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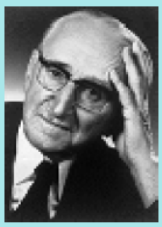



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Linkage Between Productivity and Innovation in Different Service Sectors

Diskurs 2011 – 2

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Abstract

The purpose of the paper is to find out whether linkages between productivity and innovation are different among Estonian service sector sub-sectors. In this paper productivity is measured as value added per employee. An original approach toward measurement of productivity is used, decomposing it into three components: labour costs, depreciation and gross profit per employee. Four types of innovation are studied: product, process, organizational and marketing innovation. The empirical analysis is based on productivity data from the Estonian Business Register and innovation data from the Estonian Community Innovation Survey 5, covering the period between 2004 and 2006. Results based on Estonian service sectors reveal that in different sub-sectors different types of innovation are linked to productivity. Still, all linkages between innovation and productivity or its components are positive. There is one exception: among assisting services marketing innovation and gross profit are negatively associated with each other.

Keywords:

service sector, productivity, productivity components, four innovation types

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Linkage Between Productivity and Innovation in Different Service Sectors

Introduction

The importance of service sector has grown over time. In 2008, the share of the service sector in total value added was 70% in the EU-27. In Romania the share of service firms' value added was the lowest (55%) and in Luxembourg the highest (85%). In Estonia service sector value added was 68%. The average share of service sector value added is higher in older member states. (Eurostat 2011) The service sector and its productivity need to be studied, because in Western Europe the level of productivity is lower compared to the productivity level of the United States. The key reason for differences in productivity levels is lower productivity growth in Western European service sector. (van Ark *et al.* 2008)

There is growing interest in analyzing the relationship between productivity and innovation (see, for example, Janz *et al*. 2004, Griffith *et al*. 2006, Masso and Vahter 2008, Mairesse and Robin 2009, Polder et al. 2010) Compared to the manufacturing sector, the service sector has been less analyzed, mainly because productivity measurement in the service sector is complicated and the service sector itself is very heterogeneous. The development of measuring productivity has been slower in the service sector (Adam *et al*. 1981; Mills *et al.* 1983) mainly because of the nature of services – their labour intensiveness, perishability, simultaneity, and intangibility (Drucker 1974). There are many factors that have an influence on service sector productivity. In this paper those factors have been narrowed down to innovation types.

The importance of innovation as a productivity factor stems from the Solow growth theory (1956, 1957) where productivity is related to accumulated physical and human capital, and innovation. Innovation is also considered to be one of the five drivers of productivity among skills, investment, enterprise and competition (HM Treasury 2006).

The aim of the paper is to explore the differences in linkages between productivity and innovation among service sub-sectors through analyzing different service sectors in Estonia. Compared to previous studies concerning the relationship between productivity and innovation, in this paper four innovation types are considered. In many previous related articles only technical innovation has been considered, partly because there were not any well structured questions about organizational and

[1] Author acknowledges the support of the Estonian Science Foundation's Grants 7405 and 8311 and target financing of the Estonian Ministry of Education and Research 0180037s08. The author is grateful to Urmas Varblane and Priit Vahter for their comments and ideas used in the paper. The author would also like to thank Kadri Ukrainski and Andrew Rozeik for their comments.

marketing innovations included in innovation surveys before Community Innovation Survey (CIS) 4 (2002-2004).

The second original contribution in this paper is that productivity is decomposed into three constituent components of the value added: labour costs, depreciation and gross profit[2] per employee. This enables the analysis of which components of value added are related to innovation. The linkages between productivity and innovation can be very different among countries (see Janz *et al*. 2004 for a comparison of Sweden and Germany), but they can also differ in one country between different sub-sectors. The third point of novelty is the use of a different classification of services to analyze whether the linkage between productivity and innovations is the same in different sub-sectors or not. Masso and Vahter (2012) and Evangelista and Vezzani (2010) have divided services into different groups, although they use different classifications. Masso and Vahter use the Eurostat classification of knowledge intensive services (KIS) and less knowledge intensive services (less-KIS) and a classification by Soete and Miozzo (1989) who divided services into four groups using Pavitt's (1984) taxonomy. In contrast, in this paper services are divided into three groups according to the report "Innovation in Services: Typology, case studies and policy implications" (2006). This classification has not been used before for studying linkages between productivity and innovation. Usually firms are classified by their production process, for example labour/capital intensiveness, mass production, etc. Compared to previously used classifications, the one used in this paper divides services from the customer's (and not the producer's) point of view: this classification is based on how services create value for the costumer. These service groups are the following: assisting services, distributive services and problem solvers.

Literature review

In order to study the linkage between productivity and innovation it is useful to classify services to see whether these linkages are different among service sectors. Service firms have been classified in several ways, for different classifications see Judd (1964), Rathmell (1974), Soete and Miozzo (1989), Erramilli (1990), Lovelock *et al.* (2004), Viitamo (2007), Glücker and Hammer (2011), etc.

As mentioned previously, there is growing interest in modelling the linkage between productivity and innovation, but most of these articles analyze productivity and innovation in the manufacturing sector, for example Griffith *et al.* (2006) and Janz *et al*. (2004). In many articles only one type of innovation is considered at once. Mostly technological innovation (product and process innovation) is considered (for example, Suriñach *et al*. 2011, Mairesse and Robin 2009), while non-technological innovation is studied less. Many articles focus on the model introduced by Crépon *et al*. (1998), known as the CDM model. In these studies information about innovation activities is taken from Community Innovation Surveys (CIS).

Often, one innovation type is included in analysis of the productivity-innovation linkage; one exception is an article by Evangelista and Vezzani (2010), who consider different innovation types and their combinations. They use both manufacturing and service sector data from the Italian CIS 4. They divide the manufacturing sector into

[2] In this paper gross profit is defined as EBIT (earning before interest and taxes).

four sub-sectors according to Pavitt's taxonomy (1984) and the service sector also into four groups according to Evangelista's previous work (2000). Firstly, they identify the most common innovation behaviour in firms. Four categories were found to be the most common innovation modes: product oriented, process oriented, organizational and complex. Thereafter, relations between those categories and economic indicators were controlled. All categories are positively related to productivity growth, but not in all sub-sectors. Process innovation separately is not significantly related to productivity in any sub-sectors and product innovation is significant only among the transport sector (for more detailed results see Evangelista and Vezzani 2010).

Evangelista and Vezzani (2010) found that combining product, process and organizational innovation has the strongest relationship with productivity. The relationship is the strongest among transport sector, followed by business services. Firms undertaking only one type (product or process) of innovation are less effective. Process innovation is not related to productivity. The relationship between organizational innovation and productivity in the manufacturing sector is stronger than in services. Using data from the Netherlands, Polder *et al*. (2010) found that undertaking product or process innovation separately does not have any significant relationship with productivity. Organizational innovation is the only type of innovation that has a significant relationship with productivity according to Evangelista and Vezzani (2010) and Polder *et al*. (2010) (see Table 1).

Most of the empirical studies use econometric models in order to model the linkage between productivity and innovation. Rochina-Barrachina *et al.* (2010), in contrast, use non-parametric methods. In their article, firms which undertake process innovation are compared to those which do not by comparing their cumulative distribution functions of productivity levels. They use stochastic dominance to rank those distributions, reaching the following results: firms that undertake process innovation have higher productivity levels compared to others. They also notice that there is a divergence between these different types of firms.

Gu and Tang (2004) measure innovation with four different indicators: R&D expenditures measured as a percentage of output, patents per employee, technology adoption measured by real investment in machinery and equipment, and skills intensity measured by high educated staff per employee. In order to be innovative a firm has to invest in R&D expenditures to create or use new products or production processes. Therefore, R&D is an important input for the innovation process. Also, the above mentioned CDM model shows that R&D is important in the innovation process (for a more detailed overview of the CDM model see Crépon *et al.* 1998). Many authors use the CDM model to analyze the relationship between productivity and innovation, for example Janz *et al*. (2004), Griffith *et al*. (2006), Mairesse and Robin (2009), Polder *et al*. (2010), and Masso and Vahter (2012). All these authors use CIS data for measuring innovation. Griffith *et al*. studied the relationship among four European countries – France, Germany, Spain and the United Kingdom. Process innovation is related to productivity only in France and the relationship is weak. Product innovation is significant in France, Spain and the UK. For further information about the data and measures used in above mentioned studies, see Appendix 1. Mairesse and Robin (2009) also studied the relationship between productivity and innovation in France using data from the CIS. They estimated models for both the manufacturing and service sector, with the following results: product innovation is

significant in the service sector, but process innovation does not have any significant relationship with service sector productivity.

Table 1. Previous studies on the linkages between productivity and innovation types in the service sector

Authors	**Innovation types**					
	Product	**Process**	**Organizational**	**Product and process**	**Process and organizational**	**Product, process and organizational**
Suriñach *et al*. (2011)	+ (26 European countries)	+ (26 European countries)				
Rochina-Barrachina *et al.* (2010)		+ (Spain)				
Evangelista and Vezzani (2011)			+ (Italy)			+ (Italy)
Griffith *et al.* (2006)	+ (France, Spain, UK)	+ (France) NS (Spain, UK)				
Mairesse, and Robin (2009)	+ (France)	NS (France)				
Janz *et al* (2004)	+ (Sweden, Germany)	- (Germany) NS (Sweden)				
Polder *et al.* (2010)	NS (Netherlands)	NS (Netherlands)	+ (Netherlands)	- (Netherlands)	+ (Netherlands)	+ (Netherlands)
Masso and Vahter (2012)	+ (Estonia)	NS (Estonia)	NS (Estonia)	+ (Estonia)		

Notes: "+ " indicates the relationship is positive
"- " indicates the relationship is negative
NS indicates the relationship was analyzed, but is not significant

Source: Suriñach *et al*. 2011; Rochina-Barrachina *et al.* 2010; Evangelista and Vezzani 2010; Griffith *et al.* 2006; Mairesse and Robin 2009; Janz *et al.* 2004; Polder *et al*. 2010; Masso and Vahter 2012.

A related paper about the relationship between productivity and innovation in the Estonian service sector has been written by Masso and Vahter (2012). They also consider four types of innovation and divide the service sector into sub-sectors. Two different classifications are used in their article. Using the Eurostat classification, Masso and Vahter found that technological innovation and product innovation are

positively related to productivity (for detailed analysis including sub-sectors results see Masso and Vahter 2012). Also, Suriñach *et al*. (2011) tried to analyze the relationship among sub-sectors, but dividing the economy into seven sub-sectors resulted in no significant correlations between productivity and innovations.

Methodology

As mentioned above, classifying the service sector might give some more detailed information about the relationship between productivity and innovation. As the previous articles show (Evangelista and Vezzani 2010; Masso and Vahter 2012), the relationship between productivity and innovation differs among different service sectors. The report "Innovation in Services: Typology, case studies and policy implications" (2006) is used to classify service firms in this paper. According to this report services are divided into four groups: assisting services, distributive services, problem solvers and leisure services. This classification is based on how services create value for the customer. Assisting services are those which help people to do things they can do themselves, like cleaning, but which are time consuming. Distributive services include a large amount of different services, for example banking, transport, and wholesale trade. Problem solvers are solving specific problems that customers cannot handle themselves, like law firms, architect bureaus, information technology solutions, medical services, etc. Leisure services are activities like art, entertainment, sports, and restaurants. However, leisure services are not considered in this paper, because there are too few observations in this group in the case of Estonian data. This classification is based on the NACE 5 digit nomenclature (see Appendix 2). In this paper the service sector is defined as NACE sectors E and G to O, with some exceptions in sector E, for example gas production.

A Cobb-Douglas type of production function is estimated. Labour productivity is measured as value added per employee, innovation types are taken as dummy variables whether a firm is an innovator or not (1 and 0 respectively). Also capital intensity as the capital-labour ratio is included[3]. The first model estimates productivity per employee for the whole service sector, therefore sub-sector dummies for assisting and distributive services are included. All the models are estimated with ordinary least squares (OLS). Using OLS for estimating those models, correlative relations result and causality effects cannot be estimated. See limitations for this model in the conclusion section. Four different models are estimated: one for productivity, the second for labour costs, the third for depreciation and the fourth with gross profit per employee as the dependent variable. Decomposing productivity into three different variables gives the opportunity to look deeper at the relationship between productivity and innovation. The model is the following:

$$(1) Log(value\_added\_per\_employee)_i = \alpha_0 + \alpha_1 \log(K/L)_i + \alpha_2 \log(number\_of\_employees)_i + \alpha_3 Foreign\_ownership_i + \alpha_4 \Pr oduct\_innovation_i + \alpha_5 \Pr ocess\_innovation_i + \alpha_6 Organizational\ innovation_i + \alpha_7 Marketing\_innovation_i + \alpha_8 Assisting\_services_i + \alpha_9 Distributiveservices_i + u_i,$$

[3] In the case of adding capital-labour ratio in the model, total factor productivity instead of labour productivity is estimated.

where K/L stands for capital intensity measured as capital-labour ratio, while capital is measured as firm's fixed assets. u_i is the error term and subscript i indexes firms.

As the next step, in order to analyze the linkages between productivity and innovation in a more detailed way the same model is estimated based on sub-sector data. The first four models are estimated based on distributive service firms' data, then using problem solvers' data and finally based on assisting service firms' data.

$$(2) Log(value\_added\_per\_employee\_in\_one\_sub-sector)_i = \beta_0 + \beta_1 \log(K/L)_i + \beta_2 \log(number\ of\_employees)_i + \beta_3 Foreign\_ownership_i + \beta_4 Product\_innovation_i + \beta_5 Process\_innovation_i + \beta_6 Organizational\_innovation_i + \beta_7 Marketing\_innovation_i + v_i$$

According to theoretical studies, the estimations of parameters should be as follows: based on Solow's growth theory (1956, 1957), long-term productivity growth depends on innovation and capital intensity, both variables of which are positively related to productivity. The number of employees is included in the model to control for economies of scale. Therefore, the number of employees is assumed to be positively related to productivity. Bigger firms have advantages for lowering costs and therefore also increasing productivity (Kendrick 1977, Silvestre 1987, De Witte and Marques 2011). Productivity and foreign ownership are interrelated, similar to productivity and innovation (Helpman *et al.* 2004). On the one hand foreign ownership increases firm's productivity, and on the other hand only productive firms are able to receive foreign investments. It is more costly for firms to be active in a foreign country, because the local firms have more information about the local markets, business practices and customer preferences. Therefore foreign firms must have some other competitive advantages, like higher productivity or greater market power. (Griffith *et al.* 2004) Having foreign ownership is positively related to productivity. Smarzynska Javorcik (2004) analyzed the relationship between foreign ownership and productivity in Lithuania and showed that firms that having joint ownership is positively correlated with productivity. Based on Estonian data, Vahter and Masso (2007) analyzed the relationship between productivity and foreign investments, also finding a positive relationship.

Considering previous studies capital intensity is positively related to productivity, see Griffith *et al*. (2006), Mairesse and Robin (2009), Polder *et al*. (2010), and Masso and Vahter (2012). All above mentioned studies also include the number of employees in their models. In the Griffith *et al*. and Mairesse and Robin studies the number of employees is added as a dummy variable. Mairesse and Robin found that the more employees the firms have, the lower their productivity level is. In the Griffith *et al*. paper there are both negative and positive relations between the number of employees and productivity. Polder *et al*. and Masso and Vahter use the logarithm of the number of employees to measure firm size. In both of these papers the relationship between the number of employees and productivity is negative.

Data and descriptive statistics

To investigate the relationship between productivity and innovation, data from the Estonian innovation survey CIS2006 (covering the years 2004-2006) are used as a source for innovation indicators. Four types of innovation are considered: product,

process, organizational and marketing innovation. Information about innovation activities in CIS2006 is based on self-reporting, whether firms conducted any kind of innovative activities (there are questions about 15 different activities) during this period. In CIS2006 there are 739 service firms, which comprise 38% of all the firms included in this survey.

The Estonian Business Register is used for indicators of productivity and its components. Data in the Business Register is based on firms' annual reports. In this paper labour costs, depreciation, and gross profit are taken from those annual reports for calculating value added. Data about fixed assets are taken from Business Register. Productivity is taken as the dependent variable in the regression model; therefore its values are taken for the year 2006 which marks the end of the innovation survey period. Innovation and other explanatory variables are taken as the average for the years 2004-2006, because it is assumed that changes in innovation activities are likely not affecting productivity in the same period.

In Appendix 3 descriptive statistics for the variables in the model is given. Differences between the values of sub-sectors have been tested with the t-test (see Appendix 4). It is seen in the table that among problem solvers labour costs per employee are the highest. Compared to other sectors problem solvers need more qualified employees who also have higher wages. The lowest labour costs are among distributive services. Average depreciation is the lowest among problem solvers and the highest among assisting services. This can be explained by the nature of these services, as problem solvers do not need much capital to offer services, for example law firms and architecture bureaus. There are not any statistically significant differences between sub-sectors in the case of gross profit and value added per employee.

The share of product and process innovators is the highest among problem solvers, at the same time the share of organizational innovators is the lowest. However, organizational innovation has a similar share in all other sectors, where differences are not significant. In the case of marketing innovation, distributive services have the highest share of innovators.

The number of employees and capital intensity is the highest among assisting services and the lowest among problem solvers. Similar to the share of innovators, the share of foreign owned firms[4] in sub-sectors is given. The shares of foreign owned firms are not significantly different from each other.

Results

The first model (1) is estimated with OLS for the whole service sector. Results are given in Table 2 (standard errors are given in parentheses). For models with heteroscedasticity, robust standard errors are calculated. All the models are significant at the 1 per cent level. The Ramsey RESET test shows that there might be some important omitted variables in the labour costs and depreciation model. These omitted variables could be unobserved variables, such as skills and knowledge.

[4] Either fully or partially owned.

Table 2. Productivity and its components models for all service firms

Dependent / Explanatory	Log(value added per employee)	Log(labour costs per employee)	Log(depreciation per employee)	Log(gross profit per employee)
Log(K/L)	0.163	0.059	0.706	0.186
	(0.026)***	(0.013)***	(0.018)***	(0.033)***
Product innovation	0.219	0.077	0.067	0.436
	(0.100)**	(0.059)***	(0.080)	(0.149)***
Process innovation	-0.037	0.070	-0.015	-0.098
	(0.089)	(0.054)***	(0.073)	(0.137)
Organizational innovation	0.102	0.178	0.069	0.147
	(0.093)	(0.053)***	(0.072)	(0.134)
Marketing innovation	0.220	0.130	-0.090	0.147
	(0.117)*	(0.060)**	(0.081)	(0.152)
Log(number of employees)	0.003	0.037	0.014	0.019
	(0.040)	(0.023)	(0.032)	(0.060)
Foreign ownership	0.600	0.501	0.207	0.592
	(0.083)***	(0.053)***	(0.072)***	(0.135)***
Assisting services	-0,147	-0,323	-0,191	-0,014
	(0,135)	(0,101)***	(0,137)	(0,245)
Distributive services	-0.357	-0.511	-0.099	0.064
	(0.089)***	(0.053)***	(0.072)	(0.132)
Constant	10.878	11.318	1.723	9.407
	(0.291)***	(0.158)***	(0.213)***	(0.396)***
Number of observations	517	558	557	468
F-statistic	13.44***	32.06***	199.23***	8.38***
R^2	0.193	0.345	0.766	0.141
Hettest	5.38**	2.19 (H_0)	2.26 (H_0)	2.56 (H_0)
Multicollinearity	1.32	1.32	1.32	1.32
Ramsey test	0.26 (H_0)	3.90**	2.47*	0.48 (H_0)

Notes: There is heteroscedasticity in the value added model; therefore robust standard errors are given for this model. This estimation is based on Estonian CIS2006 and Estonian Business Register 2004-2006 data. All models are estimated with ordinary least squares.

* - significant at 10 per cent level
** - significant at 5 per cent level
*** - significant at 1 per cent level

Productivity per employee has a positive relationship with capital intensity and the foreign ownership dummy. Of the innovation types product and marketing innovation are significant. Marketing innovators have on average 22.0% higher productivity than non-innovators, once other determinants of productivity are accounted for, and product innovators have on average 21.9% higher productivity than non-innovators. Compared to previous studies, the results found in this paper are quite similar. Product innovation is also significant and positive in the Masso and Vahter (2012) paper on Estonia, Griffith *et al.* (2006) based on data from France, Germany, Spain and the UK, and Janz *et al*. (2004) based on German and Swedish data. Marketing innovation is not significant in Masso and Vahter (2012) in the case of adding all four types of innovation in the model. Combining product and process innovation into a technological innovation dummy, they found marketing innovation significant at the 10 per cent level. Some authors like Mairesse and Robin (2009), Griffith *et al*. (2006), and Rochina-Barrachina *et al*. (2010) also found process innovation significant and positive, whilst in the Janz *et al.* (2004) study the relationship between productivity and process innovation is negative. Polder *et al.* (2010) and Evangelista and Vezzani (2010) found that productivity is positively related to organizational innovation. According to the Estonian data used in this paper, organizational innovation is related

to productivity in some service sub-sectors and process innovation is related to labour costs in the whole service sector model and among problem solvers (see Table 6). The distributive services sector dummy shows (see Table 3) that firms in the distributive service sector have on average 35.7% lower productivity level than firms that belong to the group of problem solvers.

In addition to the foreign ownership dummy and capital intensity, all four types of innovation are also significant in the labour costs model. Process innovation, which is not statistically significant in the value added model is significant in the labour costs model, but has a lower coefficient than other innovation types. The strongest linkage is between organizational innovation and labour costs per employee (compared to other innovation types). Organizational innovators have on average a 17.8% higher productivity level than non-innovators, once other productivity determinants are accounted for. Capital intensity has the lowest coefficient in the labour costs model compared to other components models. Firms that have foreign ownership have on average 50.1% higher labour costs per employee.

In the labour costs model both sub-sector dummies are significant. Both assisting services and distributive services have lower labour costs than problem solvers. The only variable that is not significant in the labour costs model is the number of employees. Therefore, in bigger firms wages are not significantly higher. In the depreciation model only two variables are significant: capital intensity and foreign ownership. In the gross profit model product innovation in significant – product innovators have on average 43.6% higher gross profit compared to non-innovators. Capital intensity and foreign ownership are significant, as in all previously described models. Sub-sector dummies are, in this model, insignificant, which means that there are no significant differences between gross profit levels comparing the sub-sectors.

In Table 3 results based on distributive service firms' data are given. For productivity, depreciation and gross profit model standard errors are corrected with heteroscedasticity. Similar to the whole service sector model, productivity per employee is significantly linked to capital intensity, foreign ownership and marketing innovation. Marketing innovators have on average 36.5% higher productivity per employee than non-innovators. The strongest linkage is between productivity and foreign ownership – firms with foreign ownership have on average 77.4% higher productivity per employee.

Analyzing the models of productivity components shows that in all the models capital intensity and foreign ownership are significant and the linkage between capital intensity and depreciation per employee is the strongest. Foreign ownership has the strongest linkage with gross profit per employee. In the labour costs model two types of innovation are also significant: organizational and marketing innovation. In the depreciation model (like in the case of the whole service sector model) only capital intensity and foreign ownership are significant. Among distributive service firms gross profit per employee is significantly and positively related to capital intensity and foreign ownership. Firms with foreign ownership have on average 82.9% higher gross profit per employee. In the case of the whole service sector only product innovation is significant in the gross profit model, but in the case of distributive services both product and marketing innovations are significant. Product innovators have on average 44.3% higher gross profit per employee and marketing innovators have on average 34.0% higher gross profit per employee than non-innovators.

Table 3. Productivity and its components models for distributive service firms

Dependent / Explanatory	Log(value added per employee)	Log(labour costs per employee)	Log(depreciation per employee)	Log(gross profit per employee)
Log(K/L)	0.170	0.064	0.739	0.167
	(0.033)***	(0.082)***	(0.022)***	(0.043)***
Product innovation	0.232	0.062	0.175	0.443
	(0.158)	(0.082)	(0.112)	(0.196)**
Process innovation	-0.129	0.041	-0.141	-0.316
	(0.128)	(0.073)	(0.099)	(0.203)
Organizational innovation	-0.005	0.172	0.047	0.022
	(0.127)	(0.070)**	(0.099)	(0.181)
Marketing innovation	0.366	0.196	-0.099	0.340
	(0.158)**	(0.077)**	(0.106)	(0.195)*
Log(number of employees)	-0.016	0.015	-0.006	0.016
	(0.047)	(0.028)	(0.034)	(0.076)
Foreign ownership	0.774	0.560	0.180	0.829
	(0.112)***	(0.070)***	(0.091)**	(0.155)***
Constant	10.506	10.796	1.322	9.725
	(0.419)***	(0.213)***	(0.273)***	(0.532)***
Number of observations	343	361	360	301
F-statistic	11.97***	18.92***	187.33***	7.56***
R^2	0.200	0.273	0.784	0.153
Hettest	5.59**	0.10 (H_0)	3.68*	7.12***
Multicollinearity	1.32	1.30	1.31	1.34
Ramsey test	0.26 (H_0)	2.07 (H_0)	1.57 (H_0)	0.35 (H_0)

Notes: There is heteroscedasticity in the value added, depreciation, and gross profit model; therefore robust standard errors are given for those models. This estimation is based on Estonian CIS2006 and Estonian Business Register 2004-2006 data. All models are estimated with ordinary least squares.

* - significant at 10 per cent level
** - significant at 5 per cent level
*** - significant at 1 per cent level

In Table 4 results from estimating the models based on problem solvers' data are given. As in the previous sectors capital intensity and foreign ownership are significant in the productivity model. Organizational innovation has positive a linkage with productivity – organizational innovators have on average 29.3% higher productivity per employee than non-innovators. The only model among problem solvers where capital intensity is not significant is the labour costs model. This is due to the nature of the problem solvers sector, where a large amount of capital is not necessary for offering services. The other difference compared to previously analyzed sectors is that the number of employees is significant in the labour costs model.

Labour costs per employee are linked to two types of innovation: process and organizational innovation. Process innovators have on average 14.2% higher labour costs per employee than non-innovators and organizational innovators have on average 22.6% higher labour costs per employee. Also, foreign ownership has a positive linkage with labour costs per employee. Surprisingly, in the gross profit model foreign ownership is not significant. This means that foreign owned and domestic firms do not have any significant differences in their gross profit levels. Product innovation has a positive linkage with gross profit per employee – product

innovators have on average 39.7% higher gross profits per employee than non-innovators.

Table 4. Productivity and its components models for problem solvers

Dependent / Explanatory	Log(value added per employee)	Log(labour costs per employee)	Log(depreciation per employee)	Log(gross profit per employee)
Log(K/L)	0.117	0.023	0.547	0.227
	(0.048)**	(0.030)	(0.043)***	(0.070)***
Product innovation	0.136	0.038	-0.026	0.397
	(0.115)	(0.083)	(0.119)	(0.224)*
Process innovation	0.147	0.142	0.147	0.240
	(0.111)	(0.076)*	(0.116)	(0.217)
Organizational innovation	0.293	0.226	0.198	0.283
	(0.152)*	(0.089)**	(0.121)	(0.226)
Marketing innovation	-0.027	-0.015	-0.056	0.004
	(0.186)	(0.117)	(0.163)	(0.263)
Log(number of employees)	-0.011	0.089	0.042	-0.107
	(0.068)	(0.048)*	(0.076)	(0.130)
Foreign ownership	0.249	0.407	0.216	0.049
	(0.101)**	(0.080)***	(0.110)*	(0.223)
Constant	11.437	11.560	3.237	9.362
	(0.489)***	(0.350)***	(0.480)***	(0.834)***
Number of observations	140	160	160	134
F-statistic	3.96***	7.51***	31.04***	3.49**
R^2	0.174	0.240	0.559	0.163
Hettest	4.22**	4.31**	4.53**	0.93 (H_0)
Multicollinearity	1.24	1.23	1.23	1.22
Ramsey test	0.52 (H_0)	0.98 (H_0)	1.67 (H_0)	1.29 (H_0)

Notes: There is heteroscedasticity in the value added, labour costs, and depreciation model; therefore robust standard errors are given for those models. This estimation is based on Estonian CIS2006 and Estonian Business Register 2004-2006 data. All models are estimated with ordinary least squares.

* - significant at 10 per cent level
** - significant at 5 per cent level
*** - significant at 1 per cent level

Table 5 illustrates the results of the estimations based on assisting services data. It is important to notice that the number of observations in assisting services is low compared to other sectors. Therefore, there are not so many significant variables in the models and the estimations are less accurate and are not as reliable as the previous results which have a bigger sample. Despite the small number of observations all models are significant at the 1 per cent level.

Assisting service firms are the only sector where productivity per employee is not linked to foreign ownership. Similar to problem solvers, organizational innovation is significant in the productivity model. Organizational innovators have on average 50.9% higher productivity per employee than non-innovators.

Table 5. Productivity and its components models for assisting service firms

Dependent / Explanatory	Log(value added per employee)	Log(labour costs per employee)	Log(depreciation per employee)	Log(gross profit per employee)
Log(K/L)	0.216	0.088	0.812	0.211
	(0.053)***	(0.036)**	(0.084)***	(0.085)**
Product innovation	0.344	0.375	-0.424	0.083
	(0.327)	(0.201)*	(0.405)	(0.526)
Process innovation	-0.046	-0.122	-0.096	0.219
	(0.269)	(0.185)	(0.317)	(0.428)
Organizational innovation	0.509	0.121	0.206	0.857
	(0.287)*	(0.200)	(0.431)	(0.467)*
Marketing innovation	-0.269	0.093	0.004	-0.878
	(0.302)	(0.201)	(0.325)	(0.484)*
Log(number of employees)	0.188	0.158	0.069	0.200
	(0.126)	(0.083)*	(0.132)	(0.201)
Foreign ownership	0.400	0.363	0.352	1.029
	(0.319)	(0.206)*	(0.321)	(0.594)*
Constant	9.259	10.170	-0.048	8.188
	(0.776)***	(0.485)***	(1.054)	(1.236)***
Number of observations	34	37	37	33
F-statistic	5.02***	4.22***	28.33***	3.93***
R^2	0.575	0.504	0.871	0.524
Hettest	0.35 (H_0)	1.56 (H_0)	3.56*	0.00 (H_0)
Multicollinearity	1.41	1.56	1.56	1.43
Ramsey test	0.82 (H_0)	5.13***	1.59 (H_0)	1.13 (H_0)

Notes: There is heteroscedasticity in the depreciation model; therefore robust standard errors are given for this model. This estimation is based on Estonian CIS2006 and Estonian Business Register 2004-2006 data. All models are estimated with ordinary least squares.

* - significant at 10 per cent level
** - significant at 5 per cent level
*** - significant at 1 per cent level

In the labour costs model foreign ownership and capital intensity are significant. Similar to problem solvers, the number of employees has a positive linkage with labour costs. Product innovation has a positive linkage with labour costs per employee: product innovators have on average 37.5% higher labour costs per employee than non-innovators. In the depreciation model only capital intensity is significant. The gross profit model is the only model with a negative linkage between innovation and productivity components. Marketing innovation has a negative linkage with gross profit per employee: marketing innovators have on average 87.8% lower gross profit per employee than non-innovators. The reason for the negative linkage could be the fact that firms that have lower gross profit are not able to undertake more expensive innovations like product or process innovations. This highlights the causality problem – whether productivity has an influence on innovation, or innovation on productivity. In this paper causality effects are not analyzed and only correlative linkages between variables are analyzed. At the same time gross profit per employee has a positive and very strong linkage with organizational innovation: organizational innovators have on average 85.7% higher gross profit per employee than non-innovators. Gross profit per employee is also highly linked to foreign ownership: firms with foreign ownership have on average 102.9% higher gross profit than those that do not have foreign ownership.

In Table 6 all significant linkages between innovation and productivity (including productivity components) are given. The “+” or “-” sign in parentheses shows whether this linkage is positive or negative. In the whole service sector all types of innovations are significant in different models. Among distributive and assisting service firms process innovation is not related to productivity nor to its components. In the problem solvers sector process innovation is positively linked to labour costs per employee. The distributive service sector is the only sector where marketing innovation has a positive linkage with productivity or its components.

Table 6. The linkages between innovation and productivity and its components in different service sectors

	Product innovation	**Process innovation**	**Organizational innovation**	**Marketing innovation**
The whole service sector	Value added per employee (+) Labour costs per employee (+) Gross profit per employee (+)	Labour costs per employee (+)	Labour costs per employee (+)	Value added per employee (+) Labour costs per employee (+)
Distributive services	Gross profit per employee (+)		Labour costs per employee (+)	Value added per employee (+) Labour costs per employee (+) Gross profit per employee (+)
Problem solvers	Gross profit per employee (+)	Labour costs per employee (+)	Value added per employee (+) Labour costs per employee (+)	
Assisting services	Labour costs per employee (+)		Value added per employee (+) Gross profit per employee (+)	Gross profit per employee (-)

Looking at the sub-sectors’ models, it can be seen that productivity per employee is linked to organizational (problem solvers and assisting service firms) and marketing innovation (distributive service firms). Technological innovation is not linked to productivity per employee. As previous studies focus more on technological innovation, they underestimate the importance of innovations in service sector. In different sub-sectors different innovation types are linked to productivity and its components. Therefore, it is important to analyze the linkage between productivity and innovations in different sub-sectors.

Limitations

Estimating this type of model with ordinary least squares has some limitations. This model has an endogeneity problem which means that all the explanatory variables are not fully exogenous. For example innovations increase the productivity level of the firm, but at the same time productive firms have more resources to adopt innovations. As there is no clear direction of influence effects between those two variables, only correlative linkages and not causality effects are studied. Analyzing

this type of model with OLS gives biased estimations of the parameters. One solution to this problem is to use instrumental variables. Another way is to estimate the model according to Olley and Pakes (1996) or Levinsohn and Petrin (2003) who added some explanatory variables to control for the unobservable parts of productivity.

Another limitation lies with the data source used in this paper – CIS2006. There can be problems that the person who answers the questions concerning innovation activities might not be able to distinguish between different innovation types, especially product and process innovation, because services have processes in their nature (Gallouj and Weinstein 1997).

Conclusion

In this paper four innovation types – product, process, organizational and marketing innovation – are considered. For analyzing the linkage between productivity and innovation, services are divided into three groups: assisting services, distributive services and problem solvers. Productivity is measured as value added per employee, which consists of labour costs, depreciation and gross profit per employee. For modelling the linkages of productivity and its components, data from Estonian CIS 5 (covering the years 2004-2006) and Estonian Business Register for the year 2006 are used.

Estimating the linkage between productivity and innovation, a Cobb-Douglas type of production function is used. Estimating the models with ordinary least squares revealed that considering the whole service sector productivity has a positive linkage with product and marketing innovation. The labour costs model is the only one where all four types of innovation are significant. The strongest linkage is between organizational innovation and labour costs and the weakest is the linkage with process innovation. In the case of the depreciation model no type of innovations are significant. Gross profit has a strong linkage with product innovation.

Among distributive services productivity is also related to marketing innovation. Among distributive services marketing innovation is significant in three models out of four. In the labour costs model organizational and marketing innovations are significant and there are not any significant innovations in the depreciation model. In the problem solvers sector organizational innovation is positively linked to productivity. Labour costs are linked to process and organizational innovation. Based on problem solvers' data, the labour costs model is the only model where process innovation is significant. Labour costs are the only productivity component that is in all sectors related at least to one type of innovation. Product innovation is significantly related to gross profit. Among assisting services productivity is related to organizational innovation and labour costs are related to product innovation. In the gross profit model there are both positive and negative linkages between gross profit and innovation: organizational innovation is positively linked to gross profit and marketing innovation has a negative linkage with gross profit.

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