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Eco-Innovation Activities in the Czech Economy 2008–2014: Impact of the Eco-Innovative Approach to the Profit Stream and Differences in Urban and Rural Enterprises

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Abstract: The environmental benefits from the eco-innovation activities of enterprises have the nature of reduced material or water use per unit of output, less pollution and waste, better CO_2 'footprint' in production and subsequent business processes. The socioeconomic impacts are associated with circular economy benefits like reduced energy use, decreased pollution and waste, and well-organized recycling possibilities of the product after use. The goal of this paper is to evaluate this innovative approach in the Czech economy. The hypotheses are aimed at the localization of enterprises, appropriability, and characteristics of enterprises that introduce eco-innovations to markets. The dataset is provided by the Czech Statistical Office and contains observations about the innovation activities of firms. Eco-innovation was surveyed in 2008 and 2014. This paper utilizes the estimation principles of CDM (Crépon, Duguet, and Mairesse) method at the firm level. The results suggest that rural–urban separation has no impact on the financial R&D intensity but urban enterprises have a higher probability to engage in innovation activities. The probability to introduce new-to-the-market innovations and eco-innovations is not dependent on localization. High-tech and knowledge-intensive industries have a lower probability to introduce eco-innovations to the market. The change in localization of enterprises to rural areas contributed to the higher sales form innovated goods and services. Higher appropriability was also observed in product eco-innovators. This paper offers a synthesis of factors that stimulate eco-innovation and shows that eco-innovation is a viable and sustainable innovative approach for rural and urban enterprises and identifies directions for future research.

Keywords: innovative; localization; environmental; green; rural; production; sustainability

JEL Classification: O31; O18; R11

1. Introduction

Eco-innovations are important factors that contribute to the reduction of environmental damages arising from economic activities. These innovations are labeled as green or environmentally friendly for society. The terms eco-innovation and sustainability are related. There are no exact definitions because both terms are used as 'buzzwords' in mass media and academic circles. There are multiple definitions and diverse interpretations (Río et al. 2016; Carrillo-Hermosilla et al. 2010).

In this paper, eco-innovation is an act of innovating or the end product of that act which is an organizational process in general and most commonly a standard business process in private enterprises. The act of eco-innovating is aimed at sustainable and green ideas. Since it is an organizational process, green ideas are to some extent incorporated into the innovation strategy of the organization. At the end of the eco-innovation process, an enterprise implements an eco-innovation (product and/or process) if there is a reduction of pollution, energy use, and environmental risks in general.

In addition, this paper focuses also on the distinctions between rural and urban areas. The eco-innovation approach in rural and urban areas can be different. These differences are often exaggerated and analyzed as developed smart cities versus developing agricultural and more passive rural areas (Irwin et al. 2010). Sometimes, even the term 'rural and urban separation' is used. However, both areas are dependent at a firm-level because of the value chains between the industry sectors (Balassa–Samuelson like effects). It is also very hard to distinguish both areas, especially in a small country like the Czech Republic. Rural and urban separation is dynamic as well as country-specific (Berdegue et al. 2015). This paper will shed some light on this issue.

Paper deals with the hypothesis about the low profitability of the eco-innovation approach. This thesis is based on Arrow's theory of 'inappropriability' of the profit stream of innovation outputs which partially have the nature of public goods. The second hypothesis deals with differences in the innovation process between rural and urban enterprises. This thesis is based on knowledge filter theory (Acs et al. 2013) which suggests that the transaction costs to acquire knowledge are higher in rural areas.

The goal of this paper is to analyze the eco-innovation approach of enterprises. The scope of analysis is limited by data availability in Community Innovation Surveys in the Czech economy in 2014. The theses and issues are introduced as well as developed using a critical review of recent literature. The estimation method is based on the innovation process rationale of Crépon et al. (1998)—the decision to innovate (being an innovator or eco-innovator), then there is research and development (R&D) expenditure analysis and the analysis of the innovation output in the last step.

2. Theoretical Background

The knowledge filter (Acs et al. 2013) as introduced in the knowledge spillover theory of entrepreneurship is, similarly like in developing countries, present in rural areas. The transaction costs to acquire knowledge are high. Also, the absorptive capacity of the enterprise is lower because there are fewer skilled workers in rural and coastal labor markets. The orientation to the green products and eco-innovations is not without risks or issues.

> Developing customer awareness about green products is not difficult but customer attitude and customer behavior in buying and paying more for green products are not the same. Some product categories are more price-sensitive than others when it comes to how much more customers want to pay for green products. Further, several new green ventures and companies are founded on the expectations of continuing government subsidies which may not last, leaving the companies very vulnerable. Finally, betting on green product technologies that may achieve technical and commercial success is not without significant risks. Only some companies with deep pockets can afford to invest in multiple technologies but it is costly. (Dangelico and Pujari 2010, p. 481)

Technology acquisition and exploitation are more likely to happen by using an open innovation framework in rural and coastal areas. Internal R&D activities to make novel products are traditionally associated with large companies. Rural space is a domain of SMEs. Dutch SMEs extensively cooperated on innovation, engaged in open innovation projects, and acquired external knowledge (van de Vrande et al. 2009).

The research that encompasses innovation activities of SMEs is quite extensive and with ambiguous results suggesting that context and national policies play an important role (Rosenbusch et al. 2011). There are some suggestions and frameworks, for example:

> Manufacturing SMEs are likely to improve their performance as they increasingly mirror large manufacturing firms with respect to strategy and formal structure" (Terziovski 2010, p. 899) or " … innovation project portfolio is generally poorly aligned with the strategy of the firm. Our study addressed this issue by discussing sustainability as part of the innovation strategy of the firm. (Brook and Pagnanelli 2014, p. 60)

These implications are more likely applicable to urban markets than rural because there are larger manufacturing companies to mirror. Indeed, sustainable ideas can help enterprises start-up their own innovation projects. However, the big issue remains unresolved: How to make strategic managers adopt the academic frameworks and green ideas in general?

Eco-innovators are regarded as sustainable entrepreneurs because they are contributing to solve environmental and societal problems. Entrepreneurship is linked with profit (or value) maximization. The sustainable entrepreneur has environmental and social preferences: "As a distinction to many views of conventional entrepreneurship, sustainable entrepreneurship furthermore extends the goal of corporate influence beyond market success … " (Schaltegger and Wagner 2011, p. 226). In a larger organization, there are also other intrapreneurs who shape the environmental growth of the company.

In other words, we observe to some extent lower private benefits and larger social benefits. (Smith [1776] 1985) introduced the unintended social benefits of an individual's self-interested actions. According this Smith's observation of society sustainable entrepreneurs are persons who see value in sustainable and socially responsible development. It is their private self-interest that brings unintended social benefits. There is a problem if there is no room for being greener and more societally responsible. The intrapreneurial and entrepreneurial attitudes toward sustainable development are already quite high in rural and coastal spaces. The benefits of marginal change towards even greener attitudes might be too costly for them. Is there a 'lock-in' situation of product eco-innovation in rural space?

Key elements for a strategic sustainability perspective that lead to product eco-innovation are suggested by Hallstedt et al. (2013). The number one key element is the senior managers' commitment. The company's mission has to be full of sustainable ideas and caring actions for the environment. The second element requires the alignment of the product innovation processes with sustainable ideas. The third element requires sustainable involvement of the supply chain. The fourth element requires building a long-term company image as a sustainable company. The fifth element suggests assigning responsible persons for sustainability implementation. The sixth to ninth elements suggest not forgetting about evaluation, long-term planning, and 'backcasting'. This is hardly applicable in the rural sector because research describes six large European manufacturing product innovators. However, the idea of supply chain involvement is viable for rural space and eco-innovation and will be tested.

The quality of the network in the territory is crucial to spark the innovativeness. The network of suppliers, universities, and other organizations are also critical to disseminate sustainable ideas and technologies. Universities are the bearer and accelerators of sustainability also according to Hart et al. (2015) and Kanda et al. (2018) who critically revived literature dealing with innovation and eco-innovation intermediation.

The issue is that the network is largely the result of market mechanisms where we observe competition and strategies of enterprises depending on costs and benefits. If sustainable ideas are too costly (with fewer benefits) for the network members, then they will not be disseminated. Public support might be the solution, which can be provided traditionally or by using the experimental and "safe-to-fail" adaptive urban design as well as pilot testing (Ahern et al. 2014).

The eco-innovations in SMEs are mostly triggered by public subsidies or regulation according to Horbach (2018). The innovative environment with public support was a key factor facilitating the success of innovative projects in Spanish rural areas in 2008–2012 (Esparcia 2014). Experimental subsidies aimed at innovation activities of rural and coastal enterprises come from the European Union LEADER initiative. The aim of the participating network members is to encourage innovations and support sustainable rural and coastal development. The German LEADER experience showed that innovation was perceived as alien to rural areas. This is because of the usual state industrial and innovation policy in the EU which is aimed at commercialization. Modern rural space is characterized by innovations that are aimed at cooperation, networking, culture, and the environment (Dargan and Shucksmith 2008).

The justification of public support of the R&D activities of enterprises is based on Arrow's (1962) work. It deals with market failures. The outcomes of all new-to-the-market innovation projects of enterprises are divided into private profit and public returns. There are issues in the market: (a) uncertainty in industries with rapid development and short-term profitability; (b) indivisibility of research and 'inappropriability' of the profit stream. The outputs of innovation projects partially have the nature of public goods. In the case of eco-innovations, the indivisibility of research and 'inappropriability' of the profit stream is more prominent. In theory, it is a good justification for public support. However, there is no way to ex-ante measure the 'extra' public component of eco-innovation projects.

To sum it up and align with our hypotheses, there are barriers to eco-innovative approach like the preference of short-term and unsustainable profit goals, theoretical implications regarding unpaid social and environmental benefits (based on Arrow 1962; Smith [1776] 1985), which relates to the issue of indivisibility of research and 'inappropriability' of the profit stream. Direct (grants, EU funds, etc.) public subsidies can help (Horbach 2018; Esparcia 2014) but they are not always considered a very effective innovation policy tool in Europe (Dargan and Shucksmith 2008; Vokoun 2017). In the case of differences between rural and urban areas, there are factors that support innovation regardless of the localization. Eco-innovation approach and sustainable ideas are more likely to be a strategy of firms in the 'countryside' (Brook and Pagnanelli 2014). It is possible because of open innovation approach (van de Vrande et al. 2009), the spread of sustainable ideas via the supply chain (Hallstedt et al. 2013) and other intermediates like universities and innovation centers (Kanda et al. 2018; Hart et al. 2015; Ahern et al. 2014).

3. Data and Variables

The 2008 and 2014 Czech Community Innovation Surveys (CIS) contain questions about innovations with environmental benefits for the enterprise or by the end-user of a product. This dataset contains microdata which is available as scientific-use files (partially anonymized data) and as secure-use files in the Eurostat's Safe Centers (see Czech Statistical Office 2015). Ecological innovation activities are, for example, aimed at the reduction of material and energy use as well as the use of green inputs (for an extended summary of statistical analysis see the Appendix A, Tables A1–A3).

Dependent variables describe the stages of innovation activities of enterprises. The innovator variable (40% of observations) represents all companies with non-zero R&D expenditures (i.e., in-house R&D expenditures, external knowledge acquisition, acquisition of machinery, equipment, software and buildings, training for innovative activities expenditures, and expenses related to market introduction of innovations). This is rather a broad definition but describes the potential of being an innovator regardless of the quality of innovation output.

The quality can be distinguished but it is based on self-reporting. There are three possible innovator variables (Table 1). The most restrictive is the patent definition which consists of observations about enterprises that applied for a patent at the European patent office (3%). New-to-the-market innovators (18%) introduced a new or significantly improved product onto their market before the competition. New-to-the-firm innovators (31%) introduced a new or significantly improved product that was already available on the market.

Product innovators (31% of the observations) are enterprises that introduced new or significantly improved goods or services (exclude the simple resale). Process innovators (32% of the observations) are enterprises that introduced (a) new or significantly improved methods of manufacturing for producing goods; (b) new or significantly improved logistics, delivery or distribution methods; (c) new or significantly improved supporting activities for your processes. Both activities are usually intertwined.

Table 1. Dependent variables

Variable	Obs.	Mean	Std. dev.	Min	Max
R&D innovator (%)	12,002	0.40	0.49	0	1
Applied for European patent (%)	12,002	0.03	0.17	0	1
New-to-the-market innovator (%)	12,002	0.18	0.39	0	1
New-to-the-firm innovator (%)	12,002	0.31	0.46	0	1
R&D per one employee (1000 CZK)	12,002	56.36	272.76	0	11,764
Product innovators (%)	12,002	0.31	0.46	0	1
Process innovators (%)	12,002	0.32	0.47	0	1
Environmental innovation (%)	12,002	0.40	0.49	0	1
Environmental product innovation (%)	12,002	0.28	0.45	0	1
Rural enterprise (%)	12,002	0.19	0.39	0	1

Note: Summary statistics based on Czech CIS datasets (2008 and 2014).

The variables of interest of this paper are about environmental benefits. Green activities within the enterprise (40% of the observations) were registered more often than benefits in terms of green products or services on the market (28%). Environmental benefits within an enterprise were not considered process innovation because the share of process innovation activities is lower (32% vs. 40%). Rural enterprises (18.6% of the observations) are located in or around cities with less than 25,000 inhabitants. It is not perfect for the identification of rural firms. The largest cities like Prague and other large county towns (33% of the population in the Czech Republic) are considered urban regions.

4. Models and Methodology

There are many simple (linear, selective, aggregated, etc.) methods of innovation modeling. However, there are only a few complex approaches to heteroscedastic panel datasets (compare theoretical models in (Godin 2017) and practical models in (Antonelli and Link 2019). The CDM (Crépon, Duguet, and Mairesse) approach used in this paper is not precise but provides good results for CIS datasets (Lööf et al. 2017). The estimation method utilizes the idea of innovation as an organizational process which starts with a decision to engage in innovation project and if successful it ends with some innovation output (Crépon et al. 1998). The CDM approach was further developed into a reasonable innovation model by Hall et al. (2009).

The first step in the logic of the CDM approach is to correct bias from non-randomly selected enterprises with innovation activities with decision and an R&D intensity analysis (Heckman procedure). The second step analyses the probability to introduce the product and process innovations with a latent R&D intensity variable (bi-probit procedure). There is also an additional output analysis which deals with sales of innovated goods and services.

Variables are in natural logarithms for continuous numerical data. The procedure (Table 2) comprises the general term $Xn_{it}\beta_n{}'s$ (with $n = 1, 2, 3, 4$, and 5) which expresses vectors of explanatory variables and control variables (for identification purposes) like the number of employees, cooperation on innovation activities, barriers of innovation activities, etc. The error terms are assumed to be independent of the exogenous variables, they are denoted as $\varepsilon\_{itn}{}'s$ (with $n = 1, 2, 3, 4$, and 5), the ρ_i denotes fixed effects. The single parameter to be estimated is α in the last equation (innovation input-output elasticity).

The process innovation equation includes an extra identification variable that is not included in the product innovation equation for identification purposes. This variable is the training dummy variable and investment rate per one employee (log of expenditures that consists of the acquisition of new machinery, equipment, buildings, and software).

Table 2. Innovation process—estimation procedure

Dependent Variable	Estimation Procedure
Innovation decision (r^*_{it})	$\begin{cases} r^*_{it} = 1 & if\ r_{it} = \left(X_{1it}\beta_1 + \varepsilon_{it_1}\right) > 0 \\ r^*_{it} = 0 & if\ r_{it} \le 0 \end{cases}$
R&D intensity variable (k^*_{it})	$k^*_{it} = \ln(k_{it})\big\vert(r_{it} > 0) = X_{2it}\beta_2 + \rho_i + \varepsilon_{it_2}$
Innovation equations	$\begin{cases} Product^*_{it} = \hat{k^*_{it}} + X_{3it}\beta_3 + \varepsilon_{it_3} \\ Process^*_{it} = \hat{k^*_{it}} + X_{4it}\beta_4 + \varepsilon_{it_4} \end{cases}$
Appropriability (t^*_{it})	$\mathrm{t}^*_{\mathrm{it}} = \ln(t_{it})\big\vert(k_{it} > 0) = X_{5it}\beta_5 + \rho_i + \alpha k^*_{it} + \varepsilon_{it_5}$

Note: We used STATA for panel data estimation.

There are biases from omitted variables, endogeneity, selection issues and due to the quality as well as the representativeness of the sample. The biases are attenuated to some extent. The first two error terms are estimated in the Heckman procedure to control for selection bias. Mills ratio was estimated for each period to evaluate the selection bias. The selection bias was not present if technological and knowledge level variables are included in the estimation (see the Appendix A, Tables A4 and A5).

The vector of parameters to be estimated is denoted by β_n (with n = 1, 2, 3, 4, and 5). In the case of Probit probability, marginal effects at means are reported (discreet change for binary independent variables and instantaneous rate of change for continuous variables—i.e., increase/decrease in the probability of product/process innovation). Their interpretation at means is not elegant because there are a lot of binary variables without meaningful means. However, the goal is to detect differences between rural and urban areas while providing significant variables that influence eco-innovation activities at the firm level.

The first innovation-decision equation (r_{it}^*) accounts for selection into all R&D activities (inhouse R&D, training, acquisitions of knowledge, machinery, equipment, buildings, and software for innovation purposes). It deals with the probability of an enterprise *i* to engage in non-zero R&D in a year *t*. This is specified as a panel Probit model, i.e., $P(r_{it}^* > 0) = \Phi(X_{1it}\beta_1)$, where r_{it}^* equals 1 if enterprise *i* has non-zero total R&D expenditures in the year *t*. This decision is usually uniquely dependent on barriers to innovation activities which gained value 1 if their importance were high or the highest. The problem is that barriers (finances, personnel, etc.) are reported only for innovators and cannot be used in the first step to identify the decision equation in the 2014 dataset. For that reason, market orientation is used in the first step and not included in the R&D knowledge function (k_{it}^*) in the second step. Average marginal effects (Delta-method) are reported in the result tables with cluster robust standard errors. In the following equations, only non-zero R&D innovators are considered.

The second linear equation (k_{it}^*) describes the log of total R&D expenditures to the number of employees in enterprise *i* in the year *t*. This equation is uniquely dependent on market orientation and public funding variables. Fixed effects are assumed to be the default for a panel estimation procedure. Random effect estimations were considered where possible and tested using the Sargan–Hansen test of over-identifying restrictions at a 5% level. This test produces better results for heteroscedastic models than the standard Hausman test. Cluster (enterprise unique identification) robust standard errors are reported.

The third step is based on bi-equations ($\mathrm{Product}_{it}^*$ and $\mathrm{Process}_{it}^*$). The bivariate Probit probability model estimates the introduction of product or process innovation. This procedure estimated two separate outcomes, product and process innovations in general, and also environmental product, as well as environmental process innovations in particular (as eco-innovation activities). The term $\hat{k^*_{it}}$ describes the latent knowledge function (estimated as linear prediction after the second step) of an enterprise *i* in the year *t* for innovators only.

The fourth equation (t_{it}^*) models the innovation output as the log of sales of goods and services from the new-to-the-market and new-to-the-firm innovated goods and services to the number of employees. This equation is the most problematic because it is based on a self-reported variable that has a nature of the category but it is estimated as a continuous variable. The robustness check procedure was based on including more control variables like the technological and knowledge level of the industry, as well as cooperation partnership.

Sales per employee are not included as a variable or estimated as a structural equation because there are no variables like fixed assets or material control variables to estimate the production function well enough. Cluster robust standard errors are reported as default. The representativeness of the sample is guaranteed by the Czech statistical office (see the frequencies in Appendix A, Table A6). Most enterprises are from the manufacturing industry (NACE C: 48.8%), information and communication (NACE J: 8%), trade (NACE G: 7.8%) as well as professional, scientific, and technical activities (NACE M: 7.6%).

We added some independent variables (enterprise's age, enterprise's age SQ, and foreign ownership) to models (marked as #A) in order to provide a robustness check analysis and produce control models (marked as #B). Significant differences in coefficients are explained and in case of substantive differences then the #B model results are considered for interpretation.

5. Results

The decision to innovate (being innovator 0/1) and innovation intensity (logarithm of R&D per employee) equations (Table 3 and full results in Appendix A Table A7) provided estimates which are necessary for the next steps (latent R&D variable and Mill's ratio). The results regarding localization suggest that rural areas have a lower probability to innovate than urban areas (models 1A and 1B). The rural enterprises have about 6.7% (+/− 4 p.p.) lower probability than default (constant-term) enterprise which is in the urban space (Table 3, model 1B).

Table 3. Innovation process—estimation process, selected coefficients

Decision to Innovate and Innovation Intensity	**Model 1A**	**Model 1B**	**Model 2**
	Innovator (0/1)	**Innovator (0/1)**	**R&D/Employee (ln)**
Employees (ln)	0.238 ***	0.245 ***	−0.367 ***
	(0.02)	(0.02)	(0.02)
Rural (non−urban)	−0.120 ***	−0.067 *	−0.106
	(0.04)	(0.04)	(0.07)
Largest market National	0.561 ***	0.571 ***	
	(0.04)	(0.04)	
Largest market Europe	0.465 ***	0.527 ***	
	(0.05)	(0.05)	
Largest market World/Other	0.562 ***	0.602 ***	
	(0.09)	(0.09)	
Enterprise's age		0.013 *	0.052 ***
		(0.01)	(0.02)
Enterprise's age SQ.		−0.00038 *	−0.002 ***
		(0.00)	(0.00)
Foreign ownership		−0.280 ***	0.245 ***
		(0.05)	(0.07)
Additional variables	YES	YES	YES
Constant	−2.175 ***	−2.267 ***	3.689 ***
	(0.09)	(0.10)	(0.16)
Observations	12002	12002	4497

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, lnsig2u constants significant at 5%, the Sargan-Hansen FE vs. RE statistic was not significant at 5%—Fixed effect reported, additional variables are reported in Appendix A Table A7.

Interesting new results (Table 3 and full results in Appendix A Table A7) for the Czech economy are for the enterprise's age variable. The probability and financial intensity of innovation activities grow with age. There is a threshold (global maximum) of 17 years for the probability and 13 years for financial intensity (about 11% higher probability and 40% higher R&D intensity). The rural–urban separation has no impact on the financial R&D intensity (model 2, Table 3) in the population of all non-zero R&D Czech innovators.

To sum up the rest of the coefficients in the first step (Table 3 and full results in Appendix A Table A7), larger enterprises have a higher probability to innovate but lower R&D intensity than smaller enterprises. Being part of a group of companies contributes to a higher probability to innovate. Higher technological and farther market orientation (based on the largest market of the respondent) contribute to a higher probability to innovate. The technological level in the Czech Republic is specific the most companies in automotive are medium-tech companies, and their probability of innovating is slightly higher than in the case of high-tech companies. Knowledge level plays no role in both equations. Public direct funding, as expected, contributes to higher R&D expenditures per employee.

The product and process innovation bivariate Probit probability provided new results for the Czech economy (Tables 4 and A8 in the Appendix A). The probability to introduce at least new-to-the-market innovation output in the form of process or product innovation is the same for rural and more populated urban areas (Table 4).

Table 4. Product and process innovation probability, selected coefficients

Innovation Equations	**Model 3A**	**Model 3A**	**Model 3B**	**Model 3B**
	Product (0/1)	**Process (0/1)**	**Product (0/1)**	**Process (0/1)**
Employees (ln)	0.249 ***	0.158 ***	0.245 ***	0.155 ***
	(0.03)	(0.03)	(0.03)	(0.03)
Rural (non−urban)	0.139	−0.062	0.137	−0.062
	(0.10)	(0.10)	(0.10)	(0.10)
Linear trend	0.033**	−0.032 **	0.030 **	−0.032 **
	(0.01)	(0.01)	(0.01)	(0.01)
Enterprise's age			0.005	−0.003
			(0.01)	(0.01)
Foreign ownership			0.009	0.094
			(0.09)	(0.10)
Latent R&D function R&D/employee (ln)	0.536 ***	0.084	0.539 ***	0.080
	(0.07)	(0.07)	(0.07)	(0.07)
Investment/Employee (ln)		0.031 *		0.030 *
		(0.02)		(0.02)
Training		0.314 ***		0.317 ***
		(0.08)		(0.08)
Additional variables	YES	YES	YES	YES
Constant	−67.783 **	63.875 **	−62.083 **	61.005 **
	(26.87)	(27.71)	(27.83)	(29.39)
Observations	1753	1753	1753	1753

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, athrho constants significant at 10%.

To sum up the other coefficients, there is almost no relationship between product innovation probability and technological level. However, medium-tech level enterprises (mostly the automotive industry) have a higher probability to innovate products and a lower probability to innovate processes. Interestingly, knowledge-intensive services and medium-tech to high-tech industries have a lower probability to introduce process innovation. The innovation input (R&D expenditures) and output (product/process innovation) elasticity are evident only for product innovation. Cooperation with suppliers contributes to a higher probability to introduce product innovation. Cooperation within the group lowers the probability of introducing product innovation. Cooperation with universities and public sector clients contributes to a lower probability to introduce process innovation.

Product and process eco-innovation probability is the same in rural and urban areas (Tables 5 and A9 in the Appendix A). The relationship between innovation inputs (latent R&D) and product and process eco-innovations is positive. High-tech and knowledge-intensive industries are less likely to introduce ecological innovations. Cooperation with suppliers contributes to a higher probability to introduce a new eco-process. Cooperation inside the group has a negative impact on the probability to introduce an eco-product. No other cooperation has an effect on the introduction of eco-innovations. Training activities and investment expenditures have no effect on eco-innovations.

Table 5. Eco-innovation, product and process innovation probability, selected coefficients

Innovation Equations	**Model 4A**	**Model 4A**	**Model 4B**	**Model 4B**
	E−Product (0/1)	**E−Process (0/1)**	**E−Product (0/1)**	**E−Process (0/1)**
Employees (ln)	0.148 ***	0.190 ***	0.148 ***	0.181 ***
	(0.03)	(0.03)	(0.03)	(0.03)
Rural (non−urban)	0.059	−0.029	0.061	−0.029
	(0.08)	(0.09)	(0.08)	(0.09)
Linear trend	−0.057 ***	−0.062 ***	−0.065 ***	−0.067 ***
	(0.01)	(0.01)	(0.01)	(0.01)
Enterprise's age			0.011 **	0.008
			(0.01)	(0.01)
Foreign ownership			−0.194 **	0.056
			(0.08)	(0.09)
Latent R&D function	0.277 ***	0.244 ***	0.283 ***	0.246 ***
R&D/employee (ln)	(0.05)	(0.06)	(0.05)	(0.06)
Investment/employee (ln)		0.024		0.024
		(0.01)		(0.01)
Training		0.078		0.082
		(0.07)		(0.07)
Additional variables	YES	YES	YES	YES
Constant	112.432 ***	123.385 ***	128.493 ***	133.633 ***
	(22.53)	(24.73)	(23.72)	(25.95)
Observations	1753	1753	1753	1753

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, artrho constants statistically significant at 1% level.

The analysis of the profit stream is based on fixed effects estimation because the random effect was ruled out by the Sargan Hansen test of overidentifying restriction (Tables 6 and A10 in the Appendix A). This analysis suggests that the intertemporal change toward environmental innovative production is on average profitable. The effect is about 28% in comparison to the baseline enterprise which does not innovate continuously, cooperate, has domestic ownership, is a low knowledge-intensive or low-tech company, not part of a group and located in the urban area. Rural companies are more capable to secure profits from innovated goods and services if they change their location from urban to a rural area in time. Not surprisingly, high-tech and knowledge-intensive industries have higher shares of the sales of innovated goods and services.

Table 6. Innovation appropriability—analysis of the profit stream, selected coefficients

Sales of Innovated Goods Per Employee (ln)	**Model 5**	**Model 6**
	Fixed Effects	**Fixed Effects**
Employees (ln)	−0.342 *	−0.370 *
	(0.18)	(0.20)
Rural (non−urban)	1.492 ***	1.814 ***
	(0.32)	(0.19)
R&D/employee (ln)	0.025	−0.009
	(0.04)	(0.04)
Patent application		−0.052
		(0.16)
New-to-the-market		0.753 ***
		(0.13)
New-to-the-firm		0.742 ***
		(0.15)
Environmental process		0.112
		(0.16)
Environmental product		0.280 **
		(0.12)
Additional variables	YES	YES
Constant	17.626	4.936 ***
	(22.36)	(1.08)
Observations	3450	2395
Adjusted R^2	0.017	0.143

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6. Discussion

Being a rural innovator with a lower probability to have R&D expenditures has two interpretations. Rural firms do not care about R&D expenditures and do not report them for tax purposes. The second reason is probably the fact that they have a limited number of direct competitors, suppliers, and clients so they are not pulled to continuous innovation activities. The coefficients changed slightly after the robustness check analysis. The innovation probability depends also on the age of enterprise and foreign ownership. In general, there is an evidence of the knowledge filter in the rural areas (Acs et al. 2013). However, results suggest that rural innovators are able to have higher sales from innovated goods and services per employee than those located in urban areas.

The probability equation is not a full model and more variables (barriers of innovation activities, indicators of competition like price-cost margin, etc.) can be used. This means that the rural innovators can have a coefficient that is closer to zero (currently −6.7%) which indicates also worse significance level (drop from 1% to 10%). Also, the comparison is made to a constant-term (default enterprise) in the panel Probit equation with random effect. This default enterprise is defined on average and makes little sense to interpret it directly because there are a lot of binary variables.

There are no differences between rural and urban areas in R&D expenditures per employee. Also, the probability of process or product innovation is the same for the rural and more populated urban areas. This can be explained using the network effect like in Hart et al. (2015) and Kanda et al. (2018). The Czech economy is small and open, all medium-tech enterprises usually use ICT and are able to adapt to technological change while universities are also quite active in the innovativeness of rural space.

Interestingly, the eco-innovation of products and processes have a statistically significant relationship with the latent R&D function (Tables 5 and A9). We do not observe this in the case of process innovation in general (Tables 4 and A8). This means that public support which mostly increases only the innovation inputs (higher R&D expenditures than unsupported firms) contributes via the latent R&D function to higher eco-innovation production and eco-innovative processes at the same time.

On the other hand, process eco-innovation (Tables 5 and A9) activities have no relationship with training and investments. Process innovations have on average this relationship (Tables 4 and A8). This is a problem and bi-probit coefficients are, to some extent, biased and poorly identified. The question is how to replace or find better control variables that would distinguish between ecological product and process activities.

Process innovation and process eco-innovation are less prominent in knowledge-intensive industries (ICT, education, etc.). In terms of the constant term, this result is still quite unintuitive. However, the low-tech industry in urban space is more likely to introduce process innovation rather than a completely new product. This suggests a catching-up effect in rural space in terms of process management methods. Also, the economic crisis period 2008–2014 was a good year for innovating processes (cost reduction orientation) for enterprises that survived it (sample selection bias towards active enterprises).

The robustness check analysis showed some issues. In the second step, it had no significant impact on the differences between coefficients because enterprise age and foreign ownership had zero influence on the probability of the process or product innovation. Suppliers contributed to a higher probability to introduce new eco-processes and product innovation (but no eco-product innovation).

Contrary to Wesseling et al. (2015), and similarly to Doran and Ryan (2016), we find that linkages with universities have no impact on eco-innovation. Doran and Ryan (2016) suggest distinguishing between several types of product and process innovation (CO_2 reduction, reduced energy, etc.) because there are differences between economic performance and types of eco-innovation. Contrary to Hojnik and Ruzzier (2016), we find that process eco-innovation does not lead directly to company growth and profitability. A similar analysis was conducted on Community Innovation Survey in Taiwan (Tsai and Liao 2017). Their logit regression was aimed at drivers of eco-innovations. Contrary to their results, innovation intensity (latent R&D variable) affects eco-innovation in the Czech Republic. There are no similar CIS driven econometric papers concerning the relationship between rural areas and eco-innovation and further research can shed some light on the types of eco-innovation in rural areas.

To sum it up and align our results with theories, there are barriers to the eco-innovative approach. There are possible explanations like the preference of short-term and unsustainable profit goals, unpaid social and environmental benefits (based on Arrow 1962; Smith [1776] 1985), which relates to the issue of indivisibility of research and 'inappropriability' of the profit stream. Direct (grants, EU funds, etc.) public subsidies can help (Horbach 2018; Esparcia 2014) and this paper suggest that public support can help even though it is not considered a very effective innovation policy tool in Europe (Dargan and Shucksmith 2008; Vokoun 2017). In case of differences between rural and urban areas, there are factors which supports innovation regardless the localization, because of open innovation approach (van de Vrande et al. 2009), the spread of sustainable ideas via the supply chain (Hallstedt et al. 2013) and other intermediates. The support of universities and public clients was not proven (compare Kanda et al. 2018; Hart et al. 2015; Ahern et al. 2014).

7. Conclusions

Eco-innovative approaches have their merits and limits. This paper contributed to the economic theory of innovation and sustainability theories which have also global socioeconomic and environmental impacts. This paper aimed at hypotheses about the low profitability of the eco-innovation approach and possible differences in the innovation process between rural and urban enterprises. Our research is based on the knowledge filter theory (Acs et al. 2013). The firm-level analysis required data from the Czech Community innovation surveys of 2008 and 2014 which contains information about eco-innovation activities. The estimation method utilized the concept of CDM modeling which provided good estimates about eco-innovative activities and rural areas. Results suggest that the product eco-innovative approach contributed to higher sales from innovated goods and services. However, being a process eco-innovator (new methods of production, etc.) is not related to higher sales from innovated goods and services. Urban localization is characterized by competitive pressures and lower sales from innovated goods and services in comparison to non-urban areas.

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Appendix A

Table A1. Summary of statistics concerning eco-innovation in 2008

Environmental Benefits Obtained within the Enterprise	Obs.	Mean Value	Standard Deviation
Reduced material or water use per unit of output	6804	0.20	0.40
Reduced energy use or CO_2 'footprint' (reduce total CO_2 production)	6804	0.28	0.45
Reduced air, water, noise or soil pollution	6804	0.22	0.42
Replaced a share of materials with less polluting or hazardous substitutes	6804	0.17	0.38
Recycled waste, water or materials for own use or sale	6804	0.31	0.46
Environmental Benefits Obtained during the Consumption or Use of a Good or Service by the End-User	**Obs.**	**Mean Value**	**Standard Deviation**
Reduced energy use or CO_2 'footprint'	6804	0.21	0.41
Reduced air, water, noise or soil pollution	6804	0.21	0.41
Facilitated recycling of product after use	6804	0.20	0.40

Note: based on CIS data 2008.

Table A2. Summary of statistics concerning eco-innovation in 2014

Environmental Benefits Obtained within the Enterprise	Obs.	Mean Value	Standard Deviation
Reduced material or water use per unit of output	5198	0.15	0.36
Reduced energy use or CO_2 'footprint' (reduce total CO_2 production)	5198	0.20	0.40
Reduced air, water, noise or soil pollution	5198	0.15	0.35
Replaced a share of materials with less polluting or hazardous substitutes	5198	0.10	0.30
Recycled waste, water or materials for own use or sale	5198	0.18	0.39
Environmental Benefits Obtained DURING the Consumption or Use of a Good or Service by the End-User	**Obs.**	**Mean Value**	**Standard Deviation**
Reduced energy use or CO_2 'footprint'	5198	0.15	0.35
Reduced air, water, noise, or soil pollution	5198	0.11	0.31
Facilitated recycling of product after use	5198	0.10	0.30

Note: based on CIS data 2014.

Table A3. Summary of statistics concerning the data sample in both survey years (2008 and 2014)

Variable	Obs.	Mean Value	Std. Dev.	Min.	Max.
Total R&D Expenditures	12,002	14,877	207,734	0	1.51×10^7
New or significantly improved goods	12,002	0.24	0.42	0	1
New or significantly improved services	12,002	0.15	0.35	0	1
New or significantly improved methods of manufacturing for producing goods	12,002	0.22	0.41	0	1
New or significantly improved logistics, delivery or distribution methods	12,002	0.13	0.34	0	1
New or significantly improved supporting activities for your processes	12,002	0.21	0.41	0	1
Within enterprise: Reduced material or water use per unit of output	12,002	0.18	0.38	0	1
Within enterprise: Reduced energy use or CO_2 'footprint'	12,002	0.25	0.43	0	1
Within enterprise: Reduced air, water, noise, or soil pollution	12,002	0.19	0.39	0	1
Within enterprise: Replaced a share of materials with less polluting or hazardous substitutes	12,002	0.14	0.35	0	1
Within enterprise: Recycled waste, water, or materials for own use or sale	12,002	0.26	0.44	0	1
Goods and Services: Reduced energy use or CO_2 'footprint'	12,002	0.18	0.39	0	1
Goods and Services: Reduced air, water, noise, or soil pollution	12,002	0.17	0.37	0	1
Goods and Services: Facilitated recycling of product after use	12,002	0.16	0.36	0	1
Applied for a patent	12,002	0.03	0.17	0	1
Turnover	12,002	920,283	6,278,209	7	2.97×10^8
The average number of employees	12,002	202	817	10	36,332

Note: based on CIS data 2008 and 2014.

Table A4. Heckman procedures and selection bias tests for the 2008 dataset

Innovator (Probit)				R&D Function (OLS)			
Variable	**Coef.**	**Std.dev.**	***p*-Value**	**Variable**	**Coef.**	**Std.dev.**	***p*-Value**
Employees (ln)	0.20	0.01	0.00	Employees (ln)	−0.34	0.05	0.00
Orientation nat.	0.48	0.04	0.00	Rural	−0.14	0.08	0.09
Orientation EU	0.48	0.05	0.00	group	0.08	0.09	0.39
Orientation W	0.60	0.10	0.00	Low-Med Tech	0.43	0.15	0.00
Low-med tech	0.22	0.06	0.00	Med-High Tech	0.45	0.17	0.01
Med-high tech	0.49	0.06	0.00	High Tech	0.63	0.24	0.01
High tech	0.40	0.10	0.00	Knowledge Int.	0.16	0.11	0.14
Knowledge int.	−0.04	0.04	0.35				
Mills ratio 2008	−0.48	0.31	0.13				
Constant	−1.69	0.06	0.00	Constant	5.13	0.58	0.00

Note: based on CIS data 2008.

Table A5. Heckman procedures and selection bias tests for the 2014 dataset

Innovator (Probit)				**R&D Function (OLS)**			
Variable	**Coef.**	**Std.dev.**	***p*-Value**	**Variable**	**Coef.**	**Std.dev.**	***p*-Value**
Employees (ln)	0.26	0	0	Employees (ln)	−0.3	0.1	0
Orientation Nat.	0.46	0	0	Rural	−0.2	0.1	0
Orientation EU	0.33	0.1	0	group	0.22	0.1	0
Orientation W	0.43	0.1	0	Low-Med Tech	0.03	0.1	0.9
Low-med tech	0.18	0.1	0.01	Med-High Tech	0.39	0.2	0
Med-high tech	0.45	0.1	0	High Tech	0.74	0.2	0
High tech	0.4	0.1	0	Knowledge Int.	0.16	0.1	0.2
Knowledge int.	0.11	0	0.02				
Mills ratio 2008	−0.3	0.4	0.34				
Constant	−1.8	0.1	0	Constant	4.89	0.6	0

Note: based on CIS data 2014.

Table A6. Frequency of enterprises by industry

#	**NACE 2 Digit**	**Freq.**	**%**	**#**	**NACE 2 Digit**	**Freq.**	**%**
B	5	14	0.12	F	41	168	1.4
	6	5	0.04		42	131	1.09
	7	2	0.02		43	153	1.27
	8	138	1.15	G 7.8%	45	118	0.98
	9	32	0.27		46	583	4.86
C 48.8%	10	370	3.08		47	238	1.98
	11	154	1.28	H 6.5%	49	418	3.48
	12	4	0.03		50	14	0.12
	13	211	1.76		51	20	0.17
	14	190	1.58		52	298	2.48
	15	121	1.01		53	30	0.25
	16	253	2.11	I	55	81	0.67
	17	193	1.61		56	83	0.69
	18	228	1.9	J 8%	58	165	1.37
	19	15	0.12		59	19	0.16
	20	276	2.3		60	13	0.11
	21	87	0.72		61	148	1.23
	22	390	3.25		62	494	4.12
	23	300	2.5		63	117	0.97
	24	260	2.17	K	64	191	1.59
	25	478	3.98		65	85	0.71
	26	262	2.18		66	137	1.14
	27	347	2.89	L	68	76	0.63
	28	464	3.87	M7.6%	69	66	0.55
	29	405	3.37		70	51	0.42
	30	154	1.28		71	427	3.56
	31	207	1.72		72	143	1.19
	32	241	2.01		73	191	1.59
	33	250	2.08		74	40	0.33
D	35	292	2.43	N	77	53	0.44
E	36	146	1.22		78	114	0.95
	37	37	0.31		79	43	0.36
	38	291	2.42		80	104	0.87
	39	11	0.09		81	95	0.79
					82	67	0.56

Note: NACE classification revision 2.

Table A7. Innovation process—estimation process

Decision to Innovate and Innovation Intensity	**Model 1A**	**Model 1B**	**Model 2**
	Innovator (0/1)	**Innovator (0/1)**	**R&D/Employee (ln)**
Employees (ln)	0.238 ***	0.245 ***	−0.367 ***
	(0.02)	(0.02)	(0.02)
Part of a group	0.393 ***	0.510 ***	0.049
	(0.04)	(0.04)	(0.07)
Rural (non-urban)	−0.120 ***	−0.067 *	−0.106
	(0.04)	(0.04)	(0.07)
Largest market	0.561 ***	0.571 ***	
National	(0.04)	(0.04)	
Largest market	0.465 ***	0.527 ***	
Europe	(0.05)	(0.05)	
Largest market	0.562 ***	0.602 ***	
World/other	(0.09)	(0.09)	
Technological level	0.264 ***	0.270 ***	0.174 **
Low–medium	(0.05)	(0.05)	(0.09)
technological level	0.601 ***	0.603 ***	0.265 ***
Medium	(0.06)	(0.06)	(0.08)
technological level	0.528 ***	0.544 ***	0.422 ***
High	(0.10)	(0.10)	(0.14)
knowledge level	−0.035	−0.026	0.077
	(0.04)	(0.04)	(0.08)
Year 2014	0.219 ***	0.206 ***	
	(0.03)	(0.03)	
Enterprise's age		0.013 *	0.052 ***
		(0.01)	(0.02)
Enterprise's age SQ		−0.00038 *	−0.002 ***
		(0.00)	(0.00)
Foreign ownership		−0.280 ***	0.245 ***
		(0.05)	(0.07)
Funding (0/1)			0.247 **
Local or regional authorities			(0.11)
Funding (0/1)			0.699 ***
Central government			(0.07)
Funding (0/1)			0.510 ***
European Union			(0.08)
Funding (0/1)			0.250 **
Framework/Horizon 2020			(0.12)
Additional variables	No	No	Yes
Constant	−2.175 ***	−2.267 ***	3.689 ***
	(0.09)	(0.10)	(0.16)
Observations	12002	12002	4497

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, lnsig2u constants significant at 5%, the Sargan-Hansen FE vs. RE statistic was not significant at 5%—Fixed effect reported, additional variables: Ongoing innovation activities, Training for innovative activities, cooperation, and own in-house R&D.

Table A8. Product and process innovation probability

Innovation Equations	Model 3A	Model 3A	Model 3B	Model 3B
	Product (0/1)	**Process (0/1)**	**Product (0/1)**	**Process (0/1)**
Employees (ln)	0.249 ***	0.158 ***	0.245 ***	0.155 ***
	(0.03)	(0.03)	(0.03)	(0.03)
Part of a group	−0.173 *	−0.064	−0.165 *	−0.098
	(0.09)	(0.09)	(0.10)	(0.10)
Rural (non-urban)	0.139	−0.062	0.137	−0.062
	(0.10)	(0.10)	(0.10)	(0.10)
Technological level	0.076	0.143	0.075	0.132
Low–medium	(0.12)	(0.13)	(0.12)	(0.13)
technological level	0.240 **	−0.242 **	0.238 **	−0.257 **
Medium	(0.12)	(0.12)	(0.12)	(0.12)
technological level	0.239	−0.528 ***	0.238	−0.543 ***
High	(0.21)	(0.17)	(0.21)	(0.17)
knowledge level	0.026	−0.293 ***	0.026	−0.301 ***
	(0.10)	(0.11)	(0.10)	(0.11)
Linear trend	0.033 **	−0.032 **	0.030 **	−0.032 **
	(0.01)	(0.01)	(0.01)	(0.01)
Enterprise's age			0.005	−0.003
			(0.01)	(0.01)
Foreign ownership			0.009	0.094
			(0.09)	(0.10)
Latent R&D function	0.536 ***	0.084	0.539 ***	0.080
R&D/employee (ln)	(0.07)	(0.07)	(0.07)	(0.07)
Cooperation	−0.373 ***	0.146	−0.372 ***	0.172
—group	(0.10)	(0.11)	(0.11)	(0.12)
Cooperation	0.224 *	0.070	0.225 *	0.098
—suppliers	(0.12)	(0.12)	(0.12)	(0.13)
Cooperation	0.420	-0.231	0.424	−0.187
—private sector clients	(0.29)	(0.25)	(0.29)	(0.25)
Cooperation	−0.114	−0.363 *	−0.110	−0.344 *
—public sector clients	(0.20)	(0.19)	(0.20)	(0.19)
Cooperation	−0.234	−0.246	−0.235	−0.219
—competitors	(0.17)	(0.17)	(0.18)	(0.17)
Cooperation	−0.224	−0.203	−0.224	−0.164
—labs	(0.17)	(0.15)	(0.17)	(0.16)
Cooperation	−0.331	−0.667 **	−0.336	−0.620 **
—universities	(0.33)	(0.27)	(0.34)	(0.27)
Investment/employee (ln)		0.031 *		0.030*
		(0.02)		(0.02)
Training		0.314 ***		0.317 ***
		(0.08)		(0.08)
Constant	−67.783 **	63.875 **	−62.083 **	61.005 **
	(26.87)	(27.71)	(27.83)	(29.39)
Observations	1753	1753	1753	1753

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, athrho constants significant at 10%.

Table A9. Eco-innovation, product, and process innovation probability

Innovation Equations	**Model 4A**	**Model 4A**	**Model 4B**	**Model 4B**
	E-Product (0/1)	**E-Process (0/1)**	**E-Product (0/1)**	**E-Process (0/1)**
Employees (ln)	0.148 ***	0.190 ***	0.148 ***	0.181 ***
	(0.03)	(0.03)	(0.03)	(0.03)
Part of a group	−0.092	0.103	−0.002	0.102
	(0.08)	(0.08)	(0.08)	(0.09)
Rural (non-urban)	0.059	−0.029	0.061	−0.029
	(0.08)	(0.09)	(0.08)	(0.09)
Technological level	0.079	−0.041	0.097	−0.047
Low–medium	(0.10)	(0.12)	(0.10)	(0.12)
technological level	−0.012	−0.127	0.011	-0.137
Medium	(0.10)	(0.11)	(0.10)	(0.11)
technological level	−0.355 **	−0.597 ***	−0.328 **	−0.605 ***
High	(0.16)	(0.17)	(0.16)	(0.17)
knowledge level	−0.397 ***	−0.874 ***	−0.385 ***	−0.878 ***
	(0.09)	(0.10)	(0.09)	(0.10)
Linear trend	−0.057 ***	−0.062 ***	−0.065 ***	−0.067 ***
	(0.01)	(0.01)	(0.01)	(0.01)
Enterprise's age			0.011**	0.008
			(0.01)	(0.01)
Foreign ownership			−0.194 **	0.056
			(0.08)	(0.09)
Latent R&D function	0.277 ***	0.244 ***	0.283 ***	0.246 ***
R&D/employee (ln)	(0.05)	(0.06)	(0.05)	(0.06)
Cooperation	−0.178 **	0.001	−0.232 **	0.013
—group	(0.09)	(0.10)	(0.09)	(0.10)
Cooperation	0.159	0.302 ***	0.095	0.313 ***
—suppliers	(0.10)	(0.11)	(0.10)	(0.12)
Cooperation	0.040	0.349	−0.054	0.372
—private sector clients	(0.21)	(0.23)	(0.21)	(0.24)
Cooperation	−0.138	0.378*	−0.178	0.395 *
—public sector clients	(0.17)	(0.21)	(0.17)	(0.21)
Cooperation	0.076	-0.069	0.016	−0.062
—competitors	(0.15)	(0.17)	(0.15)	(0.17)
Cooperation	−0.117	−0.015	−0.192	−0.003
—labs	(0.13)	(0.15)	(0.14)	(0.15)
Cooperation	0.057	−0.340	−0.049	−0.324
—universities	(0.25)	(0.27)	(0.25)	(0.27)
Investment/Employee (ln)		0.024		0.024
		(0.01)		(0.01)
Training		0.078		0.082
		(0.07)		(0.07)
Constant	112.432 ***	123.385 ***	128.493 ***	133.633 ***
	(22.53)	(24.73)	(23.72)	(25.95)
Observations	1753	1753	1753	1753

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, artrho constants statistically significant at 1% level.

Table A10. Innovation appropriability—analysis of the profit stream

Sales of Innovated Goods Per Employee (ln)	**Model 5**	**Model 6**
	Fixed Effects	**Fixed Effects**
Employees (ln)	−0.342 *	−0.370 *
	(0.18)	(0.20)
Part of a group	0.109	0.195
	(0.18)	(0.17)
Rural (non-urban)	1.492 ***	1.814 ***
	(0.32)	(0.19)
R&D/employee (ln)	0.025	−0.009
	(0.04)	(0.04)
Low–medium technological level	0.690	1.056 *
	(0.48)	(0.55)
Medium technological level	0.965 ***	0.932 *
	(0.37)	(0.48)
High technological level	1.439 ***	1.962 ***
	(0.48)	(0.60)
Knowledge-intensive service	1.885 ***	2.014 ***
	(0.53)	(0.62)
Linear trend	−0.006	
	(0.01)	
Foreign ownership		−0.156
		(0.23)
Co-operation		0.030
		(0.15)
Continuous innovation process		0.018
		(0.13)
Innovation type—Patent application		−0.052
		(0.16)
Innovation type—New-to-the-market		0.753 ***
		(0.13)
Innovation type—New-to-the-firm		0.742 ***
		(0.15)
Innovation type—Environmental process		0.112
		(0.16)
Innovation type—Environmental product		0.280 **
		(0.12)
Constant	17.626	4.936 ***
	(22.36)	(1.08)
Observations	3450	2395
Adjusted R^2	0.017	0.143

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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