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The impact of the 2008 financial crisis on European enterprises: the role of innovation systems

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Summary

While after the 2008 financial crisis most European enterprises were faced with a reduction in the demand for their products, some were not. This study examines to which extent this depends on the overall innovation performance of their domestic country. The innovativeness of a country is reflected by the share of frequent innovators in a country and by the level of technological specialisation of a country. Our results show that the share of frequent innovators in a country does not affect the probability that individual enterprises are faced with negative demand effects of an economic crisis. If we interpret the share of frequent innovators as an indicator of the overall performance level of innovation of a country, this implies that – despite the overall innovativeness of a country might help to shorten times of recovery after a crisis – it does not mitigate the crisis' effects on the turnover of individual enterprises. Our results further show a negative effect of technological specialisation: higher levels of technological specialisation are associated with a higher probability for individual enterprises to be faced with negative demand effects of an economic crisis. The size of this effect is considerable: on average, the difference in the probability that enterprises are faced with negative demand effects between the lowest and highest level of technical specialisation is approximately 10% points. Finally, our findings also show that smaller and older firms were more often faced by a reduction in their demand than larger and younger firms.

1. Introduction

Background

The 2008 financial crisis led to the most severe recession since more than 60 years. In EU, gross domestic production (GDP) fell by 4.2% in 2009. Production has declined in SMEs as well as in large enterprises. Employment levels also dropped in 2009, but not as strong as GDP levels. That the reduction in employment levels was less severe than the reduction in GDP levels, was possible (amongst others) because of a reduction in the number of hours worked per employee. For EU27, the employment growth rate in the first year after the crisis was -2.1%, ranging from -14.7% for Latvia, to 0.2% for Luxembourg (the only Member State with a positive growth rate over that period). (De Kok et al. 2011). Unemployment rates within the EU have increased to 10.0% in December 2011 and 10.7% in December 2012[1]. Again, the difference between Member States is considerable, ranging from 4.3% in Austria to more than 26% in Spain and Greece (Eurostat 2012).

Lack of demand as major cause for increase in unemployment rates

A major cause for the rise in unemployment levels was the reduction in the demand for products and services. By the end of 2010, 62% of all enterprises from the business economy of the European Union reported an overall negative impact of the economic crisis on total demand (De Kok et al, 2011). At the same time, this implies that almost 4 out of 10 enterprises did not report a negative impact of the economic crisis on total demand. This raises the question why some enterprises are faced with a reduction in demand whilst others are not. It stands to reason that this will partially depend on firm-specific factors (such as the reputation of a firm and/or its products) and country-specific factors (such as level and growth rate of a country's welfare). In addition, it is often argued that innovation may play an important role. At enterprise level, innovations in the production process may increase productivity and reduce production costs, giving firms an advantage over less innovative competitors. Regarding product innovations, it might be the case that more innovative products suffer less from the reduction in demand then less innovative products. At country level, the overall innovation performance of a country may help to soften the negative economic effects of a major economic downturn, thereby reducing the likelihood that individual enterprises are faced with a reduction in the demand for their products or services.

Research question

In an economic crisis, some enterprises are faced with a reduction in the demand for their products whilst others are not. The research question of this study is: to which extent does this depend on the innovativeness of the country of origin?

Regarding the innovativeness of a country, we will not only consider the average level of innovative activities, but also how even these innovative activities are distributed amongst the business economy of a country. This will be discussed in section two. The research question will be examined for a sample of enterprises from 24 European

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[1] Unemployment statistics are based on the Eurostat website, accessed on February 24, 2013 (http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Unemployment_statistics).

countries; section three presents the origins of this sample. The results of the empirical analysis are presented in section four, after which section five concludes with a summary of the main findings, limitations and suggestions for future research.

2. Literature review

2.1 National innovation systems

The impact of the 2008 financial crisis differs greatly between firms and between countries. While some firms exhibit a persistency in investing in innovation during recessions, others do not. Persistency of innovative activities can be contingent on several factors, both at firm level and at country level. To capture these firm-specific as well as country-specific effects, we use the concept of national innovation systems. The concept of national innovation systems has been developed to account for the different combinations and settings of industrial structure, scientific and technological knowledge accumulation, as well as public policy frameworks shaping the research and innovation activities within advanced countries (Freeman 1987; Archibugi and Pianta 1992; Nelson 1993; Lundvall 1992; Edquist 1997). The most important elements of innovation systems have been summarised in a definition provided by Edquist, stating that innovation systems are defined by "[...] all important economic, social, political, organisational, institutional, and other factors that influence the development, diffusion, and use of innovation" (Edquist 2005: 182). Translating these structural peculiarities of countries into particular "styles" (Archibugi and Pianta 1992: 9) of technological development, a large amount of historical, theoretical and empirical innovation systems research has shown that the national institutional setting has a decisive influence on the innovation behaviour and performance of economic agents and firms (Freeman 1995; Nelson 2001; Hall and Soskice 2001; Filippetti and Archibugi 2011). A national systems' style of technological development thereby can depend on multiple different factors on different levels of analysis, for instance firm-specific characteristics (e.g. such as strategies, management attitudes, and stage of development), cumulative and path-dependent nature of innovation, technological change and scientific research, particular trends of cash flows and profits, industry-specific dynamics of demand, profit opportunities or technological opportunities (Filippetti and Archibugi 2011).

However, as Nelson and Rosenberg (1993) pointed out, even within nations the institutional structures in different technology fields differ significantly from each. This raises the question whether the concept of national innovation systems makes any sense at all. The answer is that, despite international technology development and diffusion, institutional and cultural factors have a specific national expression and can significantly influence technological change. These influences are stronger or weaker depending on the size of a country and the globalism of techno-economic systems, and still justify the use of the national state as the unit of analysis, although transnational innovation systems and their effects on national innovation policies should not be excluded (Nelson and Rosenberg 1993: 16).

While differing substantially in their conceptualization of the innovation process and the analysis of economic impacts, neoclassical growth theories and evolutionary economics agree in the crucial role of knowledge accumulation and inter-sectoral knowledge spillovers for the international competitiveness of economies respectively national innovation systems. Thus, the idea of technological specialization of national systems of innovation can be traced back both to evolutionary as well as neoclassical scholars. Following the neoclassical tradition, the presence of economies of scale is likely to induce stability in terms of specialization patterns of countries (Laursen 2000). For instance, in the model presented by Krugman (1987), the productivity of resources in each sector, in each country, depends on an index of cumulative experience ('learning-by-doing') that creates economies of scale at the level of the industry. From the perspective of the international competitiveness of economies, empirical studies following the technology-gap approach (Posner 1961; Hirsch 1965; Vernon 1966), analyses of the relationship between measures of input and/or output of innovative activities (i.e. R&D and patents, respectively) and the trade performance of different industries. These studies pointed out that sectoral innovative activity is a major determinant of international competitiveness. Therefore, in a long-run perspective, non-price factors (i.e. technology, quality) are significantly more important than price related variables (Castellacci 2008). Additionally, macro-oriented studies have shown, that differences in productivity and GDP per capita between countries can be explained (among several other influencing factors) by the countries' abilities to innovate (i.e. the performance of the innovation system) as well as to exploit the international diffusion of technologies in terms of a well-developed absorptive capacity (e.g. Abramovitz 1994). Thus, the accumulation of technological knowledge is far from being an automatic or mechanistic process as often assumed in earlier models of economic growth theory. It is a costly process that requires an active effort to build up a strong social capability and an advanced industrial structure (Castellacci 2008).

Another more recent strand of research is dealing with the impact of sectoral technological regimes on the international competitiveness of industries. Technological regimes or technological innovation systems are defined "[...] in terms of knowledge and competence flows rather than flows of ordinary goods and services. They consist of dynamic knowledge and competence networks" (Carlsson and Stankiewcz 1991:111). In case there is a critical mass of knowledge flows and interaction, such competence networks can be transformed into synergistic clusters of firms and technologies within an industry or between groups of industries. Existing studies show (e.g. Malerba and Orsenigo 1995, 1996; Malerba and Montobbio 2003) that technological opportunities, properties of the knowledge base, appropriability and cumulativeness conditions are important factors to explain the patterns of international technological performance, measured by the 'revealed technological advantage' in terms of patents (Castellacci 2008). Simultaneously, the characteristics of technological regimes have also been found to have an impact in terms of export market share dynamics. Based on the estimation of a technology-gap trade model, studies have found that sectoral trade performance is closely related to a range of industry-specific technological variables, such as technological opportunities (Laursen 1999), cumulativeness (Lee and Lim 2001) and appropriability conditions (Castellacci 2007). "In a nutshell, these studies provide an extension and a refinement of the technology-gap approach, as they shed new light on the links between the structural characteristics of sectoral systems of innovation, on the one hand, and their competitiveness in international markets, on the other" (Castellacci 2008: 993).

Thirdly, there is another strand of research on the characteristics of the home market (i.e. the domestic economy) and its vertical linkages between suppliers, producers and users of advanced technology as another dimension of the competitive advantage of national systems of innovation (Porter 1990). Within the national systems of innovation approach, this perspective has taken shape in the strand of "sectoral innovation systems" to describe sector-specific sets of agents, institutions, networks, knowledge flows, technologies, market relations, and interaction patterns that makes a sector more competitiveness than others within the country (Malerba 2002). Based on the seminal work of Pavitt (1984) who originally applied the idea of sectoral specialisation trajectories to the analysis of sectoral patterns of innovation, a large number of studies have investigated the role of vertical linkages in explaining international competitiveness. Making use of data from the Community Innovation Survey (CIS), several studies provided information about different aspects of these sectoral specialisation trajectories of firms, for instance knowledge flows (e.g. acquisition of external knowledge, knowledge sources, or collaboration with users, customers, suppliers, and research organisations), type and composition of innovation expenditures, investments and acquisition in external technological solutions, machinery and equipment as well as different types of innovation (e.g. technical vs. non-technical, product vs. process, tangible vs. intangible) (e.g. Evangelista et al. 1997; Evangelista 1999; Veugelers and Cassiman 1999; Reichstein and Salter 2006).

Evolutionary economics emphasise this context specific nature of innovation activities. However, in its broader understanding the examination of sectoral patterns and impacts of innovation, the relevant context variables do not only refer to structural characteristics of the industry-specific regime (e.g. technological opportunities, cumulativeness, appropriability conditions, but also to the broader systemic context within which the innovation activities take place (Hekkert et al. 2006). Sectoral innovation is greatly shaped by the characteristics of the national system of innovation, and the latter, in turn, is affected by the former. The co-evolution of national and sectoral systems is therefore a major factor to drive international competitiveness. The idea that sectoral and national systems are intertwined has been put forward for example by Mowery and Nelson (1999), Malerba (2005), and Castellacci (2006).

These studies have pointed out the existence of three channels of interaction between the national innovation system and patterns of technological specialization:

- According to the technology-gap and home market approaches, it can be argued that sectoral innovation activities and inter-sectoral knowledge flows contribute to shape the specialization patterns, productivity dynamics and international competitive performance of the national innovation as a whole (Castellacci 2008). Moreover, several studies provide empirical evidence that the technological specialization profile of countries also account for the performance on the macroeconomic and that countries which are able to establish areas with increased technological experience obtain a more dynamic aggregate performance in the long run (Dalum et al. 1999; Fagerberg 2000; Peneder 2003).
- Secondly, the existence of core industries in which a country is specialized with the related set of well-established vertical linkages that they entail, may shape regulations and governmental decisions at the national level in terms of science, technology and innovation (STI) policies, industrial policies, IPRs regulations, and linkages between universities and industry (Castellacci 2008; Mowery and Nelson 1999). Vice versa, national policy support can directly affect sectoral innovation activities as well as collaboration patterns (e.g. clusters of excellence, promotion of specific technologies

or fields of technology), the promotion of institutional frameworks, collectively shared routines and behaviour, and mutual trust between the agents through a wide variety of incentives, schemes and regulations (Mowery 2005; Lundvall and Borrás 2005)

- Thirdly, the institutional framework, collectively shared routines, patterns of behaviour as well as the level of trust and cooperation between the innovation systems agents are being shaped and shape country-specific factors of social and cultural nature (Castellacci 2008). Network interactions and systemic relationships are embedded in, and co-evolve with, a complex set of social and cultural factors that are specific to a given national framework (Powell and Grodal 2005).

Summarising the points above, there is considerable evidence that the framework conditions in which a country's innovation activities take place are strongly affected and shaped by the characteristics and peculiarities of the national system of innovation. National innovation systems set the scene for the countries innovation activities by providing institutional frameworks, interaction channels and networks, democratic legitimised support via STI policies, technological opportunities and options for technological appropriability that paves the road for technological specialization. In turn, the overall innovation performance of a country may help to soften the negative economic effects of a major economic downturn. For individual enterprises, this could reduce the likelihood that they are faced with a reduction in the demand for their products or services. In this study we use a country's share of frequent innovators as indicator for the overall innovation performance of a country (this will be discussed in section 3). Our first hypothesis can therefore be formulated as follows:

> *H1: The likelihood that an individual enterprise is faced with a reduction in demand due to an economic crisis will be lower in countries where the share of frequent innovators is higher.*

2.2 Technological specialization and the impact of economic crisis

Following the contribution of Filippetti and Archibugi (2011), we assume that the peculiarities of national systems of innovation in terms of the level of technological specialization play a prominent role in explaining the impact of a major economic downturn. As their study indicates, countries endowed with stronger national innovation system are less affected and are better able to respond, at least in relative terms, to a recession. The structural characteristics of the national innovation system seem to play a more relevant role than demand. Specifically, the presence of qualified human resources plays a crucial role in cushioning the effects of a downswing in innovation in frontrunner countries.

This paper closely connects to Filippetti and Archibugi (2011) in taking a closer look at the technological specialization as a main structural characteristic. This aspect has indeed been included in their study. However, they used firm-level data from the European Innovation Barometer 2009 and the European Innovation Scoreboard 2008. The variable 'technological specialization' thereby on the one hand only refers to firms' perceptions, and, on the other hand, as they were taking other structural characteristics into consideration as well, the variable of technological specialisation only focuses on specific fields of "high-technology". Thus, our paper aims to improve the insight about whether technological specialization affects the impact of an economic downturn, i.e. whether its effects are cushioned or aggravated by technological specialisation.

To analyse this question, this paper follows the conceptual approach of Filippetti and Archibugi (2011) as well as Archibugi et al. (2013b). Based on the seminal work of Schumpeter, they argue that there are two main patterns of innovation knowledge accumulation: “The young Schumpeter looked at innovation as an event that could revolutionise economic life by bringing to the fore new entrepreneurs, new companies and new industries. The mature Schumpeter, on the contrary, observed and described the activities of large, oligopolistic corporations, able to perform R&D and innovation as a routine activity by building on their previous competences.” (Filippetti and Archibugi 2011: 304).

In the pattern of creative accumulation routines, research and development is more important as a key source in the innovation process than sudden, earth braking and risky ideas that question previous stocks knowledge. This pattern favours knowledge accumulation through the exploitation of internally already available bases of knowledge and core competences. Moreover, this includes also the recourse on existing practical know-how and experiences as well as modifications of existing solutions (David and Foray 1995; Kline and Rosenberg 1986). Beside the performance of institutionalised R&D, the type of knowledge accumulation can also be described by modes like “learning-by-doing”, “learning-by-using”, “learning-by-interacting”, “learning-by-producing” and “learning-by-searching” (Lundvall and Johnson 1994). In a nutshell, creative accumulation is linked with frequent, but more incremental innovation patterns, driven largely by past innovation activities.

This pattern of knowledge accumulation favours a solid and specialised structural framework provided by the national innovation system in terms of existing excellence networks and clusters of technology, established long-term collaborations, specific regulations, extensive market knowledge, institutional settings and policy support. All these factors allow them to build on and add to their already existing competences. While particularly in times of crises, complexity and uncertainty drastically increases, a stable institutional environment provided by a specialised innovation system might be able to reduce complexity and uncertainty by providing reduced transaction costs and increased technological opportunities and appropriability. Moreover, along its specialisation in terms of an excellent institutional setting in limited number of technological fields, the innovation system might be more robust against institutional and interaction failures in times of crisis. Therefore, our second hypothesis can be formulated as:

> *H2: The likelihood that an individual enterprise is faced with a reduction in demand due to an economic crisis will be lower in countries with a higher level of technological specialisation.*

The pattern of creative destruction, on the contrary, is linked to path-breaking innovations and radically new solutions that are incompatible with traditional solutions. Therefore, this innovation pattern might be stronger based on internal knowledge sources that in some occasions, and for limited periods of time, represent the bulk of the firm’s economic activity. Several scholars have argued that in this case innovations are more likely to be introduced by new firms, as existing firms can face problems in terms of a lack of adequate new skills and competences (Tushman and Anderson 1986; Henderson and Clark 1990; Leonard-Barton 1992), organisational adaptation (Levinthal and March 1993), and difficulties in changing context (Christensen 1997). This will also be combined to the concentric exploration of new opportunities, to specific ventures with companies operating in other industries, or generating symbiotic contacts with university departments (Castellacci 2008; Archibugi et al. 2013b).

Those who support the destruction hypothesis argue that there are periods of turbulences associated with a change in the leading sectors and/or the emergence of new sectors, which bring about a decline of technological and profit opportunities in established industries (Perez, 2002, 2009). This, in turn, could lead to a change in the knowledge and technological base relevant for business innovation, and could disturb the hierarchy of innovators. This thesis has been supported by Simonetti (1996) and Freeman and Louca (2001), who suggest that a stream of new firms join incumbent firms during periods of discontinuities (Archibugi et al. 2013b). Creating new technological regimes, new technological trajectories or new-to-the-world products, the innovation pattern of creative destruction is likely to escape from existing stocks of knowledge, existing network structures and collaborations. Moreover, existing institutional settings and regulations might be outdated and even become dysfunctional to the results of creative destruction as the novel and radical solution does not fit into the given institutional structures of existing markets, regulation, standards, and norms.

From the innovation systems perspective, high levels of technological specialisation can even hamper the emergence of creative destruction or radical innovations due to network failures. From the systemic perspective, interaction failures can have their origin either in too much or too little interaction (Klein-Woolthuis et al. 2005) which can both hamper innovation activities. Strong network failures refer to the risk that highly intensive cooperative relationships between actors can develop a certain degree of closure, which can lead to myopia and inertia (Bogenrieder and Nooteboom 2001; Nooteboom 2009). As a result, insufficient attention is paid to developments outside the collaboration and the firms inside the network may be locked-in to existing (technological) trajectories or paths. Hence, it is important for networks to have a sufficient amount of 'weak ties' (Granovetter 1983).
Moreover, a high level of an innovation systems' technological specialisation also shapes the individual innovation activities of the firms' embedded in the innovation system. As organisations evolve over time, they develop increasingly entrenched information filters, communication channels, and problem-solving strategies (Nelson and Winter 1982). The actions of firms today determine the nature of the options open to them tomorrow. The resulting path dependency is the combined result of the ex-post irreversibility of investment in capital assets, the externalities generated in the technological locality of the particular path the firm has chosen to follow, and the feedback benefits such as those generated by learning-by-doing. However, being located within a highly specialised innovation system, such path dependency could give rise to structural inertia (Hannan and Freeman 1984) and increasingly inflexible management models on the firm level as well (Lundvall 1988; Tripsas and Gavetti 2000). This structural inertia leads to the lock-in of firms to a particular combination of technology and business model so that they feel unable to adopt a new superior technology, which,

in the end, hinders organisational-level adaptation to rapid environmental change (Sydow et al. 2009; Schreyögg and Sydow 2010).

This problem of systems inertia becomes even more severe in times of crisis when the highly specialised core industries of a country are faced with drastically decreased levels of demand. In terms of biological evolutionary theory, this would mean that a highly specialised species is not able to adapt to sudden and dramatic changes in its environment with complete new mechanisms of selection. Likewise, as a consequence of its path dependency and structural inertia, an innovation system that is highly specialised to one or a few technologies might be not able either to flexibly adjust its innovation activities to other fields of technology that are less affected by economic crisis nor to strengthen innovation activities that explore new technological fields. Following this strand of argumentation, our third hypothesis is the opposite of our second hypothesis:

> *H3: The likelihood that an individual enterprise is faced with a reduction in demand due to an economic crisis will be higher in countries with a higher level of technological specialisation.*

3. Methods

For this study, we have combined the results of a European enterprise survey with macro-economic statistics regarding the welfare and innovation of European countries. The combination of these datasets resulted in a sample with observations on more than 4,000 SMEs for 24 European countries.

3.1. Micro-economic data: Enterprise Survey 2010

The Enterprise Survey 2010 is a telephone survey that has been conducted during the final quarter of 2010 amongst more than 7,500 employer enterprises from 37 different European countries. The objective of the questionnaire was to obtain information on relevant indicators on the quantity and quality of jobs at enterprise level, and on the impact of (and the reaction to) the 2008 financial crisis.

The questionnaire included questions on general characteristics of the enterprise, general characteristics of the workforce and indicators on the quantity of jobs. In addition, the questionnaire asked for various negative effects of the crisis that might have occurred during the past two years. The main question was whether enterprises were faced with an overall negative effect on the number of orders or total demand. This variable is used as the dependent variable for this study.

The questionnaire contains three questions on innovation: whether product innovation, process innovation and innovative activities had occurred during the past three years. These questions are aligned with the Community Innovation Survey. Next, respondents were asked how often their enterprise was engaged in activities to develop new goods, services, or production processes. Based on this question, we define frequent innovators as enterprises that were engaged in innovative activities at least once a month. This is one of the main independent variables in our study.

The Enterprise Survey 2010 was conducted amongst 37 European countries: the 27 Member States of the EU and 10 non-EU countries. It targeted enterprises from the business economy, which is defined in terms of the NACE sector classification (NACE D, F-K, N, O excl. 91). With respect to enterprise size, the following size classes are distinguished: micro enterprises, small and medium-sized enterprises, and large enterprises (LSEs). The sample plan of the survey was stratified amongst these three dimensions (country, sector and size class), which resulted in a disproportionally stratified sample plan. The fieldwork started at the end of September 2010 and lasted until February 2011. More details can be found in De Kok (2011).

An overview of the variables from the Enterprise Survey 2010 that have been used for this study is presented in Table 1. These include characteristics of the enterprise (including size, age, sector and innovative behaviour) as well as characteristics of the workforce.

Table 1 Main variables based on the Enterprise Survey 2010

Variable	*Brief description*
Neg_effect (dummy)	Enterprise reported an overall negative effect on the number of orders or total demand during the past two years, due to the current economic crisis
Firm size (ln)	Natural logarithm of the total number of employees of the firm
Firm age (ln)	Natural logarithm of the age of the firm
Fixed-term	Share of employees with a fixed-term contract
Fulltime	Share of employees working on a fulltime basis
Edu_medium	Share of employees with a medium educational level
Edu_high	Share of employees with a high educational level
Age_medium	Share of employees between 25 and 50 years of age
age_high	Share of employees aged 50 years of more
Female	Share of female employees
Frequent innovator (dummy)	The enterprise is engaged in activities to develop new goods, services, or production processes at least once a month
Sector dummies:	
Manufacturing	Enterprise is in the manufacturing sector
Construction	Enterprise is in the construction sector
Wholesale	Enterprise is in the wholesale sector
Retail	Enterprise is in the retail sector
Transport	Enterprise is in the transport and communication sector
Business	Enterprise is in the business services sector
Personal	Enterprise is in the personal services sector

Note: all dummy variables are coded as 0/1 variables (0=no, 1=yes).
Source: Enterprise Survey 2010, SMEs and EU Labour Market, EIM/GDCC (N=7559); conducted during the final quarter of 2010.

3.2. Macro-economic statistics

Table 2 presents an overview of the macro-economic indicators that we include in our model, regarding welfare, innovation, technological specialisation and two control variables.

A country’s welfare is included through the level and growth rate of a country’s gross domestic product, which have been obtained from Eurostat. This information is available for all EU Member States, but not for all of the remaining countries. We include the share of enterprises that is a frequent innovator as an indicator for the overall level of innovative activities that occur within a country’s business economy. This indicator is the aggregate of the variable ‘Frequent innovator‘ (Table 1).

In order to capture a country's technological specialisation, we use a Gini-Coefficient that is based on patent data. Using an international database with patent information for the years 2000-2008, we first counted all transnational patent applications, differentiated by the country of the inventor and the technological field of the patent filing. This was done separately for each year. In a second step, we calculated the Gini-Coefficient per country and year to gain some insight into the equality of the distribution of patent filings across technological fields. We use this coefficient as a measure of technological specialisation.

Table 2 Macro-economic statistics

Variable	*Brief description*
GDP per capita (2009)	GDP per capita in 2009 in purchasing power standards, where EU27 = 100
GDP growth (2009)	Real GDP growth rate of a country in 2009
GDP growth (2010)	Real GDP growth rate of a country in 2010
Freq_innovator_aggregate	The share of frequently innovative enterprises within a country (the aggregate of *Frequent innovator)*
Technological specialisation	A Gini-coefficient based on the number of patents in each technological field over all years, representing technological specialisation
Empl_protection	Share of enterprises in a country that made use of publicly supported employment protection schemes during 2009 and 2010
Eurozone	Whether a country belonged to the Euro area in 2009

Source: GDP data: Eurostat website; Freq_innovator _aggregate: own calculations, based on Enterprise Survey 2010; Technological specialisation: own calculations, based on PATSTAT

We extracted the relevant patent data from the "EPO Worldwide Patent Statistical Database" (PATSTAT), which provides information about published patents collected from 81 patent authorities worldwide. The patent filings in the sample follow the concept of "transnational patent applications" recently suggested by Frietsch and Schmoch (2010). This approach is able to overcome the home advantage and unequal market orientations of domestic applicants, so that a comparison of technological strengths and weaknesses between countries becomes possible. In detail, all applications at the World Intellectual Property Organisation (WIPO) under the Patent Cooperation

Treaty (PCT) and all direct filings at the European Patent Office (EPO) without precursor PCT application are counted. This excludes double counting of transferred PCT applications to the EPO. Put more simply, all patent families with at least a PCT application or an EPO application are taken into account. The technology field differentiation is based on the 34 WIPO classes (Schmoch, 2008). All the patents in the dataset are counted according to their year of worldwide first filing, what is commonly called the priority year. This is the earliest registered date in the patent process and is therefore closest to the date of invention.

The resulting Gini-Coefficient ranges from zero to one, with a value of one indicating a highly unequal distribution of patent applications across technology fields and therefore a high technological specialisation of its patent portfolio and vice versa. Since not all of the countries file at least one transnational patent in each technological field in 2008, which is the case for some smaller countries, we had to treat those countries as missing. Calculating the Gini-Coefficient without excluding those countries would have led to biased results. We end up with a group of 25 European countries for which the Gini-Coefficient for 2008 is available (see the annex for a table with the Gini-Coefficients for these countries).

It should be noticed that the Gini-coefficient of technological specialisation does not measure the average level of specialisation. A high level of the Gini-coefficient does not exclude the possibility of having a relatively high number of patent applications in all technological fields, in comparison with other countries. In other words: being highly specialized does not exclude the possibility of having a broad technological base. It just indicates a high inequality across technological fields, and thus that one or more technological fields have more patent applications than the others. Thus, it could be that countries with the same Gini-coefficient in a certain year greatly differ in the absolute number of patent applications.

Therefore, we also need include an indicator for the average level of innovation. One option would be to use the average number of patent applications in a country. This would be consistent with how we measure technological specialisation. However, as we argue below, the use of the (average) number of patent applications may not be the best available indicator for the level of innovational output. Instead, we use the share of frequently innovative enterprises within a country.

Some comments on using patents to measure technological specialisation

The use of patent applications as an indicator for innovation and technological specialisation has several advantages. The most important advantages include the existence of consistent historical databases and the classification of patents by technological field.

Patent applications also face several major drawbacks as an indicator for innovation. First of all, it is an intermediate measure, i.e. the number of applications does not measure the innovative output in a country. Second, it does not include non-patented inventions and innovations. It could be the case that a relatively innovative technological field is falsely considered as being non-innovative, because nobody files for patents in that particular technological field (e.g. because of secrecy). Third, an absolute number of patent applications might not reflect the actual number of innovations, because often one new product asks for multiple patent applications.

For all these reasons, the number of patent applications is foremost an indicator of innovation activities: how active one country is regarding the fields of technology, as compared to other countries (with which it competes in international markets). The problem remains that technological specialisation is not only reflected in terms of patenting. Hence, it is an approximation due to the restrictions by available data.

The last two macro-economic variables that we include in our analysis are an indicator for membership of the Euro area in 2009, and an indicator of the usage of publicly supported employment protection schemes. The Enterprise Survey 2010 contained a question whether or not enterprises had made use of publicly supported employment protection schemes during the past two years. By aggregating this information to country level (using weights), we obtained an estimate of the share of enterprises that made use of such schemes. By using employment protection schemes, a country may limit the unemployment effects of the crisis, which may in turn help to prevent a reduction in demand. For most countries in our sample the share of enterprises using such schemes lies between 1% and 19% , but for Belgium and Denmark this share lies between 28% and 30%. To prevent these outliers from influencing the outcomes too much, we use the natural log of this share as a control variable.

3.3. Sample for analysis

The combination of the Enterprise Survey 2010 with the available macro-economic statistics results in a sample of 5,423 enterprises from all size classes from 24 European countries. These numbers refer to the total number of completed interviews. Not all enterprises have answered all questions, however. For example, 318 respondents could not tell whether the economic crisis had an overall negative effect on the number of orders or total demand during the past two years. Likewise, for 420 respondents we could not determine if they were frequent innovators or not. All in all, for approximately 25% of the total number of observations, at least one of the variables of interest could not be determined, which resulted in 4,067 observations that could be used for subsequent analyses (see Table 3 and Table 4).

Table 3 Sample size: number of available observations by country and size class

Country	*Micro (2 – 9)*	*Small and medium-sized (10 – 249)*	*Large (250+)*	*Total*
Austria	51	31	38	120
Belgium	65	21	13	99
Croatia	59	25	17	101
Cyprus	47	82	16	145
Czech Republic	78	51	57	186
Denmark	66	38	61	165
Finland	57	34	24	115
France	208	58	82	348
Germany	114	77	61	252
Greece	99	17	16	132
Hungary	74	30	23	127
Ireland	53	61	35	149
Luxembourg	12	53	14	79
Netherlands	71	33	19	123
Norway	31	40	9	80
Poland	286	56	82	424
Portugal	77	34	21	132
Romania	50	32	39	121
Slovakia	28	87	15	130
Slovenia	47	35	12	94
Spain	193	74	67	334
Sweden	65	25	15	105
Turkey	143	96	17	256
United Kingdom	163	57	30	250
Total	2,137	1,147	783	4,067

Source: Enterprise Survey 2010.

Table 4 Sample size: number of available observations by sector

Sector	*Total*
Manufacturing	1,015
Construction	410
Wholesale trade	368
Retail trade	482
Transport and communication	339
Business services	866
Personal services	587
Total	4,067

Source: Enterprise Survey 2010.

4. Results

4.1. Descriptive statistics

About two-thirds of the enterprises in our sample reported by the end of 2010 that the economic crisis had an overall negative effect on the total demand for their products or services. This share is somewhat higher for SMEs than for large enterprises (Table 5). About one in every five enterprises in our sample was engaged at least once a month in activities to develop new goods, services, or production processes. Large enterprises are twice as likely as micro enterprises to be a frequent innovator (Table 5). Notice that these statistics represent the unweighted distribution amongst the enterprises in our sample, and are therefore not representative for the business economy of the countries included.

Table 5 Frequent innovators and enterprises with negative demand effects of the crisis, by size class

Variable	*Micro (2 – 9)*	*Small and medium-sized (10 – 249)*	*Large (250+)*	*Total*
Share of enterprises that reported overall negative effect on total demand due to economic crisis (neg_effect)	66%	64%	58%	63%
Share of frequent innovators (freq_innovator_aggregate)	14%	20%	31%	19%

Note: the reported shares are unweighted and therefore not representative for the business economy of the countries included.
Source: Enterprise Survey 2010.

Our data includes three different indicators of innovation, two of which are defined at country level: technological specialisation (measured by a Gini-Coefficient) and the average level of innovative activities by enterprises (measured by the share of frequent innovators). In theory, these two indicators refer to two different aspects. This raises the question how large the correlation between these two indicators is. According to our sample, the correlation is 0.19 (Table 6), which we consider to be rather low: it shows that countries with the same Gini-coefficient in a certain year can differ considerably in the share of enterprises that innovate frequently.

The correlations between the various macro-economic statistics are relatively low (Table 6). Only one correlation exceeds 0.5: the correlation between the share of frequent innovators and the interaction of that variable with technological specialisation, which is 0.72. This suggests that multicollinearity might become an issue when we include this interaction effect in our regression model. To determine if this is indeed the case we have to consider the data at enterprise level rather than at country level (because the regressions are performed using at the enterprise level).

Table 6 Descriptive statistics and correlations between country-specific variables, for 24 European countries

Variable	*Mean*	*Standard deviation*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1: Share of enterprises that reported overall negative effect on total demand due to economic crisis	63%	0.13	1							
2: Share of frequent innovators	21%	0.10	-0.13	1						
3: Technological specialisation	0.38	0.08	0.15	0.19	1					
4: (Share of frequent innovators)*(Technological specialisation)	0.06	0.04	0.22	0.72**	0.38*	1				
5: GDP per capita (2009) (EU27 = 100)	105.6	46.7	-0.5**	0.35*	0.20	-0.05	1			
6: GDP growth (2009)	-4.32	2.33	-0.28	-0.37*	- 0.41**	- 0.45**	0.12	1		
7: GDP growth (2010)	1.72	2.44	-0.37*	0.12	0.06	-0.00	0.05	0.05	1	
8: Empl_protection (ln)	2.07	0.71	-0.23	-0.02	-0.08	0.11	-0.01	0.15	-0.14	
9: Eurozone	0.58	0.50	-0.27	0.03	-0.14	0.04	0.30	0.01	-0.16	0.15

Based on 24 observations; **: significant at 5%; *: significant at 10%
Note: the reported shares are unweighted and therefore not representative for the business economy of the countries included.
Source: PATSTAT (3 and 4), Eurostat (5, 6 and 7) and Enterprise Survey 2010 (1, 2 and 4).

To establish the presence of multicollinearity we have calculated the variance inflation factors (vif) for the variables in various regression model specifications. Often, the largest vif value amongst all independent variables is used as an indicator of the severity of multicollinearity. If this value exceeds a certain threshold, this indicates that multicollinearity may have a large influence on the regression outcomes. There is no objective criterion, but often a threshold value of 10 is used (Neter et al. 1990), although a threshold value of 5 is also mentioned. When we calculate the variance inflation factors for the independent variables described in tables 1 and 2 (excluding the interaction effect), the maximum factor is less than three (the average value is 1.54). This indicates there is no indication of multicollinearity. Once we add the interaction effect, however, the maximum variance inflation factor becomes 22.65 for the interaction effect. The variance inflation factor for the share of frequent innovators is also very high (18.93). This indicates that the results of any model including the interaction effect are unreliable, which is why we decided not to include the interaction effect in our models.

We also examined the possibility to include the relative employment share of a country's financial sector in our model, as an additional control variable. Unfortunately, the inclusion of this variable also resulted in unacceptable high variance inflation factors, which is why this variable is excluded from the models that we present next.

4.2. Regression results

To test our hypotheses, we have estimated various logistic regressions with the variable neg_effect as the dependent variable. These models try to explain the probability that enterprises were faced by a reduction in the total demand due to the crisis, by various enterprise characteristics, workforce characteristics, macro-economic conditions, and by innovation (Table 7).

Regarding the enterprise characteristics, the results consistently show that smaller and older firms were more often faced by a reduction in their demand than larger and younger firms. Enterprises from the business services sector where somewhat less often faced with these negative effects of the crisis, otherwise no sectoral differences are established. Next, a high GDP/capita level or growth rate had a positive effect, in that enterprises from countries with higher levels less often reported negative demand effects of the economic crisis. The GDP growth rate over 2010 has a larger effect than the growth rate over 2009.

If we consider the workforce characteristics (which are added in model 2), it seems that the nature of the labour contract (fixed term or not, fulltime or part-time) does not matter. Neither does the educational level of the employees. There is however a small gender effect and an age effect. The age effect indicates that enterprises with a higher share of young employees were less often faced with a negative effect of the economic crisis on their total demand. This might suggest that young employees are better able to generate additional demand. It is however also possible that this relationship is actually due to reversed causality: firms that were faced with a negative demand effect of the crisis may have laid off part of their workforce (or did not renew fixed-term contracts). Typically, younger employees are easier to lay off, because it is cheaper and/or they often have a fixed-term contract.

Table 7: Regression results (dependent variable: *neg_effect*)

	Model 1		Model 2		Model 3	
Variables	*Coefficient*	*Std error*	*Coefficient*	*Std error*	*Coefficient*	*Std error*
Constant	1,512	0,197***	0,333	0,347	-0,070	0,378
Firm size (ln)	-0,083	0,018***	-0,056	0,019**	-0,055	0,02**
Firm age (ln)	0,223	0,043***	0,207	0,044***	0,214	0,044***
Fixed term			0,001	0,001	0,001	0,001
fulltime			0,001	0,002	0,000	0,002
edu_medium			0,002	0,002	0,002	0,002
edu_high			0,001	0,002	0,001	0,002
age_medium			0,012	0,002***	0,011	0,002***
age_high			0,011	0,003***	0,011	0,003***
female			-0,003	0,001*	-0,003	0,001*
Innovation-related variables						
Frequent innovator					-0,035	0,089
Freq_innovator_aggregate					0,600	0,503
Technological specialisation					1,527	0,585**
Macro-economic variables						
GDP per capita (2009)	-0,007	0,001***	-0,007	0,001***	-0,007	0,001***
GDP growth (2009)	-0,034	0,014*	-0,031	0,014*	-0,005	0,018
GDP growth (2010)	-0,113	0,015***	-0,107	0,016***	-0,114	0,016***
Empl_protection (ln)	-0,196	0,052***	-0,189	0,053***	-0,206	0,054***
Eurozone	-0,226	0,082**	-0,218	0,083**	-0,129	0,09
Sector dummies						
Manufacturing	(omitted)		(omitted)		(omitted)	
Construction	-0,042	0,126	-0,053	0,128	-0,055	0,128
Wholesale	-0,071	0,131	-0,058	0,133	-0,068	0,133
Retail	0,003	0,12	0,070	0,122	0,067	0,122
Transport	0,190	0,137	0,179	0,139	0,162	0,139
Business	-0,270	0,099**	-0,238	0,105*	-0,240	0,105*
Personal	-0,093	0,112	-0,006	0,116	0,005	0,116
Number of observations	4067		4067		4067	
Pseudo R^2	0,0347		0,0415		0,0430	

Significance levels: * 0.01<p≤0.05; ** 0.001<p≤0.01; *** p≤0.001.

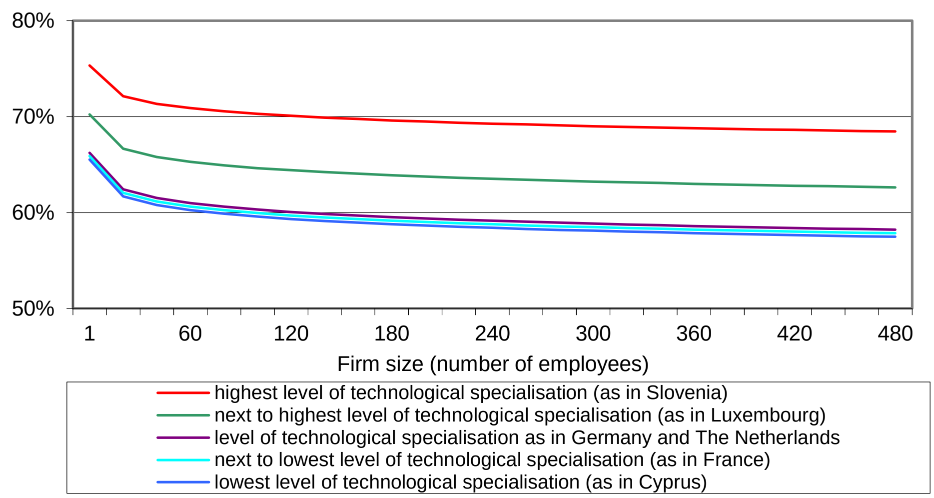
Source: Panteia/EIM.

Third hypothesis accepted

Our hypotheses are tested in model 3, where the various innovation-related variables are included. Our first hypothesis is rejected: the likelihood that an individual enterprise is faced with a reduction in the demand for its goods or services is not related to the share of frequent innovators. In addition, whether or not the enterprise itself is a frequent innovator also does not matter. However, the results support the third hypothesis that enterprises from technologically more specialised countries are more likely to have reported a negative effect of the crisis on the demand for their products or services.

The parameters of a logistic regression are difficult to interpret. Figure 1 offers a better understanding of the order of magnitude of the effect of technological specialisation on the probability that enterprises are faced with negative demand effects. Figure 1 shows how this probability is related to technological specialisation and firm size, keeping all other variables of the model constant. In particular, it shows how the probability of enterprises being faced with negative demand effects decreases with firm size, for different values of technological specialisation. On average, for large firms (with 500 employees) this probability is about 8% points lower than it is for firms with only one employee. It also shows that the effect of technological specialisation is somewhat larger than the firm size effect: given firm size, the difference in the probability that enterprises are faced with negative demand effects between the lowest and highest level of technical specialisation is approximately 10% points. At the same time, it should also be noticed that the difference between the lowest and the second-highest level is much lower at approximately 5% points.

Figure 1 Probability that enterprises are faced with negative demand effects, for countries with different levels of technological specialisation



Note: The lines do not reflect differences between countries; they only reflect the effect of technological specialisation. Apart from technological specialisation, the different lines are all based on the same values for the other variables in the model (including GDP/capita level and growth rates).

5. Conclusions

5.1. Main findings

After the 2008 financial crisis, some enterprises were faced with a reduction in the demand for their products whilst others were not. The purpose of this study was to examine to which extent this depends on the innovativeness of the country of origin. Following the contribution of Filippetti and Archibugi (2011), we assume that the peculiarities of national systems of innovation in terms of the level of technological specialization play a prominent role in explaining the impact of a major economic downturn. However, their variable 'technological specialization' only refers to firms' individual perceptions and focuses solely on specific fields of "high-technology". Thus, our paper aims to improve the insight about whether the technological specialization of a national innovation system affects the impact of an economic downturn, i.e. whether its effects are cushioned or aggravated by technological specialisation. The general innovativeness of a country is reflected by the share of frequent innovators in a country and by the level of technological specialisation of a country.

Our results show that the overall innovation performance of a country's national innovation system (in terms of the share of frequent innovators) does not affect the probability that individual enterprises are faced with negative demand effects of an economic crisis. This implies that the overall level of innovation in a country does not soften the negative economic effects that firms are faced with in terms of decreases in turnover. Thereby, this contradicts our first hypothesis that the innovation performance of the national innovation systems helps to mitigate the negative economic effects of a major economic crisis by providing channels and networks for knowledge accumulation with decreased transaction costs. However, this is clearly not to say that the performance of a national innovation system does not help firms to faster recover from the negative effects of a major economic downturn, as long as the existing networks and channels of knowledge accumulation have not become obsolete or dysfunctional due to drastically changed technological regimes or market demands.

But this result is in line with our finding of a negative effect of a national innovation systems' technological specialisation. Supporting our third hypothesis, the results show a negative effect of technological specialisation: higher levels of technological specialisation are associated with a higher probability for individual enterprises to be faced with negative demand effects of an economic crisis. The size of this effect is considerable: on average, the difference in the probability that enterprises are faced with negative demand effects between the lowest and highest level of technical specialisation is approximately 10% points. This finding clearly supports the assumption derived from evolutionary theory that the technological core competences of a national innovation system can turn into core rigidities (Leonard-Barton 1992) or even structural inertia in the course of a major global economic downturn when the global demand for highly specialised, 'high-tech' goods, on which a highly specialised country depends, faces drastic decreases.

Finally, our findings also show that smaller and older firms were more often faced by a reduction in their demand than larger and younger firms.

5.2. Policy implications

Basically, policy instruments can be distinguished whether they prioritise excellence or coherence within the innovation system. Policy tools targeted towards excellence more often stimulate the emergence of high-reputed research organizations, clusters of excellence. By preserving and supporting existing strengths these policies want to develop and extent the leading role of a nation in a certain field of technology ("spearheads" respectively "lighthouses"); in other terms, they seek to build on technological specialisation. In contrast, coherence-oriented policy instruments want to support the coherent development of regions. Subsequently, their primer goal is to firstly support disadvantaged regions or groups of actors. Today there is a tendency to put more emphasis on excellence- or specialisation-oriented policy instruments in most of the European Member States (Ebersberger et al. 2011). However, by revealing negative effects of high levels of technological specialisation in times of economic crisis, the findings presented in this paper support the concept of ”smart specialisation” coined by Soete et al. (2009). The concept favours a middle category between these both priorities which aims at supporting the specific strengths of different regions simultaneously instead of narrowly focussing only on single technological strengths.

5.3. Limitations and suggestions for future research

The analyses presented in this paper certainly have some limitations. First of all, time series data would have been favourable to investigate on the relationship between the national innovation systems' performance level and the negative economic impacts on firm level more deeply. Secondly, given the constraints of available data, the dependent variable of our study neglects the extent to which a firm is affected by the economic crisis due to its binary form. Moreover, the model misses a suitable indicator of the absorptive capacity of individual enterprises (the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities). This theoretical concept explains why some firms are more likely to absorb the available knowledge within a certain country/sector than other firms. Usable indicators of the absorptive capacity of individual enterprises are, however, not available in our dataset. In addition, the current indicator of the average level of innovative activities in a country (the share of frequent innovators) does not include innovation activities within universities and public research institutes, nor does it control for the fact that the macro-economic effects of innovation by a single multinational exceed the macro-economic effects of innovation by a single micro enterprise. Future studies may therefore search for alternative indicators for the average level of innovative activities in a country. Finally, since the independent variables of interest are measured at country level rather than enterprise level, it may be more valid to estimate a multilevel model rather than estimating an equation at enterprise level only.

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Appendix

Table 8 Sample size: number of completed interviews by country and size class

Country	*Micro (2 – 9)*	*Small and medium-sized (10 – 249)*	*Large (250+)*	*Total*
Austria	59	41	77	177
Belgium	78	31	29	138
Croatia	60	32	23	115
Cyprus	52	99	20	171
Czech Republic	93	73	103	269
Denmark	75	45	92	212
Finland	74	42	44	160
France	246	84	177	507
Germany	135	113	108	356
Greece	105	28	23	156
Hungary	76	33	38	147
Ireland	62	77	63	202
Luxembourg	14	77	24	115
Netherlands	82	42	34	158
Norway	36	44	16	96
Poland	317	95	166	578
Portugal	91	39	29	159
Romania	55	45	50	150
Slovakia	42	147	41	230
Slovenia	50	40	16	106
Spain	217	106	108	431
Sweden	78	38	31	147
United Kingdom	188	72	79	339
Turkey	153	109	25	287
Total	2,438	1,555	1,416	5,406

Note: for 17 enterprises, the size class could not be determined.
Source: Enterprise Survey 2010.

Table 9 Sample size: number of completed interviews by sector

Sector	*Total*
Manufacturing	1,384
Construction	566
Wholesale trade	485
Retail trade	631
Transport and communication	471
Business services	1,133
Personal services	753
Total	*5,423*

Source: Enterprise Survey 2010.

Table 10 Innovative behaviour of enterprises and technological specialisation for 25 European countries (2008)

Country	*technological specialisation* (Gini-Coefficient)*		*Share of frequently innovative enterprises***	
Austria	0.292	(3)	0,073	(6)
Belgium	0.293	(4)	0,164	(13)
Cyprus	0.276	(1)	0,234	(21)
Czech Republic	0.378	(13)	0,127	(10)
Germany	0.296	(5)	0,162	(12)
Denmark	0.386	(15)	0,279	(23)
Spain	0.314	(8)	0,072	(5)
Finland	0.417	(18)	0,319	(24)
France	0.286	(2)	0,069	(3)
United Kingdom	0.309	(7)	0,197	(19)
Greece	0.360	(11)	0,187	(17)
Croatia	0.411	(16)	0,046	(2)
Hungary	0.420	(19)	0,168	(14)
Ireland	0.373	(12)	0,194	(18)
Israel	0.441	(22)	0,185	(16)
Luxembourg	0.570	(24)	0,017	(1)
Netherlands	0.296	(6)	0,264	(22)
Norway	0.442	(23)	0,180	(15)
Poland	0.334	(9)	0,105	(8)
Portugal	0.383	(14)	0,129	(11)
Romania	0.439	(20)	0,069	(4)
Sweden	0.351	(10)	0,220	(20)
Slovenia	0.588	(25)	0,342	(25)
Slovakia	0.414	(17)	0,077	(7)
Turkey	0.439	(21)	0,123	(9)

Source: *: own calculations, based on PATSTAT; **: Enterprise Survey 2010

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