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Impact of ICT and Human Skills on the European Financial Intermediation Sector

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Impact of ICT and Human Skills on the European Financial Intermediation Sector

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Abstract

This paper investigates the impact of ICT- and non-ICT capital, and of labour at different skill levels, on productivity and employment in the financial intermediation sector of twelve EU member countries plus the US and Japan. A stochastic possibility frontiers (SPF) approach is applied to assess the relation between the production inputs and to compute both time-varying and average inefficiencies. For the empirical analysis, annual data from 1995 to 2005 are employed that were obtained from recently released data contained in the EU KLEMS database. The results obtained shed some light on the relative impact of ICT- and non-ICT capital and labour inputs, and provide new insights about the structural dynamics between these factor inputs. We find that the financial sectors in the twelve EU member states studied are quite similar in terms of efficiency, and that efficiency and productivity depends much more on human capital than on physical capital. We conclude that learning-by-doing and learning-by-using are more decisive elements in shaping the productivity growth path than ICT investment alone, which can leave managers and employees overwhelmed by the complexity and needs of structural adjustments in the companies' organisation.

Key words: stochastic production possibility frontiers, ICT, structural dynamics

JEL Classification Nos.: C23, C51, D23, E23, O33, O47, O57

1 Introduction

In the financial services industries there is an ongoing convergence between banking and insurance industries. On the one hand, banks increasingly try to extend the range of financial services by offering insurance contracts as well. On the other hand, insurance companies have started to acquire banks, such as e.g. Allianz the Dresdner Bank in Germany, typically by merger and acquisition, enabling them to use banks as distribution platforms for their insurance service products. With the introduction of the Euro, and the integration of a subset of the EU-27 into a common currency area, the financial integration process across the national boundaries has further made improvements and enhancing competition between banks and insurance from different Eurozone countries in particular. A further deepening of the integration of the European financial markets is one important goal to enable Europe greater independence from external shocks, such as the one that triggered the subprime crisis in the US, which has diffused far beyond the US economy to Europe and other parts of the world.

With the increasing use of standardised products and services in the banking and insurance business that are based on electronic risk ratings of customers, the banking and insurance industry increasingly utilises computers and telecommunication equipment connected via the Internet as the ordinary distribution channel of their services. Ranging from Online brokerage and Home banking to Electronic insurance contracts by companies like CosmosDirect, information and communications technologies (ICTs) have changed the financial service industry significantly over the past decade.

The banking industry exhibits the highest proportion of IT investment compared to all other industries after 1995 (for the US see e.g. Council of Economic Advisors, 2001, for the EU see EITO, various yearbooks 1996 until 2001).

The financial service industry will only be able to grow steadily in the future by innovations in terms of new financial services. While automatic teller machines and credit cards were the early enablers to reduce the need for front-desk service workers, such as cashiers etc., the pervasiveness of the Internet provides the opportunity to offer and use ubiquitous financial services from virtually everywhere. A particularly attractive option is the conduct of financial transactions via mobile communications devices. This transformation process has not been completed yet, so that one might expect that there is a still ongoing labour-saving process that could last well into the near- and even mid-term future. This begs the question on whether there is a significant skill bias involved, i.e. whether the labour-saving process is unevenly spread across different skill levels.

In this paper we investigate the impact of ICT and non-ICT capital, and labour input at different skill levels, on aggregate productivity and employment in the financial intermediation sector of twelve EU member countries, the US and Japan (the latter two as potential benchmarks). The EU countries covered are Austria, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, the Netherlands, Spain, Sweden, and the UK. More specifically, we apply a stochastic possibility frontiers (SPF) approach to assess the relation between different production inputs and to compute time-varying inefficiency trajectories and average technical inefficiencies. We employ annual data from 1995 to 2005, obtained from a recently released dataset (March 2008) contained in the EU-KLEMS database (www.euklems.eu). The empirical results obtained shed new light on the relative impact of ICT- versus non-ICT capital versus labour inputs, and provide new insights about the structural dynamics between the different factor inputs considered.

The remainder of this paper is organised as follows. Section 2 introduces the theoretical framework and model specification used, section 3 contains a description of the data, sector 4 reports on the results gained, while section 5 concludes.

2 The Model

Commonly used production functions or possibility frontiers restrict the number of input factors to a small set (e.g. two or three). The famous Solow model (1957), for instance, just distinguishes between the two primary input factors labour and capital, *L* and *K*, and additionally includes a time trend *t* representing autonomous (Harrod-neutral) technical change. If a Cobb-Douglas production function is used as a model specification, we can write

$$Y_t = f(L_t, K_t, t) = A \cdot e^{\gamma \cdot t} \cdot L_t^{\alpha} \cdot K_t^{1-\alpha}, \qquad (1)$$

where *Y* denotes output, *A* is a scaling parameter, γ the rate of technical progress, α the partial output to labour elasticity, and *t* a deterministic time trend (as a proxy for autonomous technical change). In macroeconomic production functions, typically constant returns to scale (CRS) are assumed, which implies that the partial output elasticity to capital is equal to (1-α). By following this tradition and taking logarithms, we obtain the following linear model in the transformed variables and parameters:

$$\ln Y_t = \ln A + \alpha \cdot \ln L_t + (1-\alpha) \cdot \ln K_t + \gamma \cdot t. \qquad (2)$$

We can now add the usual two random variables for a stochastic possibility frontier (Aigner et al., 1977; Kumbhakar and Lovell, 2003): an error term $v_t \sim iid\ N(0;\sigma_v^2)$ and a random variable for inefficiency $u_t \sim iid\ N^+(1/\theta_u, \sigma_u^2)$, the latter of which exhibits a left-truncated normal distribution. v_t and u_t are assumed to be independently distributed of each other and of the regressors (e.g. Kumbhakar and Lovell, 2003, p.74), which yields a stochastic Cobb-Douglas production frontier of the form

$$\ln Y_t = \ln A + \alpha \cdot \ln L_t + (1-\alpha) \cdot \ln K_t + \gamma \cdot t + v_t - u_t . \quad (3)$$

Note that a shortcoming of the Cobb-Douglas function is that irrespective of the number of input factors considered the implicit substitution elasticity between all factors is always restricted to unity, which is admittedly a very restrictive assumption.[1]

For our empirical analysis we decided to use a stochastic possibility frontier (SPF) that is based on the secondary intermediate inputs, two primary input factors (capital broken down into two different types, ICT and non-ICT), and labour input, measured in working hours, broken down into three different skill levels (low, medium, high). In other words, we consider the following variables: (1) intermediate input per total hours worked (THW); (2) ICT capital stock per THW; (3) Non-ICT capital stock per THW; (4) High-skill working hours (WH) per THW; (5) Medium-skill WH per THW; (6) Low-skill WH per THW; and (7) a linear time trend.

We estimated this model using a panel data set for the EU-12 (see section 3) plus two other major global financial markets, the US and Japan. As a particular specification we used the error component model of Battese and Coelli (1992), which not only allows to estimate average efficiency levels by country (i.e. 100 is equal to full-scale efficiency, values below measure the percentage points below the overall efficiency level of an industry production possibility frontier at a certain period of time). In order to guarantee CRS for the possibility frontier, the output and input variables were normalised by the total working hours. This led to a restricted SPF model, where the real gross production value per working hour is explained by six factor intensities using total working hours as the denominator. In addition to the constant term, a time trend was included as well to measure autonomous technical change.

[1] The constant elasticity of substitution (CES) function, suggested as a useful alternative specification by Arrow et al. (1961), has an elasticity of substitution that is constant but not necessarily equal to one. This implies that the elasticity (or complementarity) between input factors becomes measurable.

Additionally, an extension including fixed effects into the estimation of the SPF model was tested. This addresses some criticism proposed by Greene (2002, 2005) that omitting fixed effects could lead to distortions and biases in the SPF parameters estimated. Caudill and Ford (1992) showed that omitting heteroscedasticity may lead to biased estimates of ESPs. In particular an overestimation of the intercept and an underestimation of the slope coefficient might results from it.

While Kumbhakar and Wang (2005) and Kumar and Russel (2002) embodied such fixed effects in the estimation of a macroeconomic SPF, Lozano-Vivas et al. (2002) have used a latent class stochastic frontier model (LCSFM) to account for heterogeneity in the individual banks at a country level. They use environmental variables for different countries instead of simple fixed effects accounting for country differences. Numerous studies using a variety of different approaches including data envelopment analysis (DEA) have been undertaken for the banking industry. Accounting for heterogeneity by country fixed effects in the SPFs therefore offers the possibility to test the underlying assumption of a common frontier. In our analysis this implicitly would assume that by globalization, in particular in financial markets, a common global financial market frontier is a reasonable benchmark for the analysis. Due to flexible global capital markets and intensive competition across national boundaries, the separation between specific national regulatory environments and cultural traditions would become less important. However, this ideal state must not show up accordingly in the data available in the national statistics.

3 Data

The financial intermediation sector, as defined by NACE 1.1 (classification code J) includes, apart from banking services, also insurance and pension funding as well as activities related to financial intermediation. The EU-KLEMS database published by the Groningen Growth an Development Centre (GGDC) in March 2008 has insufficient information on the banking sector alone. Hence, for our econometric analysis based on estimating a SPF, we decided to focus on the somewhat broader “financial intermediation” sector.

From the current 27 EU member states only less than half supply a complete dataset that is running at least over the time period from 1995 until 2005. EU-KLEMS is generally based on annual data only. The twelve countries included in EU-KLEMS that have a consistent dataset at least for this decade are: Austria, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Spain, Sweden, and the UK. They will be denoted as “EU-12” in the following. Additionally, we have also the US and Japan as non-EU member countries but important players in global financial markets are included in our sample.

Data are available for the gross production value, total intermediate inputs, total working hours, ICT-capital stock and non-ICT capital stock input plus total working hours. The latter are broken down into working hours for three separate skill categories (high, medium, low skills).

4 Results

For the econometric estimation we used the Frontiers 4.1 software program (Coelli, 1996). The estimation results were obtained for a Cobb-Douglas production function specification. We studied three different model specifications, in order to find out how much the inclusion of fixed effects in an SPF estimation influences the outcome. The first model included fixed effects for the US and Japan but omitted the dynamic adjustment term (model 1), the second included the fixed effects and the dynamic adjustment term (model 2), and the last excluded the fixed effects but included the dynamic adjustment term (model 3). The results are summarised in table 1, while the specific t-values etc. for each single model specification have been relegated to the appendix. We also tested a model variant with fixed effects for all EU-member countries, but it turned out that eliminating the inefficiency term as a significant variable of the model leads to a collapse of the SPF model. This might be due to the still fairly short time frame of eleven years. One might test the consequences of a more unbalanced panel on the parameter estimation by using in the estimation all data back until 1970 for those countries for which these data are available. However, this exercise is beyond the current state of our analysis reported in this paper.

Table 1

Parameter Estimates of a Stochastic Possibility Frontier (SPF) for Financial Intermediation, Models 1,2 and 3

Gross Production Value per Total Working Hours based on EU-12[1] plus USA and Japan Multi-Country-Panel, 1995 - 2005

	Model 1	Model 2	Model3
Explanatory variables	parameter	parameter	parameter
Constant	0.447***	0.362***	0.441***
Intermediate Input per TWH[2]	0.291***	0.394***	0.366***
ICT-Capital Stock per TWH[2]	0.057	0.059	0.056
Non-ICT Capital Stock per TWH[2]	0.153***	0.193***	0.204***
High-Skilled-WH per TWH[2]	0.162***	0.113***	0.120***
Medium-Skilled-WH per TWH[2]	0.335***	0.243***	0.252***
Low-Skilled-WH per TWH[2]	0.024***	0.020***	0.022***
Time	0.014***	0.017***	0.017***
Fixed effect USA	0.143***	0.053	-
Fixed effect Japan	0.169***	0.077	-
sigma square	0.012***	0.026***	0.029***
gamma	0.787***	0.909***	0.921***
eta	-	-0.096***	-0.083***
Log-Likelihood	208.7	212.5	211.7
No. of iterations	21	30	27

[1] EU-12 - Austria, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Spain, Sweden, UK

[2] TWH - total working hours

Source: EUKLEMS database of GGDC, own calculations. **DIW** Berlin 2008

The parameter estimates obtained are measures for the respective output elasticity of the respective input factor, i.e. an increase of one unit in the respective input factor increases the output variable by the respective output units. Looking at the six plus one parameter values we notice that, except for the ICT capital intensity, all parameters are statistically significant at the 5% level of significance.[2] It can also be observed that for all three model specifications tested the parameter estimates are fairly stable. However, when embodying fixed effects for the US and Japan, two financial markets quite different from the EU with regard to their regional and economic environment, we find that the significant fixed effects found in model 1 are not sustained if we allow for time-varying inefficiency terms. This is due to the fact that the possibility of each country to follow a specific inefficiency trajectory is causing a trade-off with the fixed effects which can adjust for these differences in a more simple way. Keeping both effects significant is impossible with the current data set and time frame.

So model 1 and model 3 show two alternative ways to explain most of the variance of the multi-country panel dataset. Only if there were additional variation in the data there is some hope that both dimensions of fixed effects for some or even all countries and a dynamic trajectory of inefficiency become statistically significant. Based on our analysis model 3 without fixed effects seems to be the better solution because of the higher value obtained from

[2] As a rule of thumb *t*-values above 2 assure this 5%-signficance threshold of the test.

the maximum likelihood estimation. The common frontier hypothesis for the EU-12 countries, the US and Japan finds support against the one where additional heterogeneity measured by country fixed effects matter.

Statistically, the single parameters in the three models, if tested for equality by using 95%-confidence intervals calculated from the estimates of the three different models, confirm that they are equal at the chosen significance level. Only if the respective intervals defined by lower and upper bounds would not overlap, the respective parameters would be statistically significantly different from each other. Therefore, the results show a robust performance of the SPF estimates even if different specifications are applied.

Table 2

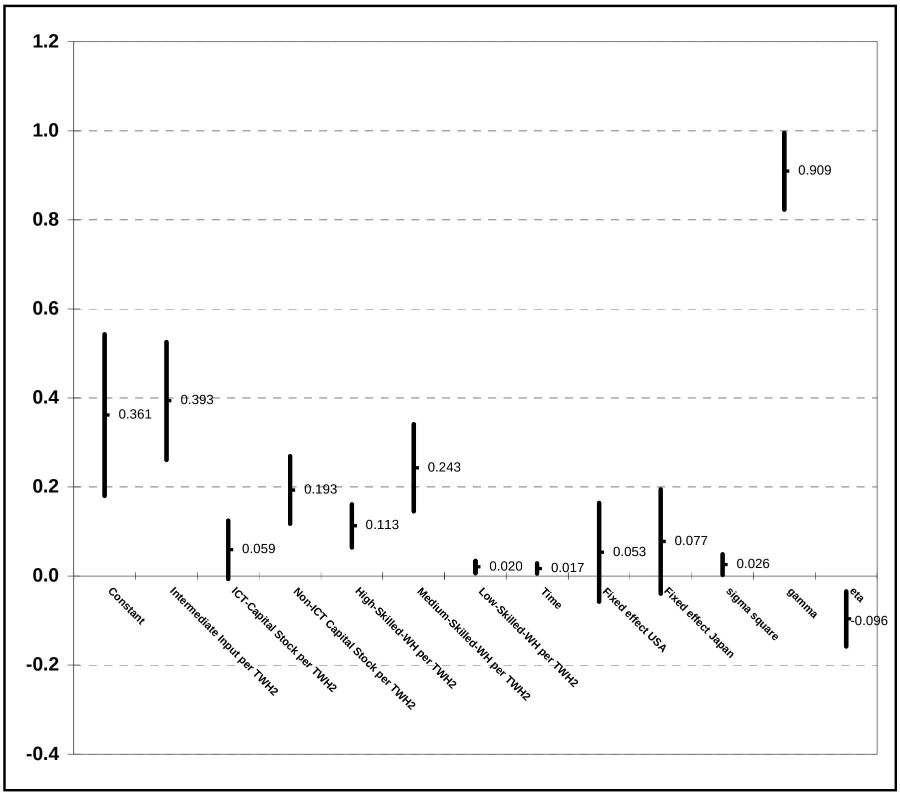
Single Parameter 95%-Confidence Intervals

Explanatory variables	Model 1		Model 2		Model 3		equality test
	lower bound	upper bound	lower bound	upper bound	lower bound	upper bound	
Constant	0.180	0.543	0.309	0.585	0.280	0.602	identical
Intermediate Input per TWH2	0.261	0.526	0.191	0.392	0.238	0.493	identical
ICT-Capital Stock per TWH2	-0.006	0.124	-0.004	0.117	-0.007	0.119	identical
Non-ICT Capital Stock per TWH2	0.117	0.269	0.088	0.218	0.133	0.274	identical
High-Skilled-WH per TWH2	0.064	0.161	0.124	0.200	0.069	0.171	identical
Medium-Skilled-WH per TWH2	0.145	0.341	0.254	0.415	0.154	0.350	identical
Low-Skilled-WH per TWH2	0.006	0.034	0.009	0.039	0.008	0.036	identical
Time	0.006	0.028	0.006	0.023	0.008	0.029	identical
Fixed effect USA	-0.058	0.164	0.024	0.262			identical
Fixed effect Japan	-0.040	0.194	0.066	0.272			identical
sigma square	0.002	0.049	0.003	0.020	0.004	0.054	identical
gamma	0.823	0.996	0.623	0.951	0.849	0.993	identical
eta	-0.158	-0.035			-0.137	-0.028	identical

Source: EUKLEMS database of GGDC, own calculations. **DIW** Berlin 2008

Figure 2 illustrate this outcome for model 2. Note that the different variability of the single parameter estimates is visualised nicely by this graph.

Figure 1 - Confidence Intervals for Parameter Estimates of Model 2



Source: EUKLEMS database of GGDC, own calculations. **DIW** Berlin 2008

Looking at the individual values we can observe that the least significant output elasticity has to be attributed to the ICT capital stock intensity. This is somewhat surprising and in sharp contrast to previous empirical findings published, e.g., by Jorgenson, Stiroh, Oliner and others (see e.g. Jorgenson et al., 2000; Stiroh, 2002). Jorgenson and associates usually found a high impact in their growth accounting studies with U.S. data on labour productivity growth. Similar finding are obtained by O'Mahony, Timmers and van Ark (2003, 2007, 2008) for Europe. However, they calculate their growth accounts using gross value added (i.e. excluding intermediate inputs) for their calculations and accounting for heterogeneity in the labour input by using a quality change indicator instead of the three more specific human capital variables differentiated by skill-classes. Therefore, there seem to be two potential trade-offs to be considered between the gross production value approach versus the gross value added. In general, it can be shown that total factor productivity measured using gross value added diminishes if the intermediate factor intensity varies with regard to the gross production value. A significant amount of outsourcing of financial intermediation services thus leads to a diminished total factor productivity growth based on gross production values.

Furthermore, in the above-mentioned growth accounting studies, insufficient accounting for the impacts of compositional changes in the labour force according to their skills apparently tends to shift the balance from human capital as a dominant factor towards a more prominent role of physical capital, and in particular the ICT capital. By more explicitly taking into account these other dimensions in our econometric analysis the results are, however, still consistent with the common EU-KLEMS database. The more detailed data structure used in this analysis shifts the emphasis from physical capital towards the important role of human capital. This view is more in line with endogenous growth theory (see e.g. Barro and Sala-i-Martin ,1995; Aghion, Howitt, 1998). It also emphasises the importance of outsourcing as a key driver of labour productivity growth in the financial intermediation industry.

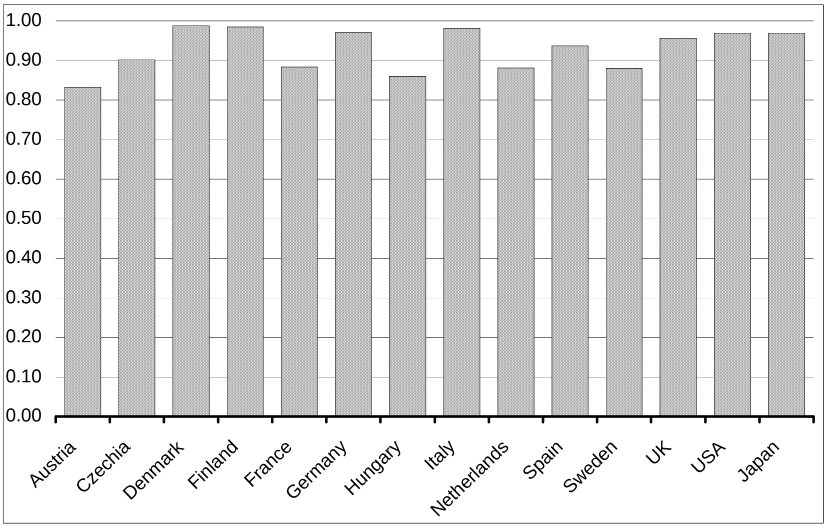
In growth accounting analysis the labour inputs have been included in a very different approach, where total working hours where not broken down into different skill classes as it is done here. Therefore, a specific skill-bias of technological progress could not explicitly be analysed. Instead, only a compositional change indicator for the compositional changes was used as a proxy variable. This might have led to an important specification bias, where too much emphasis was put on physical capital inputs and much less so on human capital inputs. Our results, however, point into a different direction compared to those attributing a high impact on physical ICT capital investment. In contrast, we find a high significance in the increasing high- and medium-skill using bias while low-skilled labour inputs have little to contribute to enhancing output productivity. We find the strongest impact on output productivity per working hour for medium-skilled labour intensity with 0.335, followed by intermediate input intensity with 0.291, in model 1. This ranking is changed, when the time varying efficiency term η is included in models 2 and 3. Now the intermediate inputs output elasticity for models 2 and 3 is even bigger, with 0.394 or 0.366 respectively, than the one for the medium-skilled labour intensity. The high value for the output elasticity of intermediate input intensity may be attributable to the productivity-enhancing effect of outsourcing of activities in the financial service industry. By focussing on the core competencies and outsourcing, those activities where financial intermediators in a particular country lack comparative advantages, the optimal make-or-buy decision-making according to Coase's theory of transaction costs (Coase, 1937) can contribute significantly to the productivity growth of the industry. This aspect has been neglected in studies which exclude intermediate inputs from their analysis. Non-ICT capital intensity and high-skilled labour intensity rank third and fourth, with output elasticities of 0.204 and 0.120, respectively, for model 3. Finally, we find an average annual rate of technical progress of about 1.7% for the labour productivity growth in the financial service industry in models 2 and 3.

Concerning the parameters σ, γ and η related to the efficiency estimates of the SPF we obtained the following findings: The first two estimates are statistically significant at the 5% level of significance, while the latter is not. η is a parameter determining the autoregressive trajectory of the inefficiency random variable. If it is statistically insignificant this shows that there is no statistically significant autocorrelation in the inefficiency random variable observable. The actual parameter value would show a mild negative autocorrelation. For this reason we omitted this parameter when estimating the average technical efficiencies by country, the results of which are summarised in figure 1.

Figure 1

Average technical efficiency estimates in financial intermediation based on fixed effects estimates
EU-12 Member States plus USA and Japan, 1995 - 2005

(average values)



[1] EU-12 - Austria, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Spain, Sweden, UK

Source: EUKLEMS data of GGDC, own calculations.

DIW Berlin 2008

The range of average efficiency estimates by country varies between 0.98 for Denmark and Austria with 0.82. It is noteworthy that with the revised EU-KLEMS data the efficiency estimates for the UK improved considerably to 0.96, from 0.77 when using the old database[3], which embodied a significant underestimation of the gross production values for the UK. All

[3] EU KLEMS (2007), Growth and Productivity Accounts Intermediate Release November 2007, Groningen.

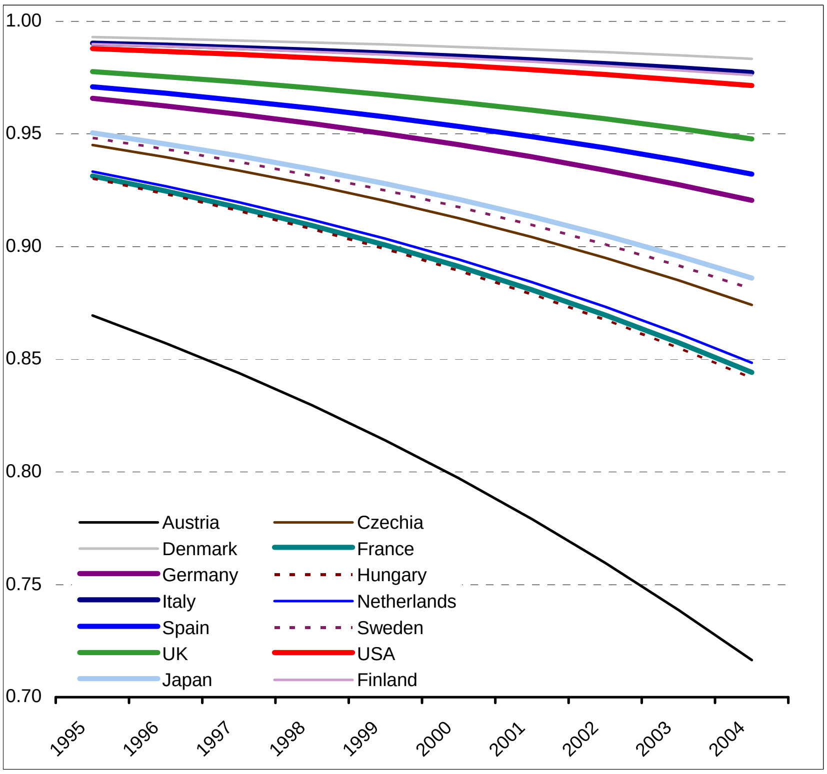
other countries exhibit average efficiency levels in between. Apart from Denmark, Finland, Germany, Italy and the UK are very close to each other, with values ranging from 0.98 to 0.96, i.e. differing only by two percentage points. Similar average efficiency levels are found for the financial intermediation industries in the US and Japan, with 0.97 each. Spain (0.94), the Netherlands (0.88), Sweden (0.88), Czechia (0.90), Hungary (0.86), and France (0.88) are lagging by 5 to 10 percentage points behind those five, with values between 0.94 and 0.86. The least efficient country in the financial service industry is Austria with 0.83.

These estimates are based on SPF including fixed effects for the US and Japan (i.e. model 1). By including a time varying model specification we obtain the dynamic inefficiency trajectories depicted in figure 2.

Figure 2

Technical efficiency estimates in financial intermediation based on fixed effects estimates and time varying efficiencies
EU-12 Member States plus USA and Japan, 1995 - 2004

(annual values)



[1] EU-12 - Austria, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Spain, Sweden, UK

Source: EUKLEMS data of GGDC, own calculations.

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From the graph we can see that the efficiencies tend to decline for all countries. This might be attributable to the fact that technological progress makes it more and more difficult for all banking and insurance companies in the different countries to stay abreast, or to catch up, with the new technologies available. Structural, regulatory and cultural impediments lead to different paths of divergence form the overall efficiency frontier. However, this outcome would need further investigation, in order to find out whether it is robust against different alternative model specification and interpretations.

5 Conclusions

The fairly invariant efficiency ranking for the 12 EU member countries obtained in our analysis might be attributable to the fact that we could utilise data ranging only over an eleven-year time span. It is worth noting that new EU-member countries are doing quite well in comparison with some of the older ones. The shock of the transition period and the complete overhaul of the financial service industry in the former socialist countries have had a significant efficiency-enhancing impact, since they did not have to gradually dismiss a defunct legacy. Starting from scratch they could realise quite reasonable efficiency levels.

Another aspect which probably should be taken into account in this industry is that with financial market integration, in particular in the Eurozone, the country-by-country efficiency perspective might be getting less and less appropriate. Due to the concentration of financial services in a few locations – like London, Paris, Frankfurt, but also Luxembourg, Dublin etc. – the industry is developing a more locally concentrated structure, supplying financial services for the entire European Union and worldwide. Therefore, the scale and scope effects of such financial centres and the mass market for local branch offices for the ordinary customers would be a much better separation principle to study the changing efficiency and productivity development. Innovations in complex financial services on the one hand, and the efficient supply of highly standardised mass at local offices of banks and insurance companies on the other hand, give very heterogeneous trajectories for the diffusion of new ICTs.

Overall, the financial service sector in the EU-12 member countries lacks a strong heterogeneity or divergence in efficiency with the exception of Austria. Furthermore, we observe that efficiency and productivity development depend much more significantly on human capital than on pure physical capital investment. In particular, there must also have been a significant overinvestment in ICT capital in this industry in the years 1995-2000, i.e. during the new economy boom. Only by developing complementary organisational changes and employing higher-skilled human capital the promises of the ICT revolution showed up in a much more gradual fashion. This would explain as well why labour productivity growth is more steadily related to human skills than to the pure ICT capital investment boom. Learning-by-doing and learning-by-using are much more determining the productivity growth trend than a pure ICT investment boom, which left both employees and managers overwhelmed by the complexity and needs for structural adjustments in the (re-)organisation of their companies. Only by solving these problems and overcoming the obstacles the true long-term benefits of the ICT revolution can be harvested by increased labour productivity growth.

The policy implications from our analysis are quite clear-cut. In a knowledge-economy driven by rapid technical change the ability to empower the work force by appropriate investments in training and skill-formation is much more important than investment in information and communications technology. ICT is an enabler, but without sufficient capabilities of the human workforce to use it efficiently, the costly investments become ineffective. The focus of managers making investment decisions should therefore be much more on the implications of a new technology related to changing needs in skill formation and consequences in the organisation of business processes than on pure technical equipment: A computer or a broadband Internet terminal device is a general purpose instrument, but the intelligence of their users determines the real benefits obtained in the end.

Table 1

Parameter Estimates of a Stochastic Possibility Frontier (SPF) for Financial Intermediation, Model 1: Error Component Model including Fixed Effects, 1995 - 2005

Gross Production Value per Total Working Hours based on EU-12[1] plus USA and Japan Multi-Country-Panel

Explanatory variables	parameter	standard-error	t-value
Constant	0.447	0.069	6.468
Intermediate Input per TWH[2]	0.291	0.050	5.814
ICT-Capital Stock per TWH[2]	0.057	0.030	1.880
Non-ICT Capital Stock per TWH[2]	0.153	0.032	4.727
High-Skilled-WH per TWH[2]	0.162	0.019	8.476
Medium-Skilled-WH per TWH[2]	0.335	0.040	8.329
Low-Skilled-WH per TWH[2]	0.024	0.007	3.258
Time	0.014	0.004	3.284
Fixed effect USA	0.143	0.060	2.400
Fixed effect Japan	0.169	0.051	3.281
sigma square	0.012	0.004	2.798
gamma	0.787	0.082	9.574
Log-Likelihood	208.7		
No. of iterations	21		

[1] EU-12 - Austria, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Spain, Sweden, UK

[2] TWH - total working hours

Source: EUKLEMS database of GGDC, own calculations.

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Table 2

Parameter Estimates of a Stochastic Possibility Frontier (SPF) for Financial Intermediation, Model 2: Error Component Model including fixed effects and time varying adjustment term

Gross Production Value per Total Working Hours based on EU-12[1] plus USA and Japan Multi-Country-Panel, 1995 - 2005

Explanatory variables	parameter	standard-error	t-value
Constant	0.361	0.091	3.987
Intermediate Input per TWH[2]	0.393	0.066	5.942
ICT-Capital Stock per TWH[2]	0.059	0.033	1.805
Non-ICT Capital Stock per TWH[2]	0.193	0.038	5.079
High-Skilled-WH per TWH[2]	0.113	0.024	4.652
Medium-Skilled-WH per TWH[2]	0.243	0.049	4.975
Low-Skilled-WH per TWH[2]	0.020	0.007	2.932
Time	0.017	0.006	3.050
Fixed effect USA	0.053	0.055	0.958
Fixed effect Japan	0.077	0.058	1.322
sigma square	0.026	0.012	2.216
gamma	0.909	0.043	21.061
eta	-0.096	0.031	-3.128
Log-Likelihood	212.5		
No. of iterations	30		

[1] EU-12 - Austria, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Spain, Sweden, UK

[2] TWH - total working hours

Source: EUKLEMS database of GGDC, own calculations.

DIW Berlin 2008

Table 3

Parameter Estimates of a Stochastic Possibility Frontier (SPF) for Financial Intermediation, Model 3: Error Component Model including time varying adjustment term

Gross Production Value per Total Working Hours based on EU-12[1] plus USA and Japan Multi-Country-Panel, 1995 - 2005

Explanatory variables	parameter	standard-error	t-value
Constant	0.441	0.081	5.463
Intermediate Input per TWH[2]	0.366	0.064	5.744
ICT-Capital Stock per TWH[2]	0.056	0.031	1.787
Non-ICT Capital Stock per TWH[2]	0.204	0.035	5.796
High-Skilled-WH per TWH[2]	0.120	0.025	4.720
Medium-Skilled-WH per TWH[2]	0.252	0.049	5.140
Low-Skilled-WH per TWH[2]	0.022	0.007	3.142
Time	0.019	0.005	3.616
sigma square	0.029	0.013	2.306
gamma	0.921	0.036	25.699
eta	-0.083	0.027	-3.054
Log-Likelihood	211.7		
No. of iterations	27		

[1] EU-12 - Austria, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Spain, Sweden, UK

[2] TWH - total working hours

Source: EUKLEMS database of GGDC, own calculations.

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