The Internal Innovation Processes in Kazakhstan

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Abstract

To evaluate the internal innovation processes in Kazakhstan, the paper involves two pieces of empirical research. In the first piece, the main drivers of innovation performance are identified based on regression analysis. The literature suggests three factors affecting innovation activities of firms, namely foreign direct investments, research and development investments, and international trade. In order to test this theoretical framework, a probit regression analysis is carried on to estimate the determinants of innovation performance in Kazakhstan. The chapter makes use of firm level data from the Kazakhstan Enterprise Survey 2009, conducted by The World Bank. The results are supplemented by descriptive analysis. The second piece deals with the examination of multi-level relationships between business organizations and innovation. The literature distinguishes between two modes of learning and innovation, based on the distinction between implicit and explicit knowledge. Promotion of R&D and codification of innovation process are the main features of the Science, Technology, and Innovation mode of innovation. On the other hand, the Doing, Using, and Interacting mode of innovation is based on learning by doing. In order to discern which of these is the main innovation mode adopted by firms within the EKMC, a survey was conducted among them in the period from November 2011 to January 2012.

1 Theoretical Background

Empirical and theoretical studies highlight three key factors affecting innovation performance: research and development activities, foreign direct investments and international trade.

Knowledge generated by firms' R&D activities creates an internal stock of scientific knowledge. According to many authors, their own installed knowledge base increases the absorptive capacity of the firms, enabling them to understand externally generated ideas and technologies, and to apply them to commercial ends (Feinberg & Majumdar, 2001). Therefore, the technological capability of firms depends on their investments in R&D and in the development of human capital (Aw, Roberts, & Winston, 2007). Other studies provide empirical evidence of a positive correlation between exporting and R&D investments. Firms exporting and investing in R&D at the same time are about 10 to 17% more efficient than those that only export (Aw, Roberts, & Winston, 2007).

International trade can be expressed in two activities, as the selling to export market and the importing of intermediate inputs. Exports as a channel of technology spillovers facilitate knowledge diffusion and transfer. Firms learn from information exchanges within foreign markets, directly or through export intermediaries (Liu & Buck, 2006). There, communication with buyers and suppliers stimulate firms to improve their own technological capacity and to increase the quality and specialisation of their products. Empirical results from Spanish manufacturing firms confirmed that international trade gives firms the opportunity to benefit from knowledge spillovers and learn from exporting and importing (Solomon & Byungchae, 2008). Firms gain from exposure to the more intense competition present in international markets that forces them to enhance their innovation activities.

Much of the empirical literature considers foreign direct investment (FDI) as an important channel of knowledge spillovers. Branstetter (2006) showed that FDI increased the flows of knowledge spillovers both from and to the firms. In particular, FDI spillovers are much higher in relatively high-technology industries than in relatively low-technology industries (Keller & Stephen R. Yeaple, 2003). Besides the fact that FDI brings employment and capital inflows, it also leads to technology transfers to domestic firms. Domestic firms gain from the accelerated technological diffusion implied by higher labor turnover. Moreover, foreign firms usually spend more on training programs than domestic firms. Since the early 1980s countries all over the world have liberalized their policies regarding FDI in order to attract foreign multinational enterprises (MNEs), based on the assumption that FDI positively affects human capital stocks, exports, capital formation, and the technological capacity and productivity of domestic firms. The contribution of FDI to knowledge accumulation by domestic firms, as well as to the increased productivity and production of the host country was well described in many articles (Blomstrom & Kokko, 1998). In them, MNEs are considered as main agents of technology transfer through the movements of skilled staff, the existence of demonstration effects, and the operation of backward linkages facilitating the adoption of new technologies by local firms.

Apart from the drivers of innovation performance there are externalities that have influence on the innovation performance of firms. These can originate from firms' and industry's characteristics such as firm size, age of firms, technological opportunity and foreign presence. Interidustry differences considerably contribute to the explanation of cross-industry variations in innovation performance.

1.1 Data and Methodology

In order to test the theoretical framework, we employed probit regression analysis to estimate the determinants of innovation performance in Kazakhstan. We used firm level data from the Kazakhstan – Enterprise Survey 2009, conducted by The World Bank, collected in Kazakhstan during calendar year 2008/2009. The survey covers firms in the manufacturing and services sectors using stratified random sampling. Three levels of stratification, industry, establishment size, and oblast (region) were used. To obtain unbiased estimates for the whole population, the survey comprises all manufacturing sectors, construction sector, services sector and transport, storage, and communications sector. Some industries are not included: financial intermediation, real estate and renting activities, except the IT subsector which was added to the population under study, and all public or utilities-sectors. To sum up, industry stratification includes 23 manufacturing industries, 2 services industries -retail and IT-, and one residual. Each sector had a target of 177 interviews. Regional stratification was defined in five regions: North, West, East, South, and Central. According to size stratification, the number of employees was defined on the basis of reported permanent full-time workers. The survey covers the entire population of Kazakhstan´s firms with more than 5 employees. 544 completed interviews are included in the sample (The world bank, 2009).

1.2 Dependent Variable

As an output variable we have the declaration of whether an enterprise has introduced new products or services in the last three years (dummy variable) and the sales share of innovative products introduced in last three years (continuous variable). The use of various indicators of innovation allows us to discover different aspects of the same phenomena and to interpret our results more properly. Firms may differ in their ways of innovating and the ways of turning research efforts into sales. Therefore reliance on the introduction of innovation variable alone might give the false impression of innovation processes in Kazakhstan. Innovation output is not easily measurable and moreover takes several years to be realized (Innovation performance of firms in manufacturing industry: Evidence from Belgium, 2007). Assessing both measures of innovation compensates partly the deficiencies inherent in selecting one measure to the exclusion of the other, like the subjectivity of innovation counts (Salomon & Shaver, 2005) or the difficulties to gather the information of innovative activities that do not lead to the introduction of actual innovations due to its failure, for instance (Archibugi & Pianta, 1996). Furthermore, the measures of new product sales throw some light about commercialization processes and the economic benefits of innovation.

In early researches on innovation, patents were used as a measure of innovation output, although technologies are not easily codifiable in from of patents or blueprints. As an alternative, Miresse and Mohnen (2002) suggested using innovative sales instead of the number of patents as a measure of innovativeness. Despite the fact that the sales of innovative products cover only product innovations, there are studies demonstrating that the majority of process innovating firms are also product innovators. The introduction of innovation is a better measure of innovation performance since it is faster than patenting.

Variables	Description
Dependent variables	
The introduction of innovation	Dichotomous variable taking the value 1 if the firm introduced an innovation during the last three years, and the value 0 otherwise
The ratio of new sales product to total sales product	Proportion of total sales represented by new product sales
Independent variables	
Domestic import	Percentage of material inputs and supplies of domestic origin in the last fiscal year
Foreign import	Percentage of material inputs and supplies of foreign origin in the last fiscal year
Export	Dichotomous variable taking the value 1 if the firm exported in last fiscal year and the value 0 otherwise
R&D investments	Dichotomous variable taking the value 1 if the firm invested in R&D in the last three years and the value 0 otherwise
Control variables	
Foreign presence	Percentage of private foreign individuals, companies or organization in ownership
Size	The number of permanent full-time employees
Technological opportunities	Dichotomous variable taking the value 1 if the firm belongs to a technology-intensive industry and the value 0 otherwise

Table 1: *Description of Variables*

The first dependent variable *y* represents the declaration of whether an enterprise has introduced new product or services in the last three years. By the definition of The Agency of Statistics of the Republic of Kazakhstan, "innovation" is the result of scientific and technological activities, been realized in the form of new or improved products (goods and services) or technology (The Agency of Statistics of the Republic of Kazkhstan). The value takes 1 if the firm introduced new products or services in the last three years and 0 otherwise (Table).

In the second model the innovation performance is measured by the ratio of new product sales to total sales in a given firm. "New product" is classified as a product or service that was introduced in the last three years. The ratio of new product sales to new total sales is a continuous variable expressed in percentage that presents a number of advantages. Firstly, it measures better the economic value and scope of innovation performance. Secondly, focusing on firms' efforts to launch new products more directly assesses innovation provoked by international knowledge spillovers. It can be interpreted then as an indicator of market acceptance and commercialization processes. Thirdly, in contrast to patent measures, the ratio consists of unpatented products that were employed in the production process i.e. "new to the firm" (Wang & Kafouros, 2009).

1.3 Independent variables

According to the theoretical framework, there are three factors that determine the innovation performance of a firm. To measure international trade we included in the model import and export variables. For exports, a dummy variable is used, taking the value 1 if the firm directly or indirectly exported in the last fiscal year, or 0 otherwise. Imports are divided into domestic and foreign imports. The last ones are measured as the percentage of material inputs and supplies of foreign origin in the last fiscal year. Domestic imports imply import of inputs from domestic manufactures. A dummy variable of R&D expenditure indicates to which extent a firm invest in R&D. R&D intensity is determined by whether or not the firm has invested in research and development in the last three years, including in-house or outsourced investments.

Unfortunately, the Enterprise Survey does not provide information on foreign direct investments. Therefore, the only way to measure foreign involvement is to take into account the share of foreign ownership in the ownership structure.

1.4 Control variables

In order to clarify the effect of explanatory variables, control variables have to be included. We included controls for a number of factors that include firm size, foreign presence and technological opportunity.

Firm size is believed to have a significant effect on innovation performance. Large firms are able to reap economies of scale that motivate them to innovate more (Liu & Buck, 2006). Size is one of the widely analysed and recognised determinants of innovation performance. We measured the size of firms by the number of permanent full-time employees.

We control for foreign presence, expecting a strong relationship between foreign participation and innovation performance. We measure foreign presence by the percentage of private foreign individuals, companies or organizations in the ownership structure (Lu & Ng, 2012).

The literature on innovation considers that there is a significant effect of industry classification on innovation performance. For example, A. Jaffe (1986) argued that firms in a given industry patent more in some classes than in others. The sectorial context relates to the fact that belonging to a particular industry may condition a firm's strategy and performance (Rodriguez & Rodriguez, 2005). Therefore, all firms were divided according to if they operate in low-technology industries or in high-technology industries, determining these categories according to Kafouros & Buckley (2008).

1.5 Methodology

We apply a probit model to measure whether firms introduced innovations or not. Then, we carried out a regression analysis for the second model, where the ratio of new product sales to total sales is the dependent variable.

Variables	Innovator	Non-innovator	Difference
Domestic import	67,51	83,9	16,39***
Foreign import	32,5	16,1	16,38***
Export	0,073	0,033	0,039**
R&D investments	0,224	0,03	0,193***
Foreign presence	0,09	0,04	0,05**
Size	142,8	87,4	55,4***
Manufacturing and non-manufacturing	0,39	0,29	0,09**

***Table 2:** Descriptive Statistics ***Significant at the 0,01 level **Significant at the 0,05 level*

Table 2 compares the mean values of innovator and non-innovator firms. As can be seen there are significant differences between both groups of firms. Innovators import and export more intensively than non-innovators.

Interestingly, their imports are approximately double than those of non-innovators. As it was expected, non-innovators export and invest in R&D significantly less than innovators. In our dataset there is a distinction between imports of domestic origin and imports of foreign origin. Domestic inputs are inputs from other districts but within the country and foreign origin inputs are inputs imported from abroad.

Figure 1 visually shows the composition of innovative firms by trade orientation. Unsurprisingly, the majority of importers are service sectors. However, they have a very low rate of innovation. The highest rate of innovation is observed in high technology sectors such as chemicals, electronics, machinery and equipment and fabricated metal products. The country exports considerably less than imports. Exporters are mostly represented by manufacturing sectors, for instance electronics, machinery and equipment, fabricate metal products, chemical and non-metallic product.

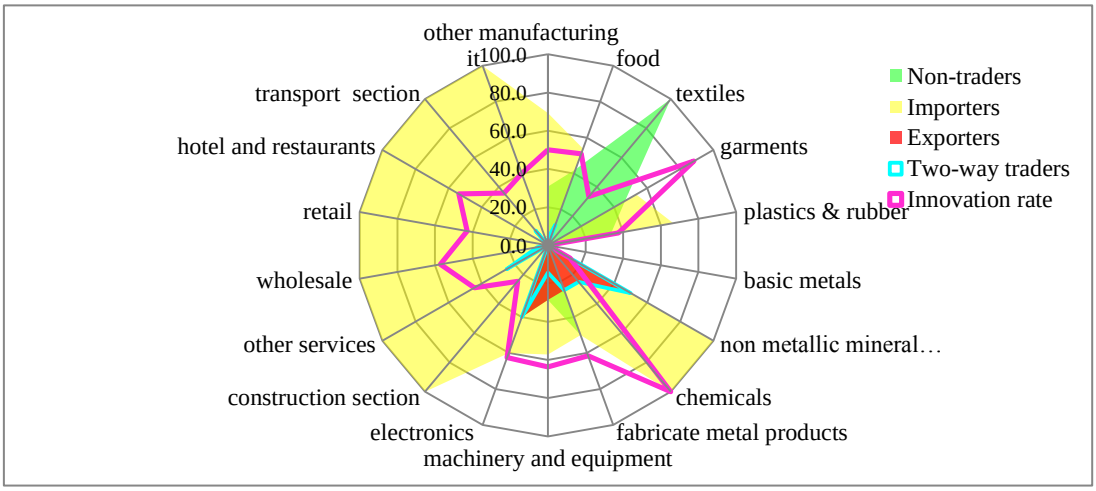

Figure 1: *The Composition Of Innovative Firms By Trade Orientation*

Table 3 represents the results of the regression analysis of determinants of innovation performance. As can be seen, imports of material inputs and supplies of foreign origin have a positive and highly significant impact on the introduction of innovation. However, domestic imports have a negative and significant effect on innovation performance. Both R&D investments and the percentage of foreign imports are statistically significant. For each unit increase in foreign imports, the probit index of the predictor (introduction of innovation) increases by 0,007. Similarly, for one unit increase in R&D investments, the z-score of the predictor increases by 1,12.

Although the coefficients of size, export and foreign ownership are positive, they are not important in the decision to introduce innovation. In contrast to theory, technological opportunity does not show a significant effect on innovation performance. Moreover, the coefficient has a negative sign.

	First model	Second model
Variable	Coefficient	Coefficient
Domestic import	-0.0071762**	
Foreign import	0.0071726**	0.00
Export	0.0434462	-0.01
R&D investments	1.116533**	1.45***
Foreign presence	0.2866239	0.15**
Size	0.0012847	0.18***
Technological opportunity	-0.003	
Foreign technology		0.11
Intercept	-0.3899152*	5.77
Dummy variable for 5 regions		------
Dummy variable for 18 sectors		------
Number of observations	172	496
Likelihood Ratio	28.99	
Pseudo R^2	0.1220	
Log Likelihood	-104.30523	
R^2		0.22
Adj R^2		0.17

Table 3: *Regression´s Results*

****Significant at the 0,01 level **Significant at the 0,05 level *Significant at the 0,1 level*

The results of the second model show that foreign presence, as share in the ownership of company is positively correlated and significant with proportion of new product sales, in contrast to the introduction of innovation. In order to estimate the "pure" effect of explanatory variable on our dependent variable, we control sector and region differences. Until the control of region, the results show positive and significant effect of foreign import on our dependent variable. However, the variable of foreign presence does not change if other explanatory variables are introduced. Unsurprisingly, the variable of R&D investment is highly significant and the increase of investments by 1 percent leads to the growth of new product sales by 1.5 percent approximately.

The foreign import does not influence on the firm´s decision to sale new products, controlling for the East region. In contrast to the results at national level, the size is insignificant to the dependent variable. The foreign presence is positively and statistically significant correlated with the share of new product sales. This can lead to the conclusion that the most of innovative firms are large-size and foreign firms in the East Region.

2 The Modes of Innovation

The innovativeness of an organization depends on its prior accumulation of knowledge that makes possible to assimilate and exploit new knowledge. From this point of view, both cognitive and organizational learning play important roles.Two key models of innovation can be distinguished: the STI model and the DUI model. The first one is the Science, Technology and Innovations (STI) mode that relies on codified scientific knowledge. The other is the Doing, Using and Interacting (DUI) mode, based on tacit knowledge and collective knowledge.

All the improvements in machinery, however, have by no means been the inventions of those who had occasion to use the machines" (Smith, 1904). This phrase proves the crucial importance of the STI mode, especially in radical innovations. R&D departments of big firms serve as key players in the STI mode. Usually, any R&D project is evoked by a practical problem. However, the primary search for a solution is based on the STI mode due to the availability of explicit knowledge, such as scientific publications or written recommendations. In order to communicate with scientists and scientific institutions it is needed to know their language in codified form. On the other hand, all research results have to be tested, and in this case the results have to be presented in an uncodified tacit form, the language of potential users. Then, it is not sufficient that the single scientist keeps results in his own memory as tacit knowledge (Jensen, Johnson, Lorenz, & Lundvall, 2007).

Social interactions, context and organizational environment are important for learning and knowledge creation. What makes the DUI mode crucially important as a key source of innovations? It is empirically proved that the successful innovation process involves interaction between people, departments or organizations. Steven Cohn (1980) has observed strong relationships between technical progressiveness and the openness of the formal inter-departmental communication structure. Since human knowledge is mainly tacit and subjective, it is difficult to codify and transfer it. Therefore, the transfer requires good functioning of social interactions, shared understanding and common interpretive schemes (Polanyi, 1966).

	Indicators	
1	**DUI-mode** **Interdisciplinary workgroups**	1 if the firm makes some use of interdisciplinary workgroups, 0 otherwise
2	**Quality circles**	1 if the firm makes some use of quality circles, 0 otherwise
3	**System for collecting proposals**	1 if the firm makes some use of system for collecting proposals, 0 otherwise
4	**Autonomous groups**	1 if the firm makes some use of autonomous groups, 0 otherwise
5	**Integrations of functions**	1 if the firm makes some use of integrations of functions, 0 otherwise
6	**Softened demarcations**	1 if demarcation between employee grouping have become more indistinct or invisible, o if they are unchanged or have become more distinct
7	**Cooperation with customers**	1 if the firm has developed closer cooperation with customers to a high extent, 0 if to a small or medium extent or not at all
1	**STI-mode** **Expenditures on R&D as a share of total revenue**	1 if the firm's expenditure on R&D are positive, 0 otherwise
2	**Cooperation with researchers**	1 if the firm cooperates with researchers attached to universities or scientific institutes rarely, occasionally, frequently or always, 0 if it never engages in these forms of cooperation

Table 4: *Indicators Of STI And DUI Modes* ***Source****: Jensen, Johnson, Lorenz, & Lundvall (2007)*

The DUI model can be described in terms of organizational practice and organizational design. Certain types of organizational design and practice are more likely to yield superior innovative performance in a particular

environment. They are more adapted to reduce or avoid transaction costs and cope with market failures. In contrast to the STI mode, the DUI mode does not pay a lot of attention to research-based knowledge. It focuses instead on experience and interactions. Employees combining their work experience with their previous education solve problems on the basis of teamwork and trial-and-error exercises. Usually, they rather cooperate with customers and suppliers than with research institutions and universities. Innovations in their majority are just incremental changes in already existing products and processes.

Nevertheless, we have to bear in mind that these two modes of innovation are theoretical concepts that do not exist in pure form in reality. Usually, industries combine in some proportion both models at the same time. The choice of methodology for our empirical analysis is based on that applied on the 2001 Danish DISKO Survey (Jensen, Johnson, Lorenz, & Lundvall, 2007). Methodology suggests using 7 and 2 indicators to measure the DUI-mode and STI-mode, respectively. The first six indicators of DUI model distinguish between rigid and bureaucratic organizations and more flexible and decentralized ones. Cooperation with customers reflects to which extent firms learn by interacting. Expenditure on R&D and cooperation with researchers are the indicators of the STI-mode. Since the evaluation of the DUI-mode is a more complicated and difficult process, more indicators are applied. As it is shown on Table , variable have been coded for further statistical analysis.

Our empirical analysis is based on 419 firms in the East Region, including private and government sectors. The majority of the firms (85%) present less than 50 employees. Medium size firms, from 51 to 250 employees, account to 9% of the firm population. Firms with more than 250 employees are the minority (6 %).We identified firms belonging to 11 sectors related to the metallurgical cluster. The half of total firms are classified as engaged in architecture and engineering activities, technical testing and analysis. East Kazakhstan is divided into 4 big cities and 15 administrative districts. The firms belonging to the metallurgical cluster are present in all four big cities and only nine districts. The largest share of firms is concentrated in the cities of Oskemen (54%) and in Semey (27%). At the initial stage, we identified 456 firms as belonging to the metallurgical cluster. During the research preparation stage and after interwieving some firms and specialists in this area, the number of firms was reduced to 388. Some firms were deleted due to being irrelevant to our cluster (34 firms). Twelve firms changed the sector where they operate in. Three firms moved into another district and ten are not active any more.

By 2011, nine firms ceased to exist, but 31 firms were created in the sectors identified as part of the metallurgical cluster. Therefore, we increased number of firms to 419 observations by adding 31 new firms.

We were able to contact only with 70 firms, to which we sent the questionnaire. Of these, we got an answer from 33 (i.e., a response rate of 48%).

In order to categorize firms into different innovation modes, we have pursued hierarchical cluster analysis. The goal of cluster analysis is to have observations in the same group to be more alike than observations in the other groups. The hierarchical method of clustering gradually forms groups going from small to large. The process starts out with each observation considered as its own separate “group”. Then, the closest two groups are merged into one group and this procedure continues until all observations belong to one group. The cluster tree in Figure 2 allows to visualize the results.

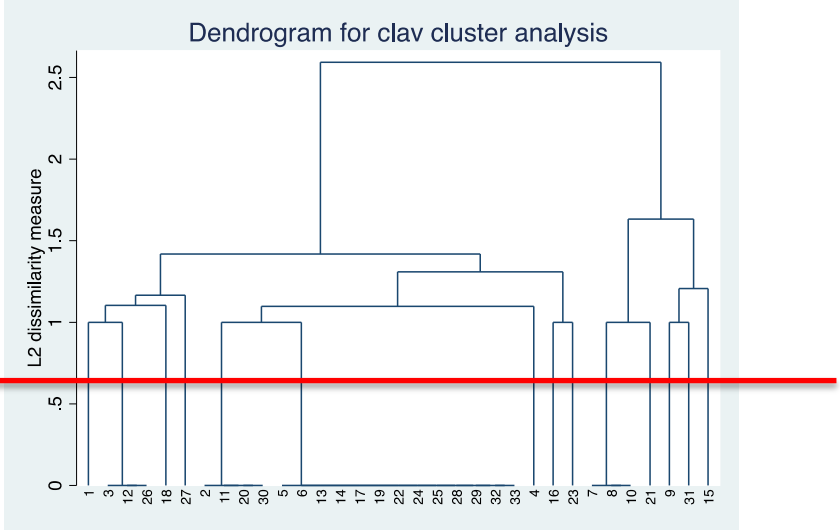

Figure 2: *Cluster Tree Diagram*

The most appropriate number of clusters is four. The low learning cluster includes 4 firms. This cluster join together firms that are neither have highly developed forms of DUI or STI modes. The group includes 5 firms

that support DUI-learning and spend on R&D and cooperate with researchers, so can be considered as tending to a pure DUI mode of innovation, while three other firms tend to a pure STI mode of innovation.

The majority of the firms, 60% of them, combine both modes of innovation. They use a mixed strategy of informal experience-based learning with activities that indicate a strong capacity to absorb and use codified and scientific knowledge.

3 Conclusion

Our analysis has produced some important findings. Firstly, high percentage of material inputs and supplies of foreign origin increases probability to introduce innovations. Nevertheless, the firms, importing domestically produced inputs, are less likely to innovate. According to theory, the import of foreign intermediate inputs is more than simply purchasing foreign goods and passively installing it. Whole process includes the development of technological capabilities to introduce new technologies developed abroad, to absorb and use them efficiently, and to adapt them to local conditions. In Kazakhstan, import facilitates the assimilation of skills and knowledge embodied in goods. As a result it enhance local capabilities, since it requires activities required to adopt, adapt, repair and commercialize new inputs. The results confirm that Kazakhstan innovate mostly absorbing new knowledge and technologies embodied in import. Import may involve the purchases of foreign intermediate inputs as well as the import of machinery and equipment. Therefore, reverse engineering and learning-by-doing may take place.

The second finding is that foreign imports and the presence of foreign ownership increase the ratio of new product sales. The explanation can be that imports are accompanied by the absorption of new knowledge and skills. The introduction of new products always requires some experience and practice in launching new production. Usually, purely or partly foreign ownership is associated with new knowledge and experience embodied in personnel. This significantly contributes to the introduction and commercialization of "new to firm" products. However, foreign presence is critical only to firms´ capability to launch new product rather than to introduce innovation. This leads us to conclude that the firms with the high ratio of new product sales are mostly foreign companies.

The comparison of results at regional and national levels showed that imports do not influence firms' decisions to launch new product lines in the East region nor at national level. In both cases, foreign presence increases a firm´s probability to introduce new products. Regression results indicated the insignificance of the size variable at the regional level, where most of the firms introducing new products are large.

Exports are only statistically significant in high-technology industries such as chemical, electronics, machinery and equipment, and fabricated metal products. The relationship between industry characteristics and the likelihood to innovate appears to be complex. The extent of technological opportunity, foreign ownership and firm size are not important determinants of innovation. However, a larger number of employees is associated with a higher probability to sell new products. Unsurprisingly, manufacturing industries innovate more than non-manufacturing ones because they are more involved in international trade. The innovation performance of services industries and construction depends heavily on imports, which is also consistent with theory.

Our finding that firms in the low learning cluster are all firms with less than 50 employees supports the "Schumpeterian hypothesis" of the relative innovative advantage of large firms where markets are characterized by imperfect competition (Schumpeter, 1950). Since the innovation activity is positively correlated with R&D expenditures, large firms invest and innovate intensively than small and medium size firms. The evidence from our analysis confirms that business R&D expenditure (88%) are predominating over the public R&D expenditure.

Our findings are particularly important and relevant for metallurgical cluster. Mining and metallurgical sectors usually requires the large amounts of capital investments for long period of time under conditions of substantial technological, geological and market risk. Therefore, only large firm is able to take large up-front investments with long time of payback possibilities. Almost all firms in the low learning cluster belong to the Casting of other non-ferrous metals sector (code 24540). This can be explained by the technological nature of the sector, which is not technological intensive sector.

The majority of firms with employment higher than 250 employees adopted organizational practice designed to promote scientific and codified knowledge exchange, problem-solving and learning among their employees (DUI/STI modes). The small number of respondents does not give us opportunity to apply regression analysis in order to analyse the effect of learning modes on firm innovative performance, which might be an important topic for future research. Our research raised a number of problems caused by the lack of data and/or the interpretation of the data. For example, there are a large number of pseudo firms that seriously hampers the usefulness of the statistical information available. The high number of firms that do not actually exist may lead to an overestimation of the economic effect of the metallurgical cluster. Because of all this, it is difficult to achieve a meaningful description of the economic processes occurring in the East Region, so we want to conclude this

paper with a note of caution regarding statistical data in Kazakhstan. They should be treated with care, taking into account the particularities involved in gathering data about transition economies.

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