high level of development on the one hand and widening differences in growth performance of the 30 OECD member countries during the 1990s on the other hand afforded a good opportunity to investigate the key drivers of economic growth.

The study started with three main hypotheses, which have been consequently tested. It was outlined that the significant differences in GDP growth performance of OECD countries arise from large differences in Total Factor Productivity growth. Thus, improvement in TFP is important. In their turn, differences in TFP growth among OECD countries are explained by the state and development of knowledge and agglomeration economies. Firstly, the regression results confirmed that knowledge and agglomeration economies stand for the key sources of economic growth in OECD countries for the period 1992–2005.

Table 4. Dependent Variable: GDP Growth per Worker. Regression with Agglomeration, Period: 1995–2004

	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5	Reg 6	Reg 7 Agg
K/L (CAGR)	0.3179*** (6.6700)	0.2980*** (6.1875)	0.3298*** (7.0807)	0.3257*** (6.9365)	0.2924*** (6.8649)	0.2784*** (5.0003)	0.1713*** (3.5371)
Initial GDP per Worker, 1994		−0.7404* (−1.7253)	−1.1929** (−2.1380)	−1.2149** (−2.0451)	−1.4638*** (−5.7804)	−1.5058*** (−5.1165)	−2.3366*** (−4.4758)
I.1 BERD (%)			0.2711** (2.4818)	0.2205** (2.2883)	0.2083** (2.0880)	0.2041** (2.0679)	0.2041** (2.2871)
III.1. Tertiary Education (Δ=%-%)				0.0363 (0.7831)	0.0505 (1.2868)	0.0458 (1.1129)	0.0365 (1.1601)
IV.1. Foreign Trade (Δ=%-%)					0.0155*** (3.7945)	0.0160*** (3.6156)	0.0062 (0.7941)
IV.2. Market Capitalization (CAGR)						0.0073 (0.8238)	0.0227** (2.1618)
Agglomeration (Δ=%-%)							0.1007** (2.0915)
Constant	1.0197*** (5.6201)	1.6320*** (3.9163)	1.4374*** (3.4392)	1.3392*** (2.9299)	1.3195*** (4.3857)	1.3614*** (3.9677)	2.2019*** (4.4439)
R Squared	0.5915	0.6307	0.6906	0.7019	0.7782	0.7828	0.8682
Observation	30	30	30	30	30	30	27

*,**,*** denotes significance at the 90,95 and 99 percent confidence level respectively
t-Statistics in brackets
Robust standard errors obtained using White's correction for heteroskedasticity

In addition to capital, and initial level of GDP per worker, different proxies of knowledge and agglomeration economies exhibited positive and statistically significant impact on GDP growth per worker. The contribution of: 1) innovation pillar (BERD or USPTO patents), 2) Information Communication Technologies pillar (mobile phones), 3) human capital pillar (tertiary education attainment); 4) economic regime and institutions pillar (foreign trade and market capitalization); and 5) agglomeration economies to economic growth has been quantified and explained. The closer look at concentration of economic activities (agglomeration economies) reveals that the international differences in growth rates are smaller than differences among regions within the same country.

Secondly, it is the growth / changes in various proxies of knowledge and agglomeration economies that is highly correlated with output growth per worker. Only business expenditures on research and development (BERD) as a share of gross value in industry is considered as percentage share, due to data limitations for construction of BERD variable in the growth form. However, alternative regression showed that growth rate of USPTO patents (innovation pillar I) gives an impact on GDP per worker growth rate. Most important, the majority of independent variables like-mobile phones (pillar II), tertiary education attainment (pillar III), trade/GDP ratio (pillar IV.1), market capitalization (pillar IV.2); agglomeration economies (pillar V) have been constructed and tested in the growth form. Therefore, the growth in knowledge and agglomeration economies leads to increase in GDP per worker in OECD countries. This result has serious and promising implications for the developing countries in the following manner. Even if the level of knowledge infrastructure in the developing countries is much lower in comparison with the developed countries (KAM ratings), the increase in each pillar of knowledge economy and agglomeration economies will foster economic growth.

Thirdly, the results were checked for robustness in two different ways. Initially, principal regression 1992–2005, 30 observations is compared with regression combining 2 sub-periods 1992–1998 and 1999–2005, 60 observations. Regression with 2 combined periods afforded to 1) increase the number of observations; 2) pool together shorter periods for evidence of qualitative difference. The results of two regressions are consistent.

Later, comparison of results from the earlier period 1992–1998 regression and from the later period 1999–2005 regression provide evidence of a structural shift between the earlier period and the later period. For instance, the coefficient of capital slightly diminished from the earlier to later period, suggesting that recently capital growth reduced its impact on GDP per worker growth, while TFP increased its impact on GDP per worker growth. The coefficient of BERD, tertiary education, and trade increased, while the coefficient of mobile phones only slightly decreased in period 1999–2005 in comparison with period 1992–1998. Therefore, even if capital accumulation is limited in the developing countries, there is a scope to promote GDP growth owing to qualitative and quantitative improvements in TFP components, especially innovation, ICT, education, institutions and economic openness, and agglomeration economies. As to agglomeration economies, the size and growth in regional GDP is influenced by country-specific factors, region-specific factors and regional polices.

Two policy measures are clear. First, components of total factor productivity (pillars I-V) explain the significant share of differences in growth performance among countries, and deserve specially designed economic policies even in situations with limited capital accumulation. The current stage of innovation-driven development calls for further development and investment in knowledge and agglomeration economies to accelerate economic growth. Second, based on the provided statistical evidence, even before the achievement of certain high knowledge economy level, the forward growth in knowledge and agglomeration economies variables significantly influences economic growth. Moreover, regional development policies must be designed to capitalize on regional centers of growth as well as balance regional development.

Notes

1) Currently, authors use the term Total Factor Productivity (TFP) and Multi-Factor Productivity (MFP) interchangeably. This article implies "Total Factor Productivity (TFP)". Only when we make direct citation from OECD publications, we must mention term "Multi-Factor Productivity".

2) Please refer to Table 1. This is a simple average of figure in column 6 "Share of knowledge industries, %."

3) Technology and knowledge-based industries comprise: high technology manufactures, medium-high technology manufactures, post and telecommunications services, finance and insurance services, business activities (renting of machinery and equipment ISIC71, computer-related services ISIC72, research and development ISIC73 , and other services (ISIC 74; excluding real estate activities); education and health.

4) As can be seen from the formula below (with labor force and number of employed people simultaneously cancelled), the estimation of GDP per worker growth is correct:

$$\frac{GDP}{population} = \frac{Labor}{population} + \frac{employed}{labor} + \frac{GDP}{employed}$$

5) Data for the total labor force used in this paper are comprised of people who meet the International Labor Organization definition of the economically active population.

6) The author first tested various proxies for knowledge and agglomeration economies, and finally presents those with better fits.

7) Although both estimates are rounded up to 0.07, the actual estimation is 0.07312 for the earlier period 1992–1998 and actual estimation is 0.06642 for the later period 1999–2005.

8) In regards to period 1999–2005, the trial of instrument variables (foreign trade in period 1992–1998 and level of foreign trade in 1999) instead of foreign trade in period 1999–2005 did not improve the significance of the estimated coefficient in the complete specification. By doing this, it was attempted to control for endogeneity issue, namely that GDP growth may have an impact on foreign trade growth.

9) The trial of instruments instead of market capitalization for period 1999–2005 did not improve the significance of the estimated coefficient in the complete specification.

10) Author's calculations. The regional GDP for 27 OECD countries have been obtained from National Statistics Accounts. Data for European countries are from Eurostat, in millions of EUR at current prices. The figures have been recalculated into millions of national currency units (including euro zone former currencies) at current prices by utilizing the annual average exchange rates between the euro and the national currencies. At the next stage GDP deflator has been applied to get regional GDP figures in constant prices.

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