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Labour Productivity Convergence in 52 Industries: A Panel Data Analysis of Some European Countries

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ABSTRACT: β-convergence and the speed of convergence of labour productivity for 52 industries are studied with a panel of data including 13 European countries. We use fixed effect approach to model the heterogeneity across countries. In primary sector and in service sector, the existence of β-convergence is found for all industries. In manufacturing sector, convergence is found for all industries except for electronic and computing equipment industries. In general the speed of convergence estimates show slow adjustment. Speed is highest in the capital intensive industries. In primary production the convergence is slowest in agriculture and fastest in fishing industry. In manufacturing sector the convergence is slowest in food, drink and tobacco, and it is fastest in oil refining and nuclear fuel manufacturing industries. By augmenting the productivity models with labour utilization variable speeds up the convergence. Labour utilization is positively related to productivity growth in primary production industries, ICT producing manufacturing industries, and ICT producing services industries.

Keywords: Convergence; Speed of convergence; Labour productivity per person; Labour productivity per hour; Labour utilization
JEL Classifications:E1; E2; J; O4

1. Introduction

Between 1956 and 2000, EU countries converged with the U.S. in productivity levels. However, thereafter a productivity upsurge in the US reversed this convergence process and a new divergence path has followed ever since. Investments in Information and Communications Technologies (ICT) were found responsible for the higher productivity growth in the US, where the new technologies had been introduced earlier and at a faster pace than in the EU. The US-EU gap increased most in the ICT production sector (where US labour productivity growth was almost double that of the EU over 1995-2004) and the market services sector (see Inklaar et al., 2008). Many other studies show that fast growth in US labour productivity was accompanied by an investment boom in ICT equipment. There now seems general agreement that a large part of the increase in output can be accounted for by rapid growth in the stock of ICT equipment (see Bassanini et al., 2000; Triplett and Bosworth, 2000; Gordon, 2000; Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000).

The ICT influence growth through three main channels, namely: 1) rapid productivity growth in ICT manufacturing and the increasing size of these industries; 2) intensification of investment in equipment, incorporating information and communication technologies, and subsequent improvement in labour productivity; and 3) spillover effects on productivity generated by these technologies (OECD 2002).

Slow but significant improvement in labour productivity has been found in some European economies during past decade. The main reason for this development is efficient use of information and communication technology (ICT) in these economies (OECD, 2002). For example, ICT, average contribution to French GDP growth was estimated to be approximately 0.2% per year from 1969 to 1999. This figure increased to 0.3% between 1995 and 1999 (Cette et al., 2001). Another example is Finland and Sweden; these both countries have experienced stronger hourly labour productivity growth. In Finland the relatively high hourly labour productivity growth compared with the larger euro area countries is mainly a result of the high contribution of TFP growth and, at the sectoral level, the high contribution of the ICT-producing manufacturing sectors. The hourly labour productivity growth observed in the information and communication (ICT) using service sectors has also contributed to raising labor productivity growth relative to the larger euro area countries (Annenkov and Madaschi, 2005).

Therefore, two questions are relevant here. First, are the IT-related industries (i.e. ICT using and ICT producing industries) in different sectors (i.e. agriculture, industrial and services sector) contribute to labour productivity convergence in Europe? Secondly, what is the speed of convergence? Within this context, the aim of this paper is to analyze the labour productivity convergence and speed of convergence in the 56 industries during the last two decades.

The extent to which economies converge has received a lot of attention in economic literature (see O'Mahoney and DeBoer, 2002; Pilat, 2003; Crafts and O'Mahoney, 2001; Disney et al., 2003; Van Ark et al., 2008). Research has been constructed on the question of labour productivity convergence and its main determinants (for example see Mankiw et al., 1991). Many studies has been constructed the research on labour productivity convergence on combined manufacturing and services. For example, Bernard and Jones (1996a-c) claim that β-convergence at the level of GDP per capita is not caused by productivity convergence in manufacturing sector but instead by convergence in the services sector (see also Gouyette and Perelman, 1997). The catch-up and convergence of GDP per capita can never be established unless labour productivity at industrial level is understood. Therefore, the main objective of this study is to analyse the labour productivity convergence and its speed at disaggregated level, at level of 52 industries. This is a novel approach that helps us to understand the productivity convergence in details.

The convergence debate has been increasingly shifting into a debate on econometric techniques with claims that the rate of convergence has been overestimated (Lichtenberg, 1994) or underestimated (Islam, 1995; Lee et al., 1998). The researcher has also to confront over the choice of β or σ-convergence. β -convergence implies that less developed country performs better (catches up) on average when compared to more developed country. In β-convergence regression framework based on the difference equation the effect of labour productivity in first period on its relative change in the consecutive periods should be negative. However, the idea behind σ-convergence is that the variance of (log) labour productivity decreases in time as production technique becomes more similar among the countries (see Barro and Sala-i-Martin, 1995).

In this study, we estimate the value of β-convergence and the speed of convergence. We use cross country fixed effect estimation method for panel data of disaggregated level of 52 industries for 13 European countries in period 1979-2003. The analysis focuses also on economy sector level, labour utilization, and ICT productivity effects. In agriculture sector and in service sector, the existence of β-convergence is found for all industries. In manufacturing sector, convergence is found for all industries except for electronic and computing equipment industries. In general the speed of convergence estimates show slow adjustment. Speed is highest in the capital intensive industries. In primary production the convergence is slowest in agriculture and fastest in fishing industry. The convergence speed is fastest in oil refining and nuclear fuel manufacturing industries. By augmenting the productivity models with labour utilization variable speeds up the convergence. Labour utilization is positive related to productivity growth in primary production industries, ICT producing manufacturing industries, and ICT producing services industries.

The study is organized as follows. Section 2 reviews the theoretical model of labour productivity. Section 3 presents data and variables. Section 4 presents labour productivity convergence at economy sector level. Section 5 gives the results, and 6 conclude the paper.

2. Labour Productivity and Production Function

Labour productivity implies quantity of goods and services that can be produced by one worker or by one hour of work (for example, see Fernando and Yvonn 2008). Assume that output (Y) is a function of the capital stock (K) and hours worked (L). Output also depends on the amount of knowledge or technology *(A)* in the economy. These assumptions can be captured by the following production function as:

$$Y = AF(K, L), \tag{1a}$$

where F is a general form of production function . The variable A is also referred as total factor productivity. To the contribution of these three sources of growth, a growth accounting framework is used (Solow 1957, Jorgenson 1995).

$$Y = Ae^{Ct}K^{\beta}L^{\alpha} \quad , \text{ we have } \alpha + \beta = 1 \text{, and } \alpha = 1 - \beta . \quad (1b)$$

If we divide both sides by L and get output per capita

$$(Y / L) = A(K / L)^{\beta} . \quad (1c)$$

A study by Solow (1956) assumed that the economy can be characterized with a new classical aggregate production function with exogenous technological change. However when recent literature is followed the above productions function has the following form.

$$Y_t = K^{\alpha}{}_t (A_t L_t)^{1-\alpha} . \quad (1d)$$

Here, A_t is exogenous labour-augmenting technological change. The second element is the assumption that the capital stock accumulates according to

$$\dot{K}_t = sY_t - \delta K_{t,} \quad (1e)$$

where, s is the investment share of output, also assumed to be exogenous. The properties of this model can perhaps be better understood by using the following reformulated version. Defining the capital-output ratio as

$$X_t = \frac{K_t}{Y_t}, \quad (1f)$$

output per worker can be expressed as

$$y_t = \frac{Y_t}{L_t} = A_t X_t^{\frac{\alpha}{1-\alpha}} \quad (1g)$$

and productivity dynamics can then be expressed as

$$\dot{y}_t = g + \lambda(y^*{}_t - y_t) . \quad (1h)$$

g is growth rate of technological change. The convergence speed λ, of the capital-output ratio is also the so-called conditional convergence speed of output per worker. In other words, this is the speed at which output per worker closes the gap towards its steady-state level. The labour productivity of country is an indicator for increase in national income per capita. The growths of labour productivity differ significantly among countries and in time.

Various scolars agree that the economic forces are the most important determinant of productivity growth. For example, Solow (1957) described a way of decomposing different sources of growth in order to quantify the influence of technological change on variation in output per head, together with the influence of capital accumulation per head. Maddison (1995) argued that growth of productivity increased since 1870. In this period, the world population increased by a factor 5 in the period 1820 to 1992, while GDP per capita increased eight folds. In the model of Mankiw et al., (1992) savings and population growth are exogenous. The estimation results imply a large role of human capital. Therefore, we can say that productivity growth in each industry is not only relates to its past level, but economic forces, such as capital, labour and human capital are also the main sources of growth. Here, we restrict ourself to analyze the labour productivity convergence and its speed at disaggregated level, at level of 52 industries, which is a novel approach.

Note that when disaggregating the capital input to two parts, the production function can be written as:

$$Y = A\,F(K_{ICT}, K_N, L) . \quad (2)$$

Here, capital stock (K) is divided into ICT (information and communication technology) capital services (K_{ICT}) and non-ICT capital services (K_N). Note that productivity growth can be traced to the effects of the ICT revolution through at least three transmission channels, i.e. from investment in

ICT, the production of ICT, and possible “spillovers” from the use of ICT (see Van Ark and Inklaar, 2005). We condensate these effects to have two separate capital input effects, K_{ICT} and K_N.

The factor productivity growth is derived under Cobb-Douglas assumption as the growth of output minus a share weighted growth of inputs:

$$\Delta \ln A = \Delta \ln Y - \bar{v}_{ICT} \Delta \ln K_{ICT} - \bar{v}_N \Delta \ln K_N - \bar{v}_L \Delta \ln L \ , \qquad (3)$$

where Δ refers to time difference, and $\bar{v}$ ’s denotes average shares in total factor income. Because of constant return to scale, we have $\bar{v}_{ICT} + \bar{v}_N + \bar{v}_L = 1$. By rearranging equation (3) with labour productivity, defined as $y = Y/L$, we observe that

$$\Delta \ln y = \bar{v}_{ICT} \Delta \ln k_{ICT} + \bar{v}_N \Delta \ln k_N + \Delta \ln A \ ,$$

where $k \equiv K / L$ is capital labour ratio or the capital stock divided by hours worked. The result obtained underlines the importance of ICT based effects of labour productivity. In empirical analysis we divide the industries analyzed in three classes depending on their ICT extension and intensity.

The calculation of labour productivity needs some remarks in this context. Madden and Savage (1998) calculates labour productivity by dividing real GDP by total participants in the labour force. It is argued that as the composition of the labour force, in terms of the number of part-time workers, varies over time, the output per worker becomes an inadequate or misleading measure of labour productivity. In other words, if productivity is defined as output per worker, an increase in the number of part time workers (while output and total number of hours worked in the economy remains unchanged) over-estimate the decline in productivity. In order to overcome this problem productivity is defined both as output per hour worked and output per person. We analyze these separately and compare the results. The most obvious difference is the way the two measures behave over the business cycle. During economic downturn firms tend to retain workers but reduce their working hours (the labour hoarding phenomena). This lowers the output per worker compared to output per hour. During recovery this ratio reverts (for example, see Bauer and Lee, 2005).

3 Industrial Data Base

This section draws on internationally comparable GGDC (Groningen Growth and Development Centre) industry dataset that covers the period 1979-2003. It provides at the different level of details the industrial structures of the 13 European (the Schengen) countries (i.e. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Norway, Portugal, Spain, and Sweden, see GGDC, 2006). The dataset is an expanded version of OECD Structural Analysis (STAN) database. It contains a large number of variables for the 52 industries, including labour utilization rates, and most importantly for present study, labour productivity per hour and labour productivity per person.

Definition of Variables

Labour Productivity per Person (**LPP**):	Value added per person employed.
Labour Productivity per Hour (**LPH**):	Value added per hour worked.

LPP and **LPH** are volume indices 1995=100 (for more details, see GGDC 2006).

Labour Utilization (**LU**):	Labour utilization = total annual hours worked.
Total annual hours worked:	persons in work (i.e. in thousands of persons) × annual hours worked per employee.

Disaggregation of All Industries (ISIC REV 3)

The ICT classification of industries is based on the study of O'Mahony and van Ark (2003). Productivity growth is analyzed by industry taxonomy groups (ISIC codes) augmented with the ICT taxonomy.

1. Primary Production

Less Intensive ICT Using Industries

Agriculture (01)	Forestry (02)	Fishing (05)	Mining (10-14)

2. Manufacturing

ICT Producing Manufacturing

Office and computing equipment (30)	Insulated wire and cables (313)
Semiconductors and other electronic (321)	Radio and TV receiver (323)

Intensive ICT Using Manufacturing

Clothing (18)	Printing and publishing (22)	Other electrical machinery (31-313)
Other instruments (33-331)	Building and repairing of ships (351)	Aircrafts and space crafts (353)
Railroad and transport equipt (352+359)	MISC manufacturing (36-37)	

Less intensive ICT using Manufacturing

Food, drink, and tobacco (15-16)	Textiles (17)	Lather and footwear (19)
Wood product (20)	Pulp and paper product (21)	Oil refining and nuclear fuel (23)
Chemicals (24)	Rubber and Plastics (25)	Non-metallic Mineral products
Basic metals (27)	Febricated metal products (28)	Motor vehicles (34)

3. Services

ICT Producing Services

Post and telecommunications (64)	Computer and related services (72)

Intensive ICT Using Services

Whole sale trade (51)	etaile trade (52)
Financial intermediation (65)	Insurance and pension funding (66)
Activities auxiliary to financial (67)	Renting machinery equipment (71)
Research and development (73)	Professional business services (741-3)

Less intensive ICT using Services

Repairs (50)	Hotels and restaurants (55)
Inland transport (60)	Water transport (61)
Air transport (62)	Auxiliary transport activites (63)
Real estate activities (70)	Other business services (749)
Electricity water and gas supply (40-41)	Construction (45)
Public administration and defense (75)	Education (80)
Health and social work (85)	Other community, social and personal services (90-93)
Private house hold with employed persons (95)	

In recent years we have seen a growing interest in non-stationary (or difference stationary) panels. We tested unit roots in panel setting (N = 13, T = 25) for logs of following series: labour productivity per person (LLP), labour productivity per hour (LPH) and labour utilization (LU) in each industry. We use LLC test (see Levin, Lin and Chu, 2002), and Fisher–PP test (Maddala and Wu 1999). We found series lnLPP, lnLPH, and lnLU to be stationary in all 52 industries. The detailed test results are provided by request.

4. Labour Productivity Convergence

The theory of convergence is one of the most important issues in modern macro economics. Barro regression for cross-country analysis is an extension of neo-classical model of economic growth. The basic assumptions of this model are that production entails diminishing returns to capital and constant returns to scale (see Barro and Sala-i-Martin, 1995). The main feature of this model is the conditional convergence, i.e. countries converge towards their steady state in the long run. If different counties have the same steady state level of output then they will converge same level of output. We model the convergence in labour productivity at industry level in different economy sectors augmented with ICT taxonomy. Here, the concept of β -convergence builds on the notion that industry that is further away from its steady state level experiences faster productivity growth. This can be motivated by marginal productivity of capital, imitation, and positive catch-up and spill-over effects in each country's industry development process.

As a result an empirical test thus builds on a regression of productivity growth on initial productivity level. This convergence relation can be written in the following general functional form:

$$\Delta \ln y_{i,t} = f\left(y_i^*, y_{i,0}\right), \quad (4)$$

where $\Delta \ln y_{i,t}$ the growth rate of labour productivity. y_i^* is the steady state level of labour productivity of the country *i*, and $y_{i,0}$ is the initial level of labour productivity. The steady state level of productivity for a country depends upon different variables that control the country differences. There are too many possibilities to control country differences (see Durlauf and Quah, 1999, Durlauf et al 2005). To overcome this "regression fatigue" we use first only fixed effect dummy variables to control country specific differences. If we control for the steady state properly then the linear relationship between $\Delta \ln y_{it}$ and $\ln y_{i,t-1}$ estimates the convergence for each industry. If the coefficient on $\ln y_{i,t-1}$ is negative, then corresponding industry us converging. If the relationship is positive then it is a sign of divergence. Therefore, for each industry the convergence equation for labour productivity per person in panel of observations can be written as follows:

$$\text{LPP:} \quad \Delta \ln y_{i,t}^{p} = \alpha_i + \beta^{p} \ln y_{i,t-1}^{p} + u_{i,t} \quad (5)$$

Similarly, for each industry the convergence equation for labour productivity per hour in panel of observations can be written as follows:

$$\text{LPH:} \quad \Delta \ln y_{i,t}^{h} = \alpha_i + \beta^{h} \ln y_{i,t-1}^{h} + u_{i,t} \quad (6)$$

Following Islam (1995) we use five-year non-overlapping averages in order to reduce the influence of business-cycle fluctuations and serial correlation of the error term. This reduces the number of time observations *t* from 25 to 5, i.e. we have panels of 13×5 observations for each industry in the growth rate regression Equations 5 and 6.

5. Results

Table 1, 2 and 3 present the estimate obtained from equations 5 and 6. Using the estimated value of β, the speed of convergence λ at which the productivity level is converging to a uniform productivity level can be calculated according to $\lambda = -\left[(1/T)\ln(\beta+1)\right]$. *T* denotes the length of the time interval under consideration (*T = 5* in this study). A convenient way to express the speed of convergence is the time needed for the productivity level to move halfway its initial level y_0 and steady state productivity level y^*. This period of time is commonly referred to as the "half life" (*H*)[1] (see Peter 2006). The implied values of λ are also shown in following tables.

5.1 Primary Production[2]

Both LPP and LPH models produce negative estimate of β for labour productivity growth in all primary production industries, indicating the existence of β convergence. Moreover, the estimate is statistically significant in all industries at 5% level. The estimated value of β is highest in Fishing industry (ISIC 05) and lowest for Agriculture industry (ISIC 01), indicating that convergence in primary production is slowest in Agriculture industry and fastest in Fishing industry.

The implied values for the speed of convergence (λ) conform the finding of a rate of convergence in labour productivity per person and labour productivity per hour: the time needed for labour productivity to move halfway its initial level y_0 and steady state y^* varies from 27 years (fishing) to 66 years (agriculture) in LPP. It varies from 30 years (fishing) to 61 years (agriculture) in LPH. Note that agriculture sector is heavily subsided in Europe making the production and market adjustment process slowly. The convergence speed (λ) in the LPP is higher than the convergence

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1 Approximating around the steady state, convergence speed is given by

$$d\ln(y_t)/dt = \lambda\left[\ln(y^*) - \ln(y_t)\right].$$

Rewriting gives $\ln(y_t) - \ln(y_0) = (1 - e^{-\lambda t})\left[\ln(y^*) - \ln(y_0)\right]$, where y_0 level at some initial date. From this equation we can derive the half-life (*H*) satisfying the equality $e^{-\lambda H} = 0.5$. So $H = \ln(2)/\lambda$.

2 Appendix gives test values for the estimation results.

speed in LPH for all industries except agriculture. Agriculture sector in Europe is modern and capital intensive today. Therefore, use of high technological machines has increased the labour productivity per hour in agriculture sector. The adjustment happens via labour force decline not necessarily via worked hours.

Table 1. Results based on Less Intensive ICT using industries)

	β convergence (LPP)			β convergence (LPH)		
ISIC	β	λ	**H**	β	λ	**H**
01	-0.051**	0.010	*66*	-0.055**	0.011	61
02	-0.089**	0.018	37	-0.081**	0.016	41
05	-0.117**	0.024	27	-0.107 **	0.022	30
10-14	-0.064***	0.013	52	-0.062***	0.012	54
Mean	-0.080	0.016	41	-0.076	0.015	44

*** 1% level, ** 5% level. For more details see Appendix A 1.

5.2 Manufacturing

ICT Producing Manufacturing: Both in LPP and LPH models a negative estimate of β is obtained for all industries except electronic and computing equipment producing manufacturing industries (ISIC 30 and 321). The estimated (absolute) value of β is highest in insulated wire and cables producing manufacturing (313) and lowest in Radio and TV receiver producing manufacturing (323). The convergence speed (λ) in the LPP is slower than the convergence speed in LPH for all industries.

Intensive ICT Using Manufacturing: Negative estimate of β is found for labor productivity growth in all industries, indicating the existence of β convergence. The results are approximately same in both LPP and LPH models. The adjustment is slowest in Clothing manufacturing (ISIC 318) and fastest in Railroad and transport equipment manufacturing industries (ISIC 352+329). Thus estimated half-life varies from 15 years to 73 years. Similarly, from LPH model the estimated half-life varies from 18 years (to 89 years. Typically the Clothing industry is less capital intensive compared to Railroad and transport equipment industries.

Less Intensive ICT Using Manufacturing: The results in LPP and LPH models are approximately same. The estimates are statistically significant in all industries. The estimated (absolute) value of β is highest for the capital intensive Oil refining and Nuclear fuel manufacturing (ISIC 23), and lowest for Food, drink, and tobacco manufacturing industry (ISIC15-16). Estimated half-life varies from 11 years (Oil refining and nuclear fuel) to 229 years (Food, drink, and tobacco). The convergence speed in the LPP is higher than the convergence speed in LPH for all industries except Food, drink, and tobacco.

5.3 Services

ICT Producing and Intensive ICT Using Services: Negative estimate of β is found in all services industries, indicating the existence of β convergence. However, results of LPP and LPH models are quite different. The estimates are statistically significant in all industries except Wholesale trade (ISIC 51), Retaile trade (ISIC 52), and Financial intermediation services industries (ISIC 65) in LPH models. In LPP, convergence is lowest in financial services industry and fastest in Insurance and pension funding services industries (ISIC 66). Contrary to this, in LPH convergence is slowest in Insurance pension funding and renting machinery services industry (ISIC 71) and fastest in Professional business services industry (ISIC 741-3). From LPP the estimated half life is between 28 years (Renting machinery and equipment) and 163 years (Retail trade). Similarly in LPH, the estimated half life is between 28 years (Professional business services) and 202 years (Retailer trade).

Table 2. Results based on Manufacturing Industries

	β convergence (LPP)			β convergence (LPH)		
ISIC	β	λ	**H**	β	λ	**H**
ICT Producing Manufacturing						
30	0.059***	---	---	0.062***	---	---
313	-0.061**	0.012	55	-0.065**	0.013	51
321	0.022	---	---	0.028	---	---
323	-0.047**	0.009	71	-0.057**	0.011	59
Mean	-0.006	0.001	572	-0.008	0.001	431
Intensive ICT Using Manufacturing						
18	-0.046**	0.009	73	-0.038**	0.007	89
22	-0.054**	0.011	62	-0.045**	0.009	75
31-313	-0.048*	0.009	70	-0.040*	0.008	84
33-331	-0.082**	0.017	40	-0.072**	0.014	46
351	-0.137**	0.029	23	-0.051	0.010	66
353	-0.175**	0.038	18	-0.133**	0.028	24
352-359	-0.198**	0.044	15	-0.168***	0.036	18
36-37	-0.097***	0.020	33	-0.070***	0.014	47
Mean	-0.104	0.022	32	-0.077	0.016	43
Less intensive ICT using Manufacturing						
15-16	-0.015*	0.003	229	-0.020*	0.004	171
17	-0.075***	0.015	44	-0.067***	0.013	49
19	-0.101***	0.021	32	-0.082***	0.017	40
20	-0.048**	0.009	70	-0.035*	0.007	97
21	-0.063**	0.013	53	-0.041**	0.008	82
23	-0.245***	-0.043	15	-0.253***	0.058	11
24	-0.029*	0.005	117	-0.029*	0.005	117
25	-0.064***	0.013	52	0.051***	0.010	66
26	-0.073***	0.015	45	-0.061***	0.012	55
27	-0.051**	0.010	61	-0.051**	0.010	66
28	-0.060**	0.012	56	-0.052**	0.010	64
34	-0.066**	0.013	50	-0.068**	0.014	49
Mean	-0.074	0.015	45	-0.067	0.014	50

**** 1% level, ** 5% level, and * 10% level. For more details see Appendix A2-A3*

Less intensive ICT using **Services:** Negative estimate of β is found in all industries, indicating the existence of β convergence. The results are approximately same in LPP and LPH models. The estimates in both models are statistically significant in all industries except in ISIC 61,64, and 40-41. The estimated (absolute) value of β is highest for Business services industries (ISIC 749) and lowest for Electricity water and gas supply services industry (ISIC 40-41) In many industries the convergence speed in the LPP is higher than in LPH.

Table 3. Results based on Services Industries

	β convergence (LPP)			β convergence (LPH)		
ISIC	β	λ	**H**	β	λ	**H**
ICT Producing Services						
64	-0.006	0.001	375	0.0003	--------	---------
72	-0.105**	0.022	31	-0.096**	0.020	34
Mean	-0.055	0.011	61	-0.047	0.009	72
Intensive ICT Using Services						
51	-0.023	0.004	148	-0.023	0.004	48
52	-0.021	0.004	163	-0.017	0.003	202
65	-0.023	0.004	148	-0.018	0.003	190
66	-0.130**	0.027	124	-0.089**	0.018	37

67	-0.106***	0.022	30	-0.098**	0.020	33
71	-0.115***	0.024	28	-0.090***	0.018	36
73	-0.096	0.020	34	-0.104	0.021	31
741-3	-0.105**	0.022	31	-0.116***	0.024	28
Mean	-0.063	0.013	53	-0.069	0.014	48
Less intensive ICT using Services						
50	-0.111**	0.023	29	-0.078**	0.016	42
55	-0.098***	0.020	33	-0.126***	0.026	25
60	-0.053***	0.010	63	-0.052***	0.010	64
61	0.0001	---	---	-0.0003	---	---
62	-0.104**	0.021	31	-0.121***	0.025	26
63	-0.026	0.005	20	-0.34*	0.006	100
70	-0.159***	0.034	15	-0.138***	0.029	23
749	-0.204***	0.045	110	-0.204***	0.045	15
40-41	-0.031**	0.006	21	-0.007	---	---
45	-0.146**	0.031	33	-0.116***	0.024	28
75	-0.097**	0.020	29	-0.058**	0.011	58
85	-0.111**	0.023	50	-0.103**	0.021	31
90-93	-0.080***	0.016	41	-0.090**	0.018	36
95	-0.126***	0.026	26	-0.091***	0.019	37
80	-0.128***	0.027	25	-0.088***	0.018	38
Mean	-0.074	0.020	33	-0.087	0.018	38

**** 1% level, ** 5% level, and * 10% level. For more details see Appendix A4-A7*

5.4 Mean Convergence

Tables above included means of industry convergence estimates in analysed seven classes. In order to evaluate class mean differences we assume that calculated mean values are independent random values without sampling and estimation error. Anova-F and Welch-F tests are used to test mean value equality across the seven classes.

Table 4. ANOVA and WELCH TEST

	ANOVA-F(6,46)	**WELCH-F (6,9.05)**
Mean β, **LPP**	2.00 (0.08)	1.36 (0.32)
Mean β, **LPH**	1.30 (0.27)	0.72 (0.54)

Test results reveal that we are not able to reject the hypothesis of mean equality across all classes (p-values in parenthesis). Note that this result does not reject the industry level differences in convergence. The result indicates only that used ICT classification at the level of three main economy sectors may not produce different convergence estimates.

5.5 Sector Level Convergence

In analysis above, a separate regression model for each of 52 industries was estimated across 13 sample countries in years 1979 - 2003. This is one way to deal with the industry heterogeneity. However, we expect to see some correlations across industries as many production linkages exist between different industries. Thus productivity gains in industry X may affect industry Y productivity. If such correlations exist (correlations can be negative, too), they were excluded in above fixed effects OLS estimations. Instead of using spatial correlation type of methods (see Pesaran et al., 2007) we propose a two way fixed affects LPH model to be estimated at economy sector level.

$$\Delta \ln y_{ijt}{}^{h} = \alpha_i + \eta_t + \beta_j{}^{h} \ln y^{h}{}_{ijt-1} + u_{ijt} \qquad (7)$$

where i is the country index, and j is the economy sector index where industry belongs. The Primary sector includes 4 industries, Manufacturing includes 24 industries, and Services sector 24 industries. t is for time of the observations. η_t captures the common sector level trend effects of productivity growth across the countries. This is the fixed trend effect the model. The negative value of β implies the convergence among the industries in different sectors where they are located.

A negative estimate of β for labour productivity growth is obtained for all sectors, indicating the existence of β convergence (Table 4). Moreover, the estimates are statistically significant. However the estimated value of β is close to zero in all sectors indicating very slow convergence. The result is an indication of sector level adjustment where the existence of optimal size or level of sector is not warranted. Besides this the industry cross-correlations may influence the results in spite of included common trend effect. However, note that the lack of convergence found within economy sector does not reveal the spread of the extent of convergence across industries (see Carree et al., 2000).

Table 5. Industry Productivity Convergence at Sector Level

	β convergence (LPH)		
ISIC	β	λ	**H**
Primary	-0.029***	0.0050	117
Manufacturing	-0.004***	0.0008	864
Services	-0.002***	0.0004	1731
ALL	-0.002**	0.0004	1731

**** 1% level, ** 5% level,*

5.6 β -convergence and Labour Utilization

An inverse relationship between the contributions to growth from labour utilisation[3] and labour productivity has been very evident for the EU over the second half of the 1990's. For the EU, the marked upward trend in the overall contribution from labour is driven by employment growth rather than by an increase in hours worked. While the fall in average hours worked is now substantially less than in previous decades, nevertheless the average time spent at work continues to fall in the EU, see Cecile et al (2004). However, the study by Juan et al. (1999) found that some European regions have recorded considerable productivity gains at the expense of employment, whereas other industries have obtained comparable gains but retain the status of regions in which employment is still being created. This suggests that a further analysis is needed in order to understand the relationship between labour productivity growth and labour utilization in each industry. Therefore, these contradictions enforce us to analyze the convergence in labour productivity and its relationship with labour utilization.

We estimate labour productivity per person (LPP) and labour productivity per hour (LPH) models augmented with labour utilization variable. We use two way fixed effect models to control country and time specific effects. Hence, we capture the impact of labour utilization in the convergence of labour productivity in models like

$$\Delta \ln y_{it}^{\ p} = \alpha_i + \eta_t + \beta^p \ln y^p{}_{it-1} + \gamma^p \ln LU_{it-1} + u_{i,t}\,, \qquad (8a)$$

$$\Delta \ln y_{it}^{\ h} = \alpha_i + \eta_t + \beta^h \ln y^h{}_{it-1} + \gamma^h \ln LU_{it-1} + u_{i,t}\ . \qquad (8b)$$

Here, as η_t control the business cycle effects, a negative sign for γ^p is a sign of labour hoarding phenomena in terms of hours. The level of hours utilized at previous period does not go down as the productivity growth retards. Alternatively if productivity grows less labour utilizations takes place.

We test hypothesis

$$H_0 : \gamma^{p/h} = 0 \qquad \text{or} \qquad H_1 : \gamma^{p/h} \neq 0\,.$$

[3] Labour utilization = total annual hours worked. Where, total annual hours worked = persons engaged (i.e. in thousands of persons) × annual hours worked per employee.

Rejection of H_0 implies that the coefficient of labour utilization is significant, i.e. labour utilization has an impact on labour productivity.

5.6.1 Primary Production

Negative estimate of β is still obtained for labour productivity growth in all industries. The inclusion of labour utilization in models decreases the half life (*H*) for all industries. Negative estimate of γ with significance are obtained for Agriculture (ISIC 01) and Forestry industries (ISIC 02) in LPH model. Contrary to this we obtained positive estimate of γ for LPP model in all industries. This shows that these industries are labour intensive, i.e. productivity per head growth is positive related to level of total annual hours worked.

Table 6. Results based on Primary Less Intensive ICT using industries

		β convergence (LPP)				β convergence (LPH)		
ISIC	β^p	γ^p	λ	**H**	β^h	γ^h	λ	**H**
01	-0.132*	0.116*	0.028	*24*	-0.145	-0.139**	*0.031*	*22*
02	-0.129**	0.077*	0.027	*25*	-0.111**	-0.058*	*0.023*	*29*
05	-0.146**	0.028	0.031	*21*	-0.151**	-0.51**	*0.032*	*21*
10-14	-0.067***	0.004	0.013	*49*	-0.067***	-0.010	*0.013*	*49*
Mean	-0.118	0.056	0.025	*27*	-0.119	-0.64	*0.025*	*27*

***** *1% level, ** 5% level. For more details see Appendix A.*

5.6.2 Manufacturing

All industries except Office and computing equipment (ISIC 30) are converging. In LPP model negative estimate of γ is obtained in all industries. In LPH model, positive estimate of γ is found only in ICT producing manufacturing industries. Thus manufacturing industries are not labour intensive in general.

Table 7. Results based on Manufacturing Industries

		β convergence (LPP)				β convergence (LPH)		
ISIC	β^p	γ^p	λ	**H**	β^h	γ^h	λ	**H**
ICT Producing Manufacturing								
30	0.065***	-0.126*	---	---	0.070***	0.103*	---	---
313	-0.075**	-0.058	0.015	44	-0.085**	0.057*	0.017	39
321	0.126	- 0.059	---	---	-0.031*	0.070	0.006	110
323	-0.098**	- 0.062*	0.020	33	-0.088**	0.137**	0.018	37
Mean	0.004	-0.076	---	---	-0.033	0.092	0.007	103
Intensive ICT Using Manufacturing								
18	-0.049**	-0.003	0.010	68	-0.050**	-0.013	0.010	67
22	-0.065**	-0.052*	0.013	51	-0.055**	- 0.054*	0.011	61
31-313	-0.050*	-0.021**	0.010	67	-0.050 **	-0.117**	0.010	67
33-331	-0.097**	-0.033	0.020	33	-0.080**	-0.045*	0.016	41
351	-0.236**	-0.087*	0.053	12	-0.093*	- 0.048	0.019	35
353	-0.162**	-0.053*	0.035	19	-0.119**	-0.064*	0.025	27
352-359	-0.173*	-0.638*	0.037	18	-0.137*	-0.078*	0.029	23
36-37	-0.099**	-0.004	0.020	31	- 0.069**	-0.022	0.014	48
Mean	-0.116	-0.111	0.024	28	-0.082	-0.053	0.018	40
Less intensive ICT using Manufacturing								
15-16	-0.054**	-0.076**	0.111	62	-0.047**	-0.074**	0.009	71
17	-0.092***	-0.041*	0.505	1	-0.099**	-0.074**	0.020	33
19	-0.153**	-0.059**	0.033	20	-0.134***	0.056	0.028	24
20	-0.047***	-0.014	0.009	71	-0.033***	-0.025	0.006	103
21	-0.089**	-0.069*	0.018	37	- 0.062**	-0.070*	0.012	54
23	-0.249**	-0.068	0.057	12	- 0.259***	0.014	0.059	11
24	-0.041**	0.086	0.008	82	- 0.043**	-0.083*	0.008	78

25	-0.064**	0.036	0.013	52	-0.050**	-0.017	0.010	67
26	-0.093***	- 0.090**	0.019	35	- 0.077***	-0.083*	0.016	43
27	-0.104**	-0.082*	0.021	31	-0.108**	- 0.099	0.022	30
28	-0.061**	-0.011	0.012	52	-0.052**	0.022	0.010	64
34	-0.071**	- 0.009*	0.014	47	- 0.070*	-0.019	0.014	47
Mean	-0.093	-0.033	0.019	35	-0.086	-0.037	0.017	38

**** 1% level, ** 5% level, and * 10% level.*

5.6.3. Services

For services we obtained mixed estimate of γ in LPP and LPH models. Labour utilization is positive in all ICT producing services industries. Estimated value of γ is negative for Retail trade (ISIC 52) and Professional business services (ISIC 741-3) of intensive ICT using services. The impact of labour utilization on labour productivity growth is mainly found negative for less intensive ICT using services. In Air transport (ISIC 62), Public administration and defense (ISIC 75), and Health and social work (ISIC 85) we found positive labour utilization effect on labour productivity.

Table 8. Results based on Services Industries

		β convergence (LPP)				**β convergence (LPH)**		
ISIC	β^p	γ^p	λ	**H**	β^h	γ^h	λ	**H**
ICT Producing Services								
64	-0.003	0.042	0.0006	1153	0.002	0.020	---	---
72	-0.108**	0.005	0.022	30	-0.101**	0.010	0.021	32
Mean	-0.055	0.023	0.011	61	-0.049	0.015	0.010	68
Intensive ICT Using Services								
51	-0.025	-0.005	0.005	136	-0.025	-0.005	0.005	136
52	-0.034*	-0.055*	0.006	100	-0.034*	0.055*	0.006	100
65	-0.029	0.006	0.005	117	-0.029 **	0.006	0.005	117
66	-0.129*	-0.027	0.027	25	-0.129***	-0.027	0.027	24
67	-0.100**	0.014	0.021	32	-0.100**	0.014	0.021	32
71	-0.114	0.010	0.024	28	-0.114***	0.010	0.024	28
73	-0.088***	0.007	0.018	37	-0.088	0.007	0.018	37
741-3	-0.132*	-0.046**	0.028	24	-0.132**	-0.046**	0.028	24
Mean	-0.081	-0.012	0.016	41	-0.085	-0.012	0.017	39
Less intensive ICT using Services								
50	-0.115**	0.059*	0.024	28	-0.105**	- 0.056*	0.022	31
55	-0.129***	-0.056**	0.027	25	-0.138***	-0.031*	0.029	32
60	-0.161***	-0.027	0.012	55	-0.062***	- 0.011	0.012	55
61	0.012	-0.049**	---	---	0.001	-0.045**	---	---
62	-0.120	0.052*	0.025	27	-0.143***	0.072*	0.030	22
63	-0.019	-0.040*	0.003	180	-0.024	-0.030*	0.004	142
70	-0.192**	-0.043**	0.042	16	-0.146***	-0.028*	0.031	21
749	-0.219***	-0.024*	0.049	14	-0.203***	-0.016*	0.045	15
40-41	-0.067**	-0.121**	0.013	49	-0.042**	-0.111**	0.008	80
45	-0.147***	-0.021*	0.031	21	-0.114***	-0.014	0.024	28
75	-0.091***	0.0417*	0.019	36	-0.060**	0.023*	0.012	56
85	-0.123***	0.017*	0.026	26	-0.121***	0.023*	0.025	26
90-9	-0.094*	-0.022	0.019	35	-0.097**	- 0.015	0.020	33
95	-0.132***	-0.006	0.028	24	-0.08**	0.003	0.018	37
80	-0.133***	0.007	0.028	24	-0.094***	0.007	0.019	35
Mean	-0.115	-0.015	0.024	28	-0.095	-0.015	0.020	34

**** 1% level, ** 5% level,, and * 10% level.*

5.6.4 Mean Labour Utilization

Testing for mean labour utilization across the ICT classes in different economy sectors produces a rejection of equality of γ mean estimates. Note that Welch –test is more appropriate in this context as the class cell variances are not equal.

Table 9. ANOVA and WELCH for Labour Utilization

	ANOVA-F(6,46)	WELCH-F (6,13.25)
Mean γ **LPP**	1.96 (0.09)	3.57 (0.04)**
Mean γ **LPH**	7.21 (0.00)***	9.11 (0.00)***

**** 1% level, ** 5% level*

The result is an indication of importance labour utilization in different industries when attention is paid to ICT classification across industries and economy sectors. Note that β -convergence estimates are close to each other in models with and without labour utilization variable (see tables above). Thus we can argue that convergence differences are not as important as labour utilization at the sector level productivity.

6. Conclusion

The study has analyzed the β-convergence, speed of convergence (λ), and the time needed for the productivity level to move halfway of its initial and the steady state productivity level. We used panel data of 13 European countries in period 1979-2003 for 52 industries. The results imply that labour productivity shows in all industries except in electronic and computing equipment existence of β-convergence. The value of speed of convergence is 11 years. Speed was highest in the capital intensive industries. At economy sector level the productivity convergence among industries was exceptionally slow. We used η_t to control the business cycle effects. Adding labour utilization measured as total annual hours worked in models gave higher convergence results. An extensive literature supports our finding, for example, large number of studies show that the US labour productivity performance is better than EU (see Bassanini et al., 2000; Triplett and Bosworth, 2000; Gordon, 2000; Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000). The level of labour utilization in the EU is lower than that prevailing in the US. Europe is often pointed at as making insufficient use of its potential labour, which would partly explain the gap with the US in productivity and its slower growth rate as well. This could be seen empirically in the much lower employment rate and the slower employment growth in the EU compared with the US over the long run (see Mourre, 2009). Therefore, Labour utilization augments convergence in labour productivity. Labour utilization is positive related to productivity in primary production industries, ICT producing manufacturing industries, and ICT producing services industries. Therefore, policy maker should generate more jobs in these sectors where they can reduce the unemployment not by the cost of the productivity growth.

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Appendix

Diagnostic statistics for estimation
Joint: joint test of β and fixed effects.
Dummy: test for fixed effects
AR(1) and *AR(2):* p-values of residual AR- tests

Appendix A-1: Primary Production (Less Intensive ICT Using Industries)

ISIC	β	λ	Wald test	R^2	AR(1)	AR(2)
A. β convergence for labour productivity per person						
01	-0.051** (0.01)	0.010	(joint)** (dummy)**	0.39	0.15	0.48
02	-0.089** (0.02)	0.018	(joint)* (dummy)**	0.37	0.12	0.41
05	-0.117** (0.04)	0.024	(joint)* (dummy)**	0.35	0.42	0.10
10-14	-0.064*** (0.01)	0.013	(joint)* (dummy)**	0.66	0.20	0.31
B. β convergence for labour productivity per hour						
01	-0.055** (0.01)	0.011	(joint)* (dummy)**	0.39	0.15	0.70
02	-0.081** (0.02)	0.016	(joint)* (dummy)**	0.39	0.12	0.32
05	-0.107** (0.03)	0.022	(joint)* (dummy)**	0.30	0.12	0.09*
10-14	-0.062*** (0.03)	0.012	(joint)* (dummy)**	0.66	0.17	0.34

**** 1% level, ** 5% level, and * 10% level*

Appendix A-2: Manufacturing ICT Producing Manufacturing Intensive ICT Using Manufacturing

ISIC	β	λ	Wald test	R^2	AR(1)	AR(2)
A. β convergence for labour productivity per person						
18	-0.046** (0.01)	0.009	(joint)* (dummy)**	0.57	0.10	0.43
22	-0.054** (0.01)	0.011	(joint)* (dummy)**	0.40	0.12	0.32
31-313	-0.048* (0.02)	0.009	(joint)* (dummy)**	0.30	0.10	0.38
33-331	-0.082** (0.02)	0.017	(joint)* (dummy)**	0.40	0.11	0.16
351	-0.137** (04)	0.029	(joint)* (dummy)**	0.30	0.12	0.77
353	-0.175** (0.05)	0.038	(joint)* (dummy)**	0.30	0.17	0.09*
352-359	-0.198*** (0.04)	0.044	(joint)* (dummy)**	0.35	0.16	0.52
36-37	-0.097*** (0.02)	0.020	(joint)* (dummy)**	0.47	0.10	0.26
B. β convergence for labour productivity per hour						
18	-0.038** (0.01)	0.007	(joint)* (dummy)**	0.42	0.10	0.50
22	-0.045** (0.02)	0.009	(joint)* (dummy)**	0.38	0.12	0.25
31-313	-0.040* (0.02)	0.008	(joint)* (dummy)**	0.20	0.10	0.48
33-331	-0.072** (0.02)	0.014	(joint)* (dummy)**	0.36	0.11	0.15
351	-0.051 (04)	0.010	(joint)* (dummy)**	0.25	0.10	0.70
353	-0.133** (0.05)	0.028	(joint)* (dummy)**	0.30	0.25	0.09*
352-359	-0.168*** (0.04)	0.036	(joint)* (dummy)**	0.35	0.26	0.22
36-37	-0.070*** (0.02)	0.014	(joint)* (dummy)**	0.45	0.11	0.32

**** 1% level, ** 5% level, and * 10% level*

Appendix A-3: Manufacturing (Less intensive ICT using Industries)

ISIC	β	λ	Wald test	R^2	AR(1)	AR(2)
A. β convergence for labour productivity per person						
15-16	-0.015* (0.01)	0.003	(joint)* (dummy)**	0.47	0.24	0.14
17	-0.075*** (0.01)	0.015	(joint)** (dummy)**	0.56	0.12	0.70
19	-0.101*** (0.02)	0.021	(joint)** (dummy)*	0.41	0.19	0.14
20	-0.048** (0.02)	0.009	(joint)* (dummy)**	0.47	0.11	0.13
21	-0.063** (0.02)	0.013	(joint)** (dummy)*	0.35	0.13	0.09*
23	-0.245*** (0.04)	-0.043	(joint)** (dummy)**	0.57	0.58	0.11
24	-0.029* (0.01)	0.005	(joint)* (dummy)**	0.31	0.39	0.19
25	-0.064*** (0.01)	0.013	(joint)** (dummy)**	0.64	0.16	0.23
26	-0.073*** (0.02)	0.015	(joint)** (dummy)**	0.39	0.20	0.16
27	-0.055** (0.01)	0.011	(joint)** (dummy)**	0.40	0.17	0.32
28	-0.060** (0.01)	0.012	(joint)** (dummy)*	0.40	0.24	0.14
34	-0.066** (0.01)	0.013	(joint)** (dummy)**	0.46	0.18	0.14
B. β convergence for labour productivity per hour						
15-16	-0.020* (0.01)	0.004	(joint)* (dummy)**	0.52	0.21	0.10
17	-0.067*** (0.01)	0.013	(joint)** (dummy)**	0.50	0.12	0.70
19	-0.082*** (0.02)	0.017	(joint)** (dummy)*	0.38	0.22	0.09
20	-0.035* (0.01)	0.007	(joint)* (dummy)**	0.42	0.11	0.10
21	-0.041** (0.01)	0.008	(joint)** (dummy)**	0.33	0.13	0.09*
23	-0.253*** (0.04)	0.058	(joint)* (dummy)*	0.32	0.68	0.09*
24	-0.029* (0.01)	0.005	(joint)* (dummy)*	0.31	0.46	0.10
25	-0.051*** (0.01)	0.010	(joint)** (dummy)**	0.70	0.31	0.12
26	-0.061*** (0.01)	0.012	(joint)** (dummy)**	0.40	0.18	0.10
27	-0.051** (0.01)	0.010	(joint)** (dummy)**	0.41	0.10	0.45
28	-0.052** (0.01)	0.010	(joint)** (dummy)*	0.38	0.22	0.10
34	-0.068** (0.03)	0.014	(joint)* (dummy)	0.25	0.10	0.14

**** 1% level, ** 5% level, and * 10% level*

Appendix A-4: ICT Producing Services

ISIC	β	λ	Wald test	R^2	AR(1)	AR(2)
A. β convergence for labour productivity per person						
64	0.006 (0.01)	00000	(joint) (dummy)*	0.31	0.11	0.10
72	-0.105** (0.03)	0.022	(joint)** (dummy)**	0.48	0.10	0.27
B. β convergence for labour productivity per hour						
64	0.0003	---	(joint) (dummy)*	0.35	0.11	0.10
72	-0.096** (0.02)	0.020	(joint)** (dummy)*	0.48	0.17	0.10

**** 1% level, ** 5% level, and * 10% level*

Appendix A-5: Intensive ICT Using Services

ISIC	β	λ	Wald test	R^2	AR(1)	AR(2)
A. β convergence for labour productivity per person						
51	-0.023 (0.02)	0.004	(joint) (dummy)	0.39	0.23	0.09
52	-0.021 (0.01)	0.004	(joint) (dummy)	0.53	0.12	0.49
65	-0.023 (0.02)	0.004	(joint) (dummy)*	0.30	0.12	0.32
66	-0.130*** (0.02)	0.027	(joint)** (dummy)**	0.60	0.11	0.75
67	-0.106** (0.03)	0.022	(joint)** (dummy)**	0.41	0.10	0.80
71	-0.115*** (0.02)	0.024	(joint)** (dummy)*	0.39	0.10	0.70
73	-0.096 (0.07)	0.020	(joint) (dummy)	0.10	0.20	0.05*
741-3	-0.105** (0.02)	0.022	(joint)** (dummy)**	0.43	0.12	0.60
B. β convergence for labour productivity per hour						
51	-0.023 (0.02)	0.004	(joint) (dummy)**	0.53	0.11	0.33
52	-0.017 (0.01)	0.003	(joint)* (dummy)**	0.55	0.17	0.17
65	-0.018 (0.01)	0.003	(joint) (dummy)*	0.35	0.14	0.17
66	-0.089** (0.02)	0.018	(joint)** (dummy)*	0.32	0.10	0.32
67	-0.098** (0.02)	0.020	(joint)** (dummy)**	0.46	0.10	0.70
71	-0.090*** (0.02)	0.018	(joint)** (dummy)**	0.47	0.10	0.84
73	-0.104 (0.07)	0.021	(joint) (dummy)	0.10	0.20	0.05*
741-3	-0.116*** (0.03)	0.024	(joint)** (dummy)**	0.45	0.12	0.50

**** 1% level, ** 5% level, and * 10% level*

Appendix A-6: Rest of Services (less intensive ICT using Industries)

ISIC	β	λ	**Wald test**	R^2	**AR(1)**	**AR(2)**
A. β convergence for labour productivity per person						
50	-0.111** (0.02)	0.023	(joint) (dummy)	0.41	0.34	0.07*
55	-0.098*** (0.01)	0.020	(joint) (dummy)	0.56	0.14	0.14
60	-0.053*** (0.01)	0.010	(joint) (dummy)*	0.61	0.12	0.49
61	0.0001 (0.03)	-0.0002	(joint)** (dummy)**	0.38	0.10	0.08*
62	-0.104** (0.02)	0.021	(joint)** (dummy)**	0.41	0.10	0.28
63	-0.026 (0.01)	0.005	(joint)** (dummy)*	0.56	0.10	0.11
70	-0.159*** (0.03)	0.034	(joint) (dummy)	0.47	0.22	0.10
749	-0.204*** (0.03)	0.045	(joint)** (dummy)**	0.51	0.12	0.60
40-41	-0.031** (0.01)	0.006	(joint)* (dummy)**	0.30	0.50	0.09*
45	-0.146*** (0.02)	0.031	(joint)** (dummy)**	0.50	0.11	0.28
B. β convergence for labour productivity per hour						
50	-0.078** (0.02)	0.016	(joint)** (dummy)*	0.39	0.23	0.08*
55	-0.126*** (0.02)	0.026	(joint)** (dummy)**	0.57	0.10	0.70
60	-0.052*** (0.01)	0.010	(joint)** (dummy)**	0.60	0.10	0.15
61	-0.0003 (0.03)	0.0006	(joint) (dummy)	0.64	0.10	0.08*
62	-0.121*** (0.02)	0.025	(joint)** (dummy)**	0.41	0.10	0.07*
63	-0.034* (0.01)	0.006	(joint)* (dummy)**	0.50	0.12	0.17
70	-0.138*** (0.03)	0.029	(joint)** (dummy)**	0.48	0.21	0.13
749	-0.204*** (0.03)	0.045	(joint)** (dummy)**	0.50	0.10	0.57
40-41	-0.007 (0.01)	0.001	(joint)* (dummy)**	0.30	0.64	0.09*
45	-0.116*** (0.02)	0.024	(joint)** (dummy)**	0.42	0.39	0.08*

**** 1% level, ** 5% level, and * 10% level*

Appendix A-7: Government Services (Less Intensive ICT Using Industries)

ISIC	β	λ	**Wald test**	R^2	**AR(1)**	**AR(2)**
A. β convergence for labour productivity per person						
75	-0.097*** (0.01)	0.020	(joint)** (dummy)**	0.55	0.12	0.80
85	-0.111*** (0.01)	0.023	(joint)** (dummy)**	0.70	0.13	0.50
90-93	-0.080*** (0.02)	0.016	(joint)** (dummy)**	0.47	0.32	0.10
95	-0.126*** (0.02)	0.026	(joint)** (dummy)**	0.62	0.10	0.85
80	-0.128*** (0.02)	0.027	(joint)** (dummy)**	0.58	0.15	0.19
B. β convergence for labour productivity per hour						
75	-0.058** (0.01)	0.011	(joint)** (dummy)**	0.56	0.18	0.21
85	-0.103*** (0.01)	0.021	(joint)** (dummy)**	0.67	0.14	0.22
90-93	-0.090** (0.02)	0.018	(joint)** (dummy)**	0.50	0.44	0.10
95	-0.091*** (0.02)	0.019	(joint)** (dummy)**	0.61	0.24	0.10
80	-0.088*** (0.01)	0.018	(joint)** (dummy)**	0.60	0.17	0.11

**** 1% level, ** 5% level, and * 10% level*