The Romanian Product Innovative Enterprises - A Statistical Analysis Using "R"

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Abstract: This paper presents the main characteristics of product innovative enterprises from Romania. Based on the literature review, the central proposal of the paper is a statistical analysis using logistic regression in R in order to show the relationship between firm sizes (number of employees), turnover and product innovative enterprises. The statistical analysis was conducted using unweight data from the "Inovarea în industrie şi servicii" (INOV) survey, wave 2010 – 2012 and it is representative at national level. The Romanian survey is harmonized with the Eurostat Community Innovation Survey.

Key-Words: enterprises, product innovation, Romania, logistic regression, enterprises size, turnover.

1. Introduction

1.1. Objective

In order to have a better understand of the position of Romanian enterprises towards product innovation, this paper analyses two main characteristics: enterprises size and turnover. The analysis attempts to describe the relationship between the two main characteristics of enterprises and the introduction of new or significantly improved goods on the market. For a better comprehension of the product innovative enterprises situation, in Romania, we have chosen to use unweight data from official statistics and to inference the results based on the standard methodology of the statistical tests we have used.

1.2. Literature review

Since the evolution of technology and the general concern for a sustainable development became a topic of actuality, we hear moreover about innovation in business environment and in individuals' daily life. The interest in studying the innovation concept became popular not just in science, but also in official statistics and in practice.

Rosenberg (2004) sees that in the most fundamental sense, there are only two ways of increasing the output of the economy: (1) increasing the number of inputs that go into the productive process, or (2) finding new ways in which you can get more output from the same number of inputs. Nicholas (2014) consider that economic growth can be driven in the short run by factor accumulation or by utilizing factors more efficiently, but permanent increases can only result from technological innovation. Regardless of circumstances, the majority of enterprises seem to have understood that the key of development and the success on the market is to innovate.

According to OECD (2014) among firms that innovate, the lack of own funds and the high perceived costs of innovating are the two factors most cited as hampering innovation across all countries. In all countries, innovation by small firms appears to be more affected by hampering factors than in medium and large firms; however, in any given country the types of factors perceived as important are the same independently of the size of the responding enterprise.

A wave of studies pointed out that, small enterprises are engines of innovation (Shefer and Frankel, 2005; Audretch and Feldman, 2003; Hoffman et al., 1998; Santarelli and Sterlacchini, 1990), while others underline that SMEs tend to be disadvantaged relative to larger firms that generally have better access to

funding and other resources (Olsen et. al., 2006), which facilitates the innovation process. In Romania, more then 90% of the enterprises are SMES, but just a small part of them are innovating, and overall Romania is the less innovative country among European Union countries.

Although there are many types of innovation based on different criteria, the typology used in official statistics refers to: product innovation, process innovation, organizational and marketing innovation, but by far the most important one is the product innovation. Taking into consideration the theoretical aspects and the position of Romanian enterprises regarding innovation in international top-ranking, we choose to analyze if the firm size and the financial resource (turnover) influence the introduction of new or significantly improved goods on the market, in Romanian enterprises.

2. An overview of product innovative enterprises in Romania

In 2012, according to Eurostat online data (inn_cis8_type), Romania is the country with the lowest percentage of innovative enterprises (20.7% from total enterprises) among EU states member. Romania occupy the last places in the EU ranking also regarding the product innovation, with just 1.2% of product innovative enterprises from the total number of enterprises in the population in 2012. These data raise concerns regarding the enterprises innovation capacity in Romania.

Table 1 shows us the Romanian innovative enterprises dynamics during the last six waves of the Innovation in industry and services report. It is noticed that during the 2002 – 2008, the percentage of innovative enterprises increased, and then dropped. A significant drop occurred in 2010-2012 when the percentage of innovative enterprises dropped by 10.1%.

Table 1: Innovative enterprises in Romania (% from the total number of enterprises in the population)

	Years					
	2002	**2004**	**2006**	**2008**	**2010**	**2012**
Innovative enterprises (% from the total number of enterprises in the population)	17	19.9	21.1	33.3	30.8	20.7

Source: Romanian NIS, online code: INO101A.

Going forward to analyses the situation of product innovative enterprises in 2012, we notice that just 3.4% from the total number of enterprises in the population are enterprises with product innovative activities (see table 2), the equivalent of 16.5% from the innovative enterprises. Focusing on enterprises size, we notice that the most innovative are the companies with 250 or more employees and the innovative SMEs are having a lower percentage.

Table 2: Product innovative enterprises in Romania, in 2010 - 2012

All NACE - Total	Innovative enterprises (% from the total number of enterprises in the population)	Product innovative enterprises (% from the total number of enterprises in the population)	Product innovative enterprises (% from the innovative enterprises)
Between 10 and 49 employees	18.3	2.2	11.9
Between 50 and 249 employees	26.6	5.7	21.3
250 or more employees	40.1	16.7	41.8
Total	20.7	3.4	16.5

Source: Author's calculations based on INOV microdata, weight data, wave 2010 - 2012.

Based on the previous descriptive statistics we launch two hypotheses:

H1: the product innovativeness of enterprises is influenced by the number of employees (individuals);

H2: the product innovativeness of enterprises is influenced by firm size (class - number of employees).

In order to innovate, the company needs resources and for product development the financial resources are mandatory. We can speak about innovation without taking into consideration its cost; therefore we decide to take a closer look on companies' turnover.

Table 3: Product innovative enterprises turnover in Romania, in 2012

All NACE - Total	Total turnover of the innovative enterprises (% from the total turnover of all enterprises in the population)	Total turnover of the product innovative enterprises (% from the total turnover of all enterprises in the population)	Total turnover of the product innovative enterprises (% from the total turnover of all the innovative enterprises)
Between 10 and 49 employees	19.5	2.6	13.4
Between 50 and 249 employees	32.1	6.3	19.6
250 or more employees	51.8	25.4	49.1
Total	40.1	15.9	39.7

Source: Author's calculations based on INOV microdata, weight data, wave 2010 - 2012.

The total turnover of the innovative enterprises (see table 3) is 40.1% from the total turnover of all enterprises in the population. Regarding the companies oriented toward product innovation, the total turnover of the product innovative enterprises is 15.9% from the total turnover of all enterprises in the population. Regarding the distribution of turnover on enterprises size, we notice that the percentage is very close to the share of product innovative enterprises, which strengthens our previous hypothesis.

Having in mind that the literature suggests that resources are an enabler of innovation (Gibbert et al, 2014) and the company's budget is very important (Hoegl et al, 2008), due to the fact that in our data set the only financial data is the companies' turnover our next hypothesis is:

H3: the product innovativeness of enterprises is influenced by turnover.

Our hypothesis assume that the cost of product innovation are deducted from company turnover, therefore we would like to see if in the Romania case, the theoretical perspective is sustained also by statistical evidence.

In order to test our three hypotheses, we have chosen to run logistic regressions using R Studio (rcmdr package). The general model is described below.

Logit regression model it is written as:

$$Y_i = \beta_o + \beta_1 X_1 + ... + \beta_i X_i \quad (1)$$

$$\log \frac{p_i}{1-p_i} = \beta_o + \beta_1 X_1 + ... + \beta_i X_i \quad (2)$$

where Xi is a vector of explanatory variable according to each model which will be discussed, and:

Y_i is the dependent variable: *product innovative enterprises (inpdgd)* with binomial response that can take the values 1 and 0 with probabilities p, respectively 1-p:

$y_i = 1$ if the enterprise introduced new or significantly improved goods (excluding the simple resale of new goods and changes of a solely aesthetic nature), during the three years 2010 to 2012 (CIS, 2012).

$y_i = 0$ otherwise

3. Product innovation in Romanian enterprises and the number of employees – hypothesis testing

In order to test our first hypothesis, *the product innovativeness of enterprises is influenced by the number of employees (individuals),* we have chosen the logit regression model from above, where Xi is *the average number of employees in 2012* (emp12) a quantitative variable (metric) expressed by number of employees.

Model 1:

$$\text{inpdgd} = \beta_o + \beta_1 emp12$$

Table 4: Logit regression: product innovative enterprises and the average number of employees

Independent variables	*Odds Ratio*	*Confidence Interval* *Lower 95%*	*Upper 95%*	*p-value*
emp12	1.00077	1.00033	1.00122	0.000571 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
(Dispersion parameter for binomial family taken to be 1)

Source: Author's calculations based on INOV microdata, wave 2010 - 2012.

After computing, the logit regression model become:

$\log\frac{p_i}{1-p_i}$ = -3.1509062 + 0.0007656 *emp12

The odds ratio in the first model shows that, the probability of an enterprise to introduce innovative products is not influenced by an increase of employees by a person. In other words, a one unit increase in *number of employees* will result in an estimated logit increase of 0.00076. Even there is a large literature sustaining that innovative leadership and creativity of individuals are a key competency Carson et al. (1995) in small and medium sized enterprises and are leading to innovation, our result says that a single person doesn't make the difference.

Correlating this result with the descriptive analysis where we have identified a difference between innovative enterprises by size class (number of employees), we go forward and test the second hypothesis: *the product innovativeness of enterprises is influenced by firm size (class - number of employees).* In this regard, the next step was to transform the metric variable (*the average number of employees in 2012* - emp12) in a categorical variable (factor variable in R) encoded with *emp12f*, as follows:

- small enterprises (between 10 and 49 employees): *en_small*;
- medium enterprises (between 50 and 249 employees): *en_ medium;*
- large enterprises (250 or more employees): *en_ large.*

Given the transformation of the independent variable and due to the fact that independent (*emp12f*) and dependent *(inpdgd)* variables are discrete, a first analysis was performed was to test the association between the two variables using the chi square test (χ^2).

Null hypothesis (H0): there is no significant relationship between firm size (class - number of employees) and product innovative enterprises.

Result: χ^2 = 39.9253, df = 2, p-value = 2.14e-09 => at 0.5% significance level we reject the null hypothesis. Therefore, there is a significant relationship between *firm size (class - number of employees) in 2012* and *product innovative enterprises*.

Taking into account that the chi-square test does not give us more details about the nature of the relationship between the two variables, we chose to continue our analysis with a logit regression.

Model 2:

$$\text{inpdgd} = \beta_o + \beta_1 emp12f$$

Table 5: Logit regression: product innovative enterprises and firm size

Independent variables	*Odds Ratio*	*Confidence Interval* *Lower 95%*	*Upper 95%*	*p-value*
emp12f				
en_small	0.20862	0.12377	0.34890	2.59e-09 ***
en_ medium	0.51493	0.33639	0.80138	0.00264 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

Source: Author's calculations based on INOV microdata, wave 2010 - 2012.

The reference group is the group with null regressors generated by the model, in this case *en_ large* is the reference group. Therefore, most of the product innovative enterprises are large enterprises. The odds ratio shows that the probability of small enterprises to introduced new or significantly improved goods is 20% lower compared to large enterprises. The probability of medium enterprises to introduced new or significantly improved goods is 51% lower compared to large enterprises.

4. Product innovation in Romanian enterprises and the turnover – hypothesis testing

Regarding the turnover influence on product innovative enterprises, we proceed to test our third hypothesis; *the product innovativeness of enterprises is influenced by turnover*. Taking into consideration the nature of the variables, we have chosen to conduct the same type of analysis as in the previous hypothesis.

Model 3:

In this model our independent variable is metric - *enterprises turnover in 2010 (turn10)*, expressed in Romanian currency (lei), with the general form:

$$\text{inpdgd} = \beta_o + \beta_1 turn10$$

Table 6: Logit regression: *product innovative enterprises* and *enterprises turnover*

Independent variables	*Odds Ratio*	*Confidence Interval*		*p-value*
		Lower 95%	*Upper 95%*	
turn10	1.00	1.00	1.00	0.159

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

Source: Author's calculations based on INOV microdata, wave 2010 - 2012.

Analysing the odds ratio we notice that the increase of turnover by 1 leu doesn't influence the probability of an enterprises to introduce product innovation. This result doesn't surprise us due to the fact that 1 leu is equivalent of 25 eurocents; therefore it isn't a significant amount of money.

Resonating with the economic situations in companies, we consider that this result reflects the reality. Although, we have seen that an increase of turnover by 1 leu doesn't influence the product innovativeness, we are still interested to find if the financial performance of the company influence the orientation towards product innovation, in this respect we decided to divide the companies into quintiles based on turnover, as follows:

- Q1: enterprises with a turnover between [0 and 2611136] lei, in 2010;
- Q2: enterprises with a turnover between (2611136 şi 6624714] lei, in 2010;
- Q3: enterprises with a turnover between (6624714 şi 16030753] lei, in 2010;
- Q4: enterprises with a turnover between (16030753 şi 43830079] lei, in 2010;
- Q5: enterprises with a turnover *greater* than 43830079 lei, in 2010.

Our new independent variable became: *enterprises turnover (in 2010) expressed in quintiles* and it was codified with *turn10f*. Given the two variables are factorial (*turn2010f* and *inpdgd)* we first performed the chi square test (χ^2).

Null hypothesis (H0): there is no significant relationship between financial performance of enterprises (quintiles based on turnover) and product innovative enterprises.

Result: χ^2 = 21.4, df = 4, p-value = 0.0002638 => at 0.5% significance level we reject the null hypothesis ($\chi^2_c > \chi^2_{tab}$; χ^2_{tab} =14.860). Therefore, there is a significant relationship between *financial performance of enterprises (quintiles based on turnover)* and *product innovative enterprises*.

In order to have more information regarding the nature of the relationship between the two variables, we chose to continue our analysis with a logit regression.

Table 7: Logit regression: product innovative enterprises and financial performance of enterprises (quintiles based on turnover)

Independent variables	*Odds Ratio*	*Confidence Interval* *Lower 95%*	*Upper 95%*	*p-value*
turn10f				
Q2	1.44726	0.72858	2.95350	0.29602
Q3	1.59497	0.81578	3.22192	0.17883
Q4	2.05692	1.08917	4.06218	0.03032*
Q5	3.32700	1.84807	6.36345	0.00012***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
(Dispersion parameter for binomial family taken to be 1)

Source: Author's calculations based on INOV microdata, wave 2010 - 2012.

The reference group is the first quintile of the independent variable *turn10f* which includes the 20% of all enterprises with the lowest values of turnover, between 0 and 2611136 lei, in 2010. According to the statistical significance of the model, the probability of an enterprise with turnover between 16030753 and 43830079 lei, to be product innovative is two times higher than the probability of the enterprises from the first quintile. If we look at the companies with the largest turnover, last quintile (greater than 43830079 lei), we see that the probability of an enterprise from the last quintile to be product innovative is three times than the probability of the enterprises from the first quintile.

5. Conclusions

In this paper we have shown that the companies with a large number of employees are more likely to introduce innovative products. Even if an increase with one single employee in companies doesn't increase the chance of an enterprise to introduce innovative products, when we consider the firm size (by the number of employees) we notice that larger companies have a higher probability to innovate products. In a certain way, this may be also an argument of explaining the place of Romania in the European Union ranking, through the fact that more than 90% of Romanian enterprises are SMEs. A future analysis should be conduct in order to identify those factors which are blocking the product innovation in small and medium enterprises.

The paper underlines also the importance of financial resources in companies when it comes to introduce innovative products. Through a logistic regression we have shown that companies with larger turnover are more probable to have innovative products. This emphasize with the large body of literature which highlights the importance of financial support in innovation process. The turnover divided the enterprises into quintile and we have observed that the majority of the enterprises with high turnover were medium and large enterprises.

Therefore, through a statistical analysis conducted in R the results shown that in Romania case the size of enterprises and the turnover are playing an important role in product innovation. Although this are important characteristics of enterprises we consider that there are also other important factors which may influence enterprises orientation towards product innovative and new research should be conduct in order to have complete overview regarding product innovative enterprises in Romania.

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