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Intensity of Business Enterprise R&D Expenditure and High-Tech Specification in European Manufacturing Sector

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Abstract

Endogenous growth theories draw attention to technological innovation created within the research and development (R&D) activities to explain the productivity growth of new economies. Accordingly, this study attempts to identify the relationship between the business enterprise R&D expenditure and productivity growth via indicating the role of transformation in manufacturing sector towards high tech production. Thus, the hypothesis tested in this study is whether business enterprise R&D expenditure is a main determinant of high tech sectors of manufacturing. We examine the relationship between the intensity of business enterprise R&D expenditure and high technology specification in European countries based on a panel causality analysis performed by Generalized Method of Moments (GMM) for the annual data from 2000 to 2013. Empirical findings support that there is a strong causality from increasing business enterprise R&D intensity to the expanding share of high and medium-high manufacturing. Thus, our study concludes that business enterprise R&D expenditure is one of the main sources of improvement in the technological capability of high value-added production in Europe. The important policy implication of the results is that public policies should create an appropriate incentive for private R&D activities in order to provide a transformation in manufacturing sector towards high tech specification and continued growth in economy depending on innovation.

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Keywords: Business Enterprise Research and Development; High Tech Manufacturing; Industrial Structure

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1. Introduction

In the framework of the "new economy" paradigm, while capital and labour alone cannot account for economic growth, it seems that total productivity growth related to the accumulation of knowledge is essential. Accordingly, the term "knowledge-based economy" used to call new economy results from a fuller recognition of the increasingly role of knowledge in economic growth (OECD, 1996, p.3). As a popular approach of economic growth literature, endogenous growth theory also argues that the basic source of long-run economic growth is the accumulation of knowledge**.** Accordingly, developments in science and technology as basic sources of knowledge-base play a leading role in generating economic growth**.** Indeed, numerous studies have demonstrated that technological progress has a significant impact on output performance (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992; Hannel, 2000; Wakelin, 2001).

Consequently, economies have been experienced a dramatic structural change depending on accelerating technological improvement over the last decades. In order to capture the link between technological improvement and accelerating productivity growth it is necessary to take the structural transformation of manufacturing sector into account. Therefore, economists focus on the relationship between the changing economic structure of a country and its productivity growth. Researchers have finally revealed a shift towards technology-intensive industries in the structure of the new economy. Accordingly, they argued that the output of high-tech industries clearly expanded over the last decades and hence accounts for a significant part of modern economies' growth. In other words, high-tech sector is widely regarded as the crown of industrialization and the key to long term national growth and competiveness (Lee and Tang, 2013, p.18).

Indeed, the importance of high-tech sector on the productivity growth of new economies is widely accepted although there are some controversial empirical results has been indicated in literature (Varum et al . 2009, p.405). Thus, structural change existing by increasing share of technology intensive or high-tech manufacturing in total manufacturing sector is the direct cause of the growth in economies. To put it another way, while increasing the share of technologically most progressive industries in total manufacturing sector, countries have experienced higher productivity growth. Empirical results also show that countries that have managed to increase the share of technologically most progressive industry have experienced higher productivity growth than other countries (Fagerberg, 2000; Michael 2003). Consequently, it can be argued that permanent economic growth can be provided by enlarging the share of high and medium-high technology industries in total manufacturing.

Then, the question here is what the key factor is enlarging the share of high tech manufacturing. Accordingly, after determining the leading role of high-tech enterprises in the performance of a country's growth, economists attempt to find the determinant of the increasing weight of high tech industries in new economies. It seems that studies mostly focus on the relationship between Research and Development (R&D) performance and share of high-tech manufacturing (Nunes et al 2012, p.37). To put it another way R&D activities have been taken central stage in analysing the dynamics of enlarging high-technology industries. Based on the above consideration, the main objective of this paper is also to analyze and quantify the relationship between research and development (R&D) activities and high-tech manufacturing in European countries.

The remainder of this paper is set out as follows. Section 2 reviews the literature on the relationship between R&D investments and development of high tech manufacturing. Section 3 describes data and methodology and presents empirical results. Finally, some concluding remarks and policy implications are provided.

2. Literature Review

Research and Development (R&D) activities resulting in new production process is generally accepted as a major source of technical change leading productivity growth in an economy. In order to capture the links between R&D intensity and accelerating productivity growth, it is the best way to take the structural transformation of manufacturing sector into account. Structural transformation of manufacturing sector here refers to changes in the

output shares of high tech industries in total manufacturing sector. Thus, it can be argued that, along with the increase in R&D activities, the share of high-tech manufacturing also increase**.** R&D investment is fundamental to build and enhance high-tech enterprises. R&D intensity is a significant factor that stimulates the growth of high tech enterprises.

Empirical results indicate the nexus between business R&D and transformation of industrial structure towards bigger share of high-tech manufacturing. Concerning with the literature on the relation between business R&D expenditures and structural change in manufacturing sector, Becker and Pain (2008) studied United Kingdom's manufacturing industries and highlighted the importance of industry characteristics in determining R&D intensity. Mathieu and Potterie (2010) examined the link between business sector R&D intensity and industrial structure in United States, Japan, Korea and EU-15. They concluded that business component of R&D intensity is closely connected with the degree of technological specialization in manufacturing sector of all countries. Cavalcante (2013) also indicated a direct relationship between business enterprise R&D expenditures and industrial structure for Brazilian economy. Thus, it is clearly indicated that R&D investment affects the economy's pattern of technological specialization. To put it another way, the growth in output share in the high-technology industries has been expanded by increasing business R&D intensity.

The impact of business R&D expenditure on high-tech manufacturing has also been empirically analyzed on the basis of production performance of high tech manufacturing sector in particular. Accordingly, the idea that R&D expenditure makes an important contribution to productivity growth in high tech manufacturing has been demonstrated by several authors. Ulku (2007) examines the relationship between R&D intensity and growth rate of output in some high-tech manufacturing sectors. She employs system GMM technique on the non-scale endogenous growth model during the period 1960-1997 for 17 OECD countries. Her findings suggest that R&D intensity increases the rate of innovation and productivity growth in high-tech manufacturing industries. Varum et al (2009) focus on the relationship between R&D expenditure and productivity of Portuguese manufacturing industry over the period from 1980 to 2003. Regression Model confirms the importance of business R&D in stimulating productivity growth of high-tech sectors in Portugal. They also indicate that the development of business R&D in Portuguese manufacturing relies substantially on the dynamics of high-tech industries.

More lastly, Argiles et. al (2011) try to investigate the sectoral differences in the productivity gains obtained from R&D activities. They conduct a microeconomic panel data analysis of the effect of R&D expenditure on firms' productivity by using a unique large longitudinal database comprising US and European R&D investors. Findings reveal that manufacturing firms in high-tech sectors achieve more in terms of productivity gains connected activities in comparison with their counterparts in manufacturing sector. Nunes et al (2012) analyse the effect of R&D intensity given by the ratio of R&D expenditure to sales on growth of high-tech SMEs in Portugal by using dynamic panel estimation method on data from 1996 to 2006. They found that while the effect of R&D intensity on firm growth varies according to the sector, R&D investment can positively influence the growth of firms belonging to high-tech sectors.

Finally, Lee and Tang (2013) examine the impact of high-tech research on high-tech manufacturing output by using unbalanced panel data from 1991 to 2010 for OECD countries. They found evidence that the research and development expenditure have an impact on the high-tech manufacturing sector in that, academic research has a bigger growth effect on the sector than industrial research. Liik et al (2014) also examine the impact of R&D expenditure on industry level in OECD countries by using industry-level panel data for the period from 1987 to 2009 and the stochastic frontier production function approach. Their results show that R&D has productivity enhancing effects more in high-tech industries. They also implied that in the design of R&D policy measures the structure of the industries needs to be considered.

Besides indicating the positive effect of R&D on high-tech manufacturing output, very similar results are obtained when analysing the effect of R&D on high-tech exports. Alemu (2013) estimate the effects of R&D

investment on high-tech product export competitiveness for 11 countries from East Asia from 1994 to 2010 by using a GMM panel estimation method. Empirical results reveal that countries' high level of R&D resources contributes to their high-tech product export competitiveness. Accordingly, policy instruments to foster R&D as an engine to enhance high-tech product export competitiveness are determined. Moiseeva and Mazol (2013) examine the relations between the share of public and private R&D spending on high-tech export while validating the effectiveness of national R&D sector during the period 2000-2005 for 20 countries. It was revealed that the higher share of business sector in R&D means the higher indications of high-tech export. It also concluded that in order to implement effective and profitable "high-tech policy", governments have to focus on increasing the share of business sector in total R&D expenditure.

3. Methodology

3.1. Research Goal

Based on the consideration in Literature Review, it is clear that the investigation of the relationship between business R&D investments and the development of high-tech manufacturing is very crucial in order to understanding the dynamics of productivity growth of new economies. Along with this line, we aim to examine the effect of research and development on productivity growth of high tech manufacturing in Europe. To put it another way, the investigation in this paper has attempted to empirically examine the relationship between Business Enterprise Research and Development (R&D) intensity and High Tech Specification in manufacturing sector in European countries.

3.2. Sample and Data Collection

Depending on availability of annual data from EUROSTAT database, over the period from 2000 to 2013, we have considered 15 European countries which are Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Portugal, Romania, Slovenia and Spain. Business Enterprise Research and Development (R&D) intensity is defined as the ratio of business sector R&D expenditure to Gross Domestic Product (GDP), which is the most widely, used ratios related to a country's R&D efforts.

High tech specification in manufacturing sector is measured by the ratio of the amount of high and medium high manufacturing to total manufacturing sector. Accordingly, high tech manufacturing sector comprising both high and medium high industries based on NACE Rev. 2 at 2-digit level consist of the industries producing chemicals and chemical products (20), pharmaceutical product (21), computer, electronic and optical products (26), electrical equipment (27), machinery and equipment (28), motor vehicles, trailers (29) and other transport equipment (30).

In order to check whether the variables in our model are stationary or non-stationary, Augmented Dickey-Fuller (ADF) and the IM, Peseran and Shin (IPS) panel unit root tests have been employed. The results derived from the panel unit root tests for the variables of Business Enterprise Research and Development Intensity (BERDI) and High Technology Specification in Manufacturing Sector (HTSM) are presented in Table.1. Both the panel unit root tests have the same results. The null hypothesis of the unit roots cannot be rejected for BERDI and HTSM series at the levels but it is rejected at the 1 per cent significant level at their first difference. Thus, it can be concluded that the BERDI and HTSM series are I (1).

Table.1. Panel Unit Root Tests

Variables	ADF		IPS	
	Levels	Differences	Levels	Differences
BERDI	14.637 (0.22)	57.432 (0.00)*	4.731 (0.19)	-3.223 (0.00)*
HTSM	11.346 (0.31)	53.237 (0.00)*	10.654 (0.44)	-2.542 (0.00)*

Note: p-values in parenthesis and (*) indicates significance at the 1 percent level.

3.3. Analyses and Results

In order to investigate the causal relationship between Business Enterprise Research and Development Intensity (BERDI) and High Technology Specification in Manufacturing Sector (HTSM) in European countries, the panel data causality model developed by Holtz-Eakin et. Al (1988) and Arellano and Bond (1991) will be tested. Accordingly, the model can be indicated below:

$$y_{it} = \beta_0 + \sum_{j=1}^{n} \beta_j y_{it-j} + \sum_{j=1}^{n} \alpha_j x_{it-j} + F_t + \varepsilon_{it} \quad (1)$$

In equation (1), (y) and (x) symbolize variables while (F) and (ε) represent individual fixed effect and error term, respectively. Besides, (i) refer to panel unit, (t) represents time, and finally (j) shows the lag number. In order to eliminate the unobserved country-specific effects that lead biased and inconsistent estimates, equation (1) is differenced to derive the model below:

$$y_{it} - y_{it-1} = \sum_{j=1}^{n} \beta_j (y_{it-j} - y_{it-j-1}) + \sum_{j=1}^{n} \alpha_j (x_{it-j} - x_{it-j-1}) + \varepsilon_{it} - \varepsilon_{it-1}$$

$$\Delta y_{it} = \sum_{j=1}^{n} \beta_j \, \Delta y_{it-j} + \sum_{j=1}^{n} \alpha_j \, \Delta x_{it-j} + \Delta \varepsilon_{it} \quad (2)$$

Although country-specific effects can be removed by taking the first difference of all variables in equation 2, there remains correlation between the lagged dependent variables and the error term. The Generalized Method of Moments (GMM) estimator offers a solution to this problem by using the appropriate lags of the dependent and the independent variables as instruments. Thus variables in differences are instrumented with the lags of their own levels, while variables in levels are instrumented with the lags of their own differences. This approach allows the introduction of more instruments and thereby improves efficiency. Accordingly, based on Wald Test, the null hypothesis that x does not cause y is the joint test that $H_0 = \alpha_1 = \alpha_2 =, \ldots, = \alpha_m = 0$. Thus, rejection of H_O is interpreted as causality from x to y.

In the estimation process of Equation (2) performed by GMM indicated above, two basic types of diagnostic test can also be conducted. Firstly, the Arellano-Bond (AR) test can be operated for indication of serial correlation in the residuals. The test is actually two separate statistics, one for first order correlation and one for second. If the innovations are i.i.d. we expect the first order statistic to be significant and the second order statistic to be insignificant. Secondly, Sargent Test can be operated for indication whether the instruments are correlated with the error term. The hypothesis for the Sargan test is that the instrumental variables are uncorrelated to some set of residuals and hence they are valid instruments. Thus, it tests for the validity of the instrumental variables in the model to avoid the problem of over identification.

Based on methodology concerning panel causality model indicated equation (2), in our study we specified and estimated two regressions below;

$$\Delta \mathrm{HTSM}_{it} = \sum_{j=1}^{n} \Upsilon_j \, \Delta \mathrm{HTSM}_{it-j} + \sum_{j=1}^{n} \lambda_j \, \Delta \mathrm{BERDI}_{it-j} + \Delta u_{it} \tag{3}$$

$$\Delta \mathrm{BERDI}_{it} = \sum_{j=1}^{n} \theta_j \, \Delta \mathrm{BERDI}_{it-j} + \sum_{j=1}^{n} \delta_j \, \Delta \mathrm{HTSM}_{it-j} + \Delta e_{it} \tag{4}$$

where, i : 1, 2, …., 15, number of countries, t : 2000, 2001, …., 2013, time period (year) and j: 2 (lag number). BERDI symbolises Business Enterprise Research and Development Intensity defined as the ratio of business sector R&D expenditure to Gross Domestic Product (GDP). HTSM represents High Technology Specification in Manufacturing Sector measured by the ratio of the amount of high and medium high manufacturing to total manufacturing sector.

In the framework of panel equations estimated by GMM, we employ the lagged values of the variables as instruments in levels for the first difference equations while using the lagged first differences of the endogenous variables as instruments in the level equation, for 2 and earlier. The results of estimated coefficient, Wald Causality Test and diagnostic tests for Equation (3) and Equation (4) are presented in the first and second columns of the Table.2. Wald χ^2 test checking the significance of individual coefficients in the model shows that both models are significant as a whole. The AR (1) and AR (2) tests indicate applicability of models as we expect the first order statistic to be significant and the second order statistic to be insignificant. The Sargan test does not reject the validity of the set of instruments in all equations. These results show that the models are well specified and the assumption for the panel GMM estimator is satisfied at two lags.

The results of panel equations estimated by GMM show that BERDI has a positive effect on HTSM in Europe. Looking at the coefficients, the impact of lagged BERDI on HTSM is positive and significant while there could not be indentified a significant influence from lagged HTSM on BERDI. Besides, null hypothesis of non causality from BERDI to HTSM is rejected by the Wald Causality Test statistic. However, the results cannot reject the null hypothesis that HTSM does not cause BERDI. Thus, the results of GMM Estimate and Causality Test indicate that there a one way causal relationship running from business enterprise research and development intensity (BERDI) to high technology specification manufacturing (HTSM) in European countries.

In conclusion, Empirical results show that business R&D intensity is to be considered as an important factor that can help to explain the level of high tech manufacturing in Europe. In other words, extensive share of high-tech manufacturing is due to the strength in the business sector research and development. Thus, it is important to take the business R&D intensity into consideration when analysing the connection from growing share of high-tech industry to technological improvements and economic growth. Accordingly, the target of innovation policy aimed to increase the share of high and medium-high technology sector should focus on increasing the business enterprise R&D intensity.

Table.2. GMM Estimates and Causality Test

	Dependent Variables	
Independent Variables	$\Delta HTSM$	$\Delta BERDI$
$\Delta HTSM_{it-1}$	0, 738 (0,00)*	0, 006 (0,74)
$\Delta HTSM_{it-2}$	0, 232 (0,00)*	0, 011 (0,31)
$\Delta BERDI_{it-1}$	0, 527 (0,06)***	0, 933 (0,00)*
$\Delta BERDI_{it-2}$	0, 631 (0,02)**	1,123 (0,00)*
Wald χ^2	27.31 (0.00)*	33.12 (0.00)*
AR (1)	-2.47 (0.00)*	-2.31 (0.00) *
AR(2)	-0.87 (0.21)	-0.41 (0.32)
Sargan Test	26.18 (0.291)	14.22 (0.183)
Wald Causality Test	6.18 (0,00)* ($H_o = \lambda_{t-1} = \lambda_{t-2} = 0$)	1,13 (0,27) ($H_o = \delta_{t-1} = \delta_{t-2} = 0$)

Note: p-values in parenthesis and (*), (**), (***) indicate significance at the 1, 5 and 10 percent levels, respectively.

4. Conclusion

Technological progress has long been considered as a key to long-run growth in the economic literature. Accordingly, high-tech manufacturing as a significant part of modern economies accounts for a basic dynamic of economic growth. In other words, increasing the share of technologically most progressive industries in total manufacturing sector, countries have experienced higher productivity growth. Thus, the contribution of high-tech sectors to productivity growth in new economies is very clear. The question here is what the key factor is enlarging the share of high tech manufacturing. Analysing the European experience, this study shows that business sector R&D intensity can be considered as a main driver of high-tech development in new economies.

We examine the relationship between private R&D expenditure and the share of production in high-tech industries over the period from 2002 to 2013 in European area. Our results confirm the importance of business R&D in generation and improving of high-tech sector in Europe. Accordingly, while R&D intensity as the ratio of R&D expenditure to Gross Domestic Product increases, industrial structure is becoming increasingly technology-intensive and hence the share of high tech manufacturing enlarges in total manufacturing sector. Thus, private R&D intensity has an important role in enhancing industrial technology levels and hence stimulating productivity growth. Consequently, if policy makers aim to enhance economic growth, the focus should be placed on business R&D expenditure in order to enhance the production in high and medium-high technology sectors.

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