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From Financial Normalcy to the Global Financial Crisis

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Abstract

Understanding the complexity of innovation processes and unravelling the complicated relationships between innovation and productivity is pivotal to effective and purposeful public policy, designed particularly for economically lagging economies to initiate their swifter technology-induced growth and catching-up with richer economies. In this respect, the analysis focuses on machinery and equipment (M&E) acquisition as a key innovation strategy and uses a modified CDM model (Crépon et al., 1998). The model is extended by introducing binding financing constraints to shed light on the drivers and determinants of innovation inputs, the relationship between innovation input and innovation output and, finally, the relationship between innovation output and firm productivity. We consider three different economic phases, spanning from the early 2000s and the immediate pre-crisis period to the immediate post-crisis period. The analysis uses firm-level data for a large set of Central, East and Southeast European (CESEE) and Former Soviet Union (FSU) countries and demonstrates that financing constraints were non-negligible and very harmful, inducing entrepreneurs to be less likely to invest in M&E but also to invest less in the acquisition of M&E. Moreover, it points to the important role of M&E investment efforts for an establishment's innovation success, suggesting that establishments with higher M&E investment effort are also more likely to become successful product innovators. Finally, it consistently demonstrates that successful innovative activities pay off, significantly enhancing innovators' labour productivity levels.

Keywords: funding constraints, innovation strategies, innovation outcome, establishment performance, Central, East and Southeast Europe and Former Soviet Union, pre- and post-crisis developments

JEL classification: G21, D24, L25, O1, O31, O33

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1. Introduction

Undoubtedly, innovations are key to economic outcomes, both as an engine of economic growth and the development of economies and as prerequisite for survival and growth of individual firms (Schumpeter, 1934). Hence, understanding innovation processes in general, and the complex relationships between innovation and productivity in particular, has been a major concern for economists and policy-makers alike for decades. Only if factors that are conducive or obstructive to innovation effort, innovation success and firm productivity can be identified and singled out is there hope that, by means of purposeful and effective policies, growth potentials of economically and technologically lagging economies can be sufficiently improved to induce quicker technology-driven growth and catching-up with richer economies.

In this regard, due to their detrimental effects, financing constraints have received a fair amount of attention recently, particularly since the onset of the global financial crisis whose aftereffects still weigh heavily on many economies. In particular, firms need often partly substantial resources to undertake innovative activities. However, devoid of sufficient internal funds, entrepreneurs often turn to capital markets to raise the necessary finance but – as a result of information asymmetries between them and potential outside investors – frequently encounter sizeable and insurmountable financing constraints that discourage them to start new or continue ongoing innovation projects (see sections 2 and 5.1 for a detailed discussion of the literature of innovation and financing constraints).

Given this context, the ensuing analysis addresses the role of binding financing constraints in complex innovation processes, characterised by various stages and different channels through which entrepreneurs' innovation efforts ultimately lead to productivity improvements of their establishments. In doing so, it uses firm-level data for a large set of Central Eastern and South Eastern European countries (CESEE) and Former Soviet Union countries (FSU). We attempt to shed light on, first, the drivers and determinants of innovation inputs, explicitly accounting for the role of financing constraints as potential deterrent, second, the relationship between innovation input and innovation output and, finally, the relationship between innovation output and firm productivity. The data are taken from the Business Environment and Enterprise Performance Survey (BEEPS) which is a joint initiative of the World Bank and the European Bank for Reconstruction and Development (EBRD). To account for the fundamental economic and political transformations this group of countries underwent and the far-reaching consequences of the global financial crisis, it studies innovation processes during three different economic phases that characterised the region since the turn of the century, namely (1) the phase of *'financial normalcy'* between 2000 and 2004, (2) the '*bubble phase'* between 2004 and 2008, and (3) the *'crisis phase'* following the global financial crisis of 2008. Methodologically, it uses a modified CDM model (Crépon et al., 1998), extended by the role of binding financing constraints that not only affect an entrepreneur's decision to engage in innovative activities in the first place, but subsequently also his or her decision on how much to spend on such activities.

However, in contrast to the majority of studies in this area of research which focuses on R&D as the major innovation strategy, the study focuses on the most important and prevalent innovation strategy among entrepreneurs in the region considered: machinery and equipment investments (M&E). In particular, faced with deficient own technological capabilities and innovative potentials, entrepreneurs in

the region considered are found to predominantly resort to buying technology and know-how embodied in M&E from the original innovator with enables them to either develop new products, services or processes or modify existing ones (Veugelers and Cassiman, 1999; Cassiman and Veugelers, 2006).

The contributions of the ensuing analysis are multiple: first, it studies innovation strategies, efforts, outcomes and effects of a broad group of technologically lagging emerging economies, identifying key factors and characteristics that facilitate swifter technology-induced catching-up. Second, it focuses on the acquisition of M&E as the key innovation strategy and establishes its role for innovation outcome and establishment productivity. Third, it takes a comparative approach and identifies differences of and changes in innovation processes across time, from the early 2000s until right after the onset of the global financial crisis. Finally, it explicitly accounts for the detrimental role of binding financing constraints and demonstrates whether and how entrepreneurs were affected and how that changed over time.

Results consistently demonstrate that, firstly, the M&E-based innovation strategy dominates in the set of countries considered. Secondly, financial constraints were detrimental to both, an entrepreneur's decision to invest in M&E as well as on how much to invest in M&E. In both cases, the negative effect was strongest during the crisis phase, when, as a result of the global financial crisis, GDP collapsed, both borrowers and lenders stumbled and capital markets risked drying up altogether. Given the dominance of this innovation strategy among CESEE and FSU countries, this result calls for quick and effective policy intervention to reduce or altogether dismantle existing funding constraints to help innovators increase their participation in innovative activities as well as their innovation efforts. Furthermore, results shed light on several establishment and country characteristics that render an establishment more likely to invest in M&E and that are associated with higher M&E efforts. Our results demonstrate that larger or younger establishments, internationally trading establishments as well as establishments that received subsidies were more willing to invest in M&E while, in contrast, the probability of acquiring M&E decreased with foreign and state ownership share. Similarly, our results show that M&E investment efforts are higher among internationally trading firms that need to withstand fiercer global competition, tend to be conducted jointly with R&D activities, pointing to the complementarity between M&E and R&D investment strategies, and increase with state ownership share. In contrast, M&E efforts decreased with size and age. Thirdly, results point to the important role of M&E investment efforts for an establishment's innovation success, rendering establishments with higher M&E investment efforts also more likely to become successful product innovators. This effect, however, only applies to the crisis phase. Finally, results consistently demonstrate that successful innovative activities pay off, translating into higher labour productivity levels.

The remainder of the paper is structured as follows: section 2 provides a brief overview of the related literature on the relationship between innovation input, innovation output and establishment performance. Section 3 provides an overview of the data sources and characterises the three economic periods analysed in the study. A detailed descriptive analysis of prevailing funding obstacles, innovation strategies and innovation outcomes in Central, East and Southeast Europe plus some Former Soviet Union countries is provided in section 4. Section 5 discusses in detail the structure of the modified CDM model applied in the analysis, explicitly accounting for the role of financing constraints in the decision to engage in innovative activities as well as in the decision on how much to spend on such activities. Econometric results are presented and discussed in section 6 while section 7 provides an extensive robustness check, using alternative proxies for innovation output to determine their effects on establishment performance. Finally, section 8 summarises and concludes.

2. Related literature: an overview

In order to shed light on the complexity of innovation processes and to explicitly account for the different channels through which innovation inputs are ultimately transformed into performance improvements of establishments, innovation studies have adopted the three stage CDM model, named after their authors Bruno Crépon, Emmanuel Duguet and Jacques Mairesse (Crépon et al., 1998), as their workhorse model. The CDM model portrays three different relationships in a sequential way: the drivers and determinants of innovation inputs, the relationship between innovation input and innovation output and, finally, the relationship between innovation output and firm performance.

The first stage of the model focuses on an entrepreneur's decision whether to innovate or not and if so, how much to spend on such activities. The rich empirical literature points to several factors considered pivotal to *an entrepreneur's decision to engage in R&D*. For instance, firm size appears as one of the major determinants of the propensity to do R&D, consistently showing that, in support of one of Cohen and Klepper's (1996) stylised facts about the relationship between innovation and firm size, larger firms are more likely to engage in R&D (see, e.g., Griffith et al., 2006; Benavente, 2002; Mairesse and Robin, 2009; Brown and Guzmán, 2014; Janz et al., 2003; Lööf et al., 2001; Mohnen et al., 2006; Hall et al., 2009; Crépon et al., 1998). However, as suggested by Goya et al. (2013), this pattern is not uniform across sectors but may be absent or even negative among services sector firms. In contrast, empirical evidence on the role of firm age is mixed and rather inconclusive. While some studies find that young and newly established firms are more likely to engage in R&D (e.g., Janz et al., 2003 or Klomp and van Leeuwen, 2001), others fail to find any significant relationship between a firm's age and its propensity to do R&D at all (e.g., Hall et al., 2009). Furthermore, the empirical literature points to other highly relevant determinants of a firm's propensity to perform R&D. For instance, business group affiliation is found to matter, allowing firms that belong to a group to benefit from intra-group knowledge spillovers, easier access to internal capital markets and finance or other synergies in areas like marketing or distribution, which also renders them more likely to do R&D (e.g., Mohnen et al., 2006; Hall et al., 2009; Goya et al., 2013). Similarly, firms are more likely to engage in R&D if endowed with a highly educated workforce (Goya et al., 2013), if they perform R&D on a permanent basis (see, e.g., Klomp and van Leeuwen, 2001 or Lööf et al., 2001), operate internationally and face fiercer international competition which forces them to innovate to remain competitive (e.g., Griffith et al., 2006; Janz et al., 2003; Goya et al., 2013; Lööf et al., 2001) or have a higher market share due to, among other things, past innovation success (e.g., Crépon et al., 1998; Benavente, 2002; Brown and Guzmán, 2014; Klomp and van Leeuwen, 2001). Furthermore, spillovers are found to matter for a firm's decision to engage in R&D. In this respect, Goya et al. (2013) demonstrate that firms that operate in sectors characterised by a large number of R&D performing rival firms have a stronger incentive to also do R&D. In a similar vein, firms that are able to better protect their innovations are also more likely to innovate (e.g. Mairesse and Robin, 2009; Griffith et al., 2009; Goya et al., 2013) just as firms that receive subsidies from local, national or EU sources (see, e.g., Griffith et al., 2006; Hall et al., 2009; Goya et al., 2013). In contrast, and somewhat surprisingly, foreign ownership seems of only little importance for an establishment's decision to engage in R&D (Mancusi and Vezzulli, 2011; Männasoo and Meriküll, 2011).

Comprehensive empirical evidence also sheds light on drivers and determinants of an entrepreneur's *innovation effort*. For instance, the role played by firm size is rather mixed and inconclusive and tends to differ across countries and sectors analysed (see, e.g., Benavente, 2002; Crépon et al., 1998; Janz et al., 2003; Hall et al., 2009; Lööf et al., 2001 or Mohnen et al., 2006). A similarly mixed picture emerges for business group affiliation, highlighting that, probably due to better access to internal funds, R&D efforts are higher among firms that are part of a group (e.g., Mohnen et al., 2006; Hall et al., 2009) or significantly lower if they are able to benefit from the innovative activities within the group, rendering their innovation efforts less necessary (Goya et al., 2013). Additionally, evidence is mounting that R&D efforts tend to decline with age (Klomp and van Leeuwen, 2001), are higher among firms that operate in international markets and need higher R&D efforts to stay competitive (Griffith et al., 2006; Mairesse and Robin, 2009; Goya et al., 2013), perform R&D continuously (Janz et al., 2003; Klomp and van Leeuwen, 2001; Lööf et al., 2001; Mohnen et al., 2006), have a better educated workforce that complements their R&D efforts (Goya et al., 2013) or are able to better protect their innovations or inventions through patents or trademarks, prompting them to spend more on R&D (Mairesse and Robin, 2009; Janz et al., 2003). A non-negligible role is also attributed to domestic or foreign cooperations with suppliers, customers or universities, suggesting that firms that engage in cooperative arrangements also have higher R&D intensities (Griffith et al., 2006; Mairesse and Robin, 2009; Mohnen et al., 2006). The effects, however, differ by type of cooperative arrangement and country (see, e.g., Lööf et al., 2001 for a more nuanced picture). Moreover, an establishment's institutional environment proves key to its R&D effort. For instance, access to finance and credit are critical for entrepreneurs that suffer from insufficient own resources but require extensive funds to finance their R&D projects. Evidence suggests that firms with better access to credits also spend more on R&D (Brown and Guzmán, 2014). Similarly, governments and their public R&D programmes may play a critical role in a firm's decision on how much to spend on R&D. In this respect, whether public funding boosts private R&D and therefore complements it or partly replaces it and therefore substitutes private R&D has been a hotly debated but unresolved issue in the literature. The majority of related empirical studies, however, suggests that public funding complements private R&D, rendering public R&D programmes an important determining factor of private R&D efforts (see, e.g., Klomp and van Leeuwen, 2001; Hall et al., 2009; Goya et al., 2013).

The second stage of the model portrays the *relationship between innovation input and innovation output*. In the empirical literature, numerous different indicators have been used to capture innovation output, such as the introduction of product and/or process innovations or radical innovations, the number or introduction of patents or the share of sales from innovations. With very few exceptions (e.g., Parisi et al., 2006), empirical evidence consistently demonstrates that R&D effort is conducive to innovation output and success, irrespective of the innovation output indicator applied (see, e.g., Griffith et al., 2006; Hall et al., 2009; Goya et al., 2013; Brown and Guzmán, 2014; Mairesse and Robin, 2009; Crépon et al., 1998; Janz et al., 2003; Benavente, 2002 or Klomp and van Leeuwen, 2001). However, precise effects tend to differ across countries (e.g., Lööf et al., 2001) and sectors (e.g., Goya et al., 2013). Likewise, evidence also suggests that the effect of R&D effort is stronger for product relative to process innovations (see, e.g., Griffith et al., 2006;Hall et al., 2009 or Parisi et al., 2006). Furthermore, innovation output is affected by several other factors as well. For instance, as a proxy for embodied technology, investment intensity is found to be conducive to innovation output, particularly process innovations (Griffith et al., 2006; Hall et al., 2009; Parisi et al., 2006). In a similar vein, innovation output is higher or more likely among firms with a better educated workforce, corroborating the notion that human capital strongly matters for innovation success (Lööf et al., 2001), firms that pursue cooperative arrangements

to share costs and risks of innovations and pool technical know-how to develop their innovations (Lööf et al., 2001) or firms that operate in foreign markets and therefore need to develop new products and/or processes to remain competitive internationally (Brown and Guzmán, 2014). Similarly, the importance of different sources of information for the development of new products or processes has been highlighted in the literature (see, e.g., Griffith et al., 2006). In contrast, evidence suggests that FDI may have a negative impact on innovation output, particularly in developing or emerging economies where, due to insufficient technological capabilities, high coordination costs or concerns of confidentiality or information leakage, innovations are typically still conducted by the headquarters of multinationals located in industrialised countries (Brown and Guzmán, 2014). The role of firm size for innovation output is, however, mixed and inconclusive while age seems to play no significant role at all (see, e.g., Klomp and van Leeuwen, 2001; Hall et al., 2009).

Finally, the third and last stage of the model sheds light on the *relationship between innovation output and firm performance*. With very few exceptions only (Parisi et al., 2006 or Benavente, 2003), empirical evidence consistently demonstrates that successful innovations are productivity enhancing, irrespective of the particular indicator used to capture innovation success or output. The size of the effect, however, is again country as well as industry-specific (Griffith et al., 2006 or Goya et al., 2013). In addition to productivity, other performance indicators have been used in this line of research with somewhat different results. For instance, Klomp and van Leeuwen (2001) look at the sales and employment effects of successful process innovations and emphasise that while new processes significantly enhance firm sales growth, they undermine employment growth. The latter finding is in line with the observed phenomenon that in contrast to product innovations, process innovations have the potential to displace jobs on a large scale (see, e.g., Ross and Zimmermann, 1993). In addition, related empirical results suggest that a firm's productivity increases with its investment intensity, lending support to the notion that embodied technology has a productivity-enhancing effect (Griffith et al., 2006) or with its endowment with skilled employees (Goya et al., 2013; Brown and Guzmán, 2014; Benavente, 2003). Likewise, both the exposure to international markets (Janz et al., 2003) and a high share of foreign direct investment in a firm's equity are associated with higher productivity. In contrast, the role of firm size is again mixed, though the majority of studies suggest that larger firms tend to be more productive than smaller ones (e.g., Griffith et al., 2006; Lööf et al., 2001 or Janz et al., 2003).

3. Data source and economic periods analysed

3.1. DATA

The ensuing analysis uses data for a large set of Central Eastern and South Eastern European countries (CESEEC) as well as Former Soviet Union (FSU) countries comprising Albania, Armenia, Bosnia and Herzegovina, Bulgaria, Belarus, Croatia, the Czech Republic, Estonia, FYR Macedonia, Georgia, Hungary, Kosovo, Latvia, Lithuania, Moldova, Montenegro, Poland, Romania, Serbia, Slovenia, the Slovak Republic and Ukraine. The data were collected as part of the Eastern European component of the Business Environment and Enterprise Performance Survey (BEEPS) which is a joint initiative of the World Bank Group (WB) and the European Bank for Reconstruction and Development (EBRD). It is an Enterprise Survey based on interviews with firms in the manufacturing and services sector which intends to provide an understanding of firms' perception of the environment in which they operate. In particular, it collects information on the quality of individual firms' business environment, how it is perceived by them, how it changes over time. It identifies various constraints or obstacles to firm performance and growth, and captures the effects a country's business environment has on firms' international competitiveness.

For the sake of better comparisons across countries, it follows a standard methodology. In particular, to obtain representative final samples, each country-sample is selected using random sampling, stratified by establishment size (the following size-classes were used: small with 5 to 19 employees, medium with 20 to 99 employees, and large with more than 99 employees), region and business sector (based on the ISIC revision 3.1 classification[1]). The primary sampling unit of each survey is the establishment with five or more full-time employees, located in major urban centres, which is engaged in non-agricultural activities. Country-samples are representative of the overall non-agricultural economy.

So far, the survey was conducted in five consecutive waves in 1999-2000, 2002, 2005, 2009 and in 2013. Our analysis uses the 2005, 2009 and 2013 waves (see Table A. 2 in the Annex for an overview of the set of countries covered in the analysis and the number of observations by country and economic period analysed). Furthermore, in the course of the 2013 wave, a special Innovation Module was also conducted which collects more detailed information on the nature and determinants of four different types of innovations: product innovations (referring to new or significantly improved products or services), process innovations (referring to new or significantly improved methods for production or supply of products or services), marketing innovations (referring to new or significantly improved marketing methods) and organisational innovations (referring to new or significantly improved organisational or management practices or structures). Some particularly relevant aspects are discussed in detail in section 4.3 below.

Generally, Table A.3 in the Annex shows that only very few establishments in the sample were part of a firm (around 6-10 per cent), were exporters only (between 10 and 16 per cent), importers only (between

[1] The non-agricultural economy comprises all manufacturing sectors (ISIC rev.3.1: group D), the construction sector (ISIC rev.3.1: group F), the service sector (ISIC rev.3.1: groups G and H) as well as the transport, storage and communications sector (ISIC rev.3.1: group I).

3 and 13 per cent) or were both exporters and importers (between 7 and 15 per cent). Similarly, the average foreign ownership share was only between 7 and 9 per cent, the average state ownership share was even lower, ranging between 1 and 8 per cent. This highlights that the average establishment was characterised by domestic majority ownership. Furthermore, only a small share of establishments in the sample received a subsidy (only between 9 and 11 per cent) while with around 25 per cent, the share of an establishment's workforce with a university degree was relatively high.

3.2. DIFFERENT PHASES OF ECONOMIC AND FINANCIAL DEVELOPMENT

The following analysis uses the three recent BEEPS-waves to study the nexus between innovation input, innovation output and establishment performance during three different phases of economic and financial development in the region (see Table 1 for an overview). In this respect, the 2005 wave – which refers to fiscal year 2004 – is used to study the phase of *'financial normalcy'* (between 2000 and 2004), characterised by a brief period of rapid economic growth, sizeable FDI inflows, growing money market and trade integration with the rest of the European Union, trade deepening as well as increasingly attractive housing markets in several economies which started to pull non-negligible investments in.

Table 1 / Three phases of economic and financial development

Phases	GDP growth	Money market	Trade	Innovation	Housing market
Financial normalcy (2000-04)	Rapid growth (GDP and GDP per capita) – relatively balanced investment and consumption expenditure	Sizeable FDI inflows Growing penetration of foreign banks Credit growth	Redirection of international trade flows – trade integration with EU Trade deepening	Reliance on FDI-based 'technology-transfer' model	Housing market attracted investments
Bubble (2004-08)	Rapid growth (GDP and GDP per capita) – predominantly driven by private domestic consumption & real estate investment	Sizeable FDI inflows Rapid development of financial sector Credit boom, Banks issue foreign currency-denominated loans	Strengthening of cross-border production networks (GVCs) Trade links among CESEECs strengthened	Reliance on FDI-based 'technology-transfer' model	Emergence of a housing bubble: *Superboom* (Baltics, Bulgaria), *Boom* (Poland, Slovakia, Slovenia, Czech Republic, Romania), *Strong increase* (Croatia, Hungary)
Crisis (2008 onwards)	Economic crisis: GDP growth negative or low, unemployment soared, investment and consumption slumped; Net capital flows collapsed (temporarily turned negative in some countries: e.g. Hungary, Estonia or Latvia)	Deceleration in credit and deposit growth Increase in non-performing loans Decline in profitability	Plunge in trade	Reliance on FDI-based 'technology-transfer' model Need to develop indigenous technological capabilities	Housing bubble burst, very slow recovery of real estate market

The 2009 wave – which refers to fiscal year 2007 – is used to study the phase of the *'housing bubble'* (between 2005 and 2008), which is characterised by a rapidly developing financial sector – dominated by foreign banks – which provided easy access to affordable loans, thereby helping fuel an unprecedented credit boom which brought a sharp rise in private sector debt about and culminated in an unprecedented housing bubble in several CESEECs. In particular, in the years leading up to the crisis, credit to the private sector increased rapidly in the CESEE region, particularly in Bulgaria, Estonia, Latvia, Lithuania and Romania (see Becker et al., 2010). As highlighted by e.g. Darvas and Szapáry (2008), both supply and demand side related factors fuelled the rapid pre-crisis credit growth process. On the supply side, the strong influx and dominance of foreign banks – particularly from the EU-15 – increased the banking sector's lending capacity but also increased competition among banks, which encouraged lending to the housing sector once the corporate sector was sufficiently saturated. On the demand side, the drastic decline in real interest rates together with rapid output growth and a rise in future income expectations increased private agents' willingness to get into debt. Consequently, housing sectors in the region started to boom. However, as highlighted by Mihaljek and Subelyte (2013), different types of housing booms emerged in the CESEE region. In particular, in the Baltic countries as well as Bulgaria, a so-called *superboom* developed, characterised by annual growth rates in housing prices of more than 20 per cent between 2000 and the ultimate peak. In contrast, with somewhat lower annual growth rates of between 10 and 20 per cent, Poland, the Slovak Republic, Slovenia, the Czech Republic and Romania experienced a *'normal' boom*. Finally, housing booms were relatively moderate in Croatia and Hungary which both experienced *strong increases* in annual growth rates in housing prices of between 5 and 10 per cent only.

Finally, the 2013 wave – which refers to fiscal year 2011 – is used to analyse the *'crisis phase'*. The crisis phase was initiated by the global financial crisis which hit the region at the end of 2008. In fact, the crisis hit the region particularly hard. It put an end to the pre-crisis credit frenzy, brought housing bubbles to burst and eventually sent the housing market into meltdown. Furthermore, as a result of the crisis, net capital inflows into the region collapsed temporarily as due to liquidity shortages in the home countries of subsidiaries of foreign banks in the CESEE region, capital flows into the region were disrupted and temporarily interrupted. This was further compounded by an exodus of other types of capital – particularly the most liquid type of capital flows such as portfolio investment and financial derivatives. Moreover, the region also suffered from a pronounced drop in export demand. Given the region's rapidly advancing economic integration prior to the crisis and its emergence as an important link in the globally increasing fragmentation of production value and supply chains, trade channels were strong so that the quickly spreading crisis and the plunge in global – but particularly EU-15 wide – demand reduced exports of goods and tradable services from the region. Together, the credit crunch and the drop in export demand resulted in a partly severe drop in real GDP growth in several economies in the region (the drop in real GDP growth was particularly strong in the Baltic countries, the former growth champions) and a dramatic increase in unemployment. Moreover, in the course of the crisis, banks experienced strong increases in non-performing loans and suffered sizeable losses in profitability as a large number of outstanding loans proved irrevocable. Hence, the global financial crisis has shaken the banking sector at its very core and fundamentally questioned its lax pre-crisis lending and credit allocation policies.

4. Descriptive analysis

In what follows, some major indicators of interest will be depicted for each economic phase separately and discussed in detail. In this respect, section 4.1 focuses on the prevalence of different types of financing constraints across countries while section 4.2 looks at the frequency of different innovation strategies, highlighting the dominance of the M&E-based strategy in the region. To draw a more comprehensive picture of the nature of innovations in the sample of countries considered, section 4.3 offers a detailed discussion of additional information collected in the special 2013 Innovation Module. It discusses the relative prevalence of technical and non-technical innovations, the average number of and the average percentage of sales accounted for by new products, different ways of introducing product and process innovations, the degree of novelty of new products and processes to other firms and, finally, the importance and prevalence of patenting activities.

4.1. FINANCING CONSTRAINTS

The prevalence of different types of financing constraints is depicted in Figure 1 for each country and period analysed separately. It differentiates between two types of funding constraints: credit constraints (labelled 'Applied but rejected') which result from the rejection of credit or loan applications by banks, on the one hand, and other financial constraints (labelled 'Need but not applied'), on the other. Credit constrained firms are identified from the following question covered in the BEEPS questionnaire: '*Referring to this most recent application for a line of credit or loan, what was the outcome of that application*?'. Several options are available to the interviewee: a) application was approved, b) application was rejected, c) application was withdrawn by the establishment, d) application still in process, and e) don't know. Establishments are considered to be credit constrained if the application was rejected, and unconstrained if the application was either withdrawn by the establishment or still in process at the time of the interview (Don't know is treated as missing). Firms facing other financial constraints are identified from the following question in the BEEPS questionnaire: '*What was the main reason why this establishment did not apply for any line of credit or loan?*'. A number of different options were available to the interviewee. Establishments are considered to face other financial constraints for either of the following reasons: (i) application procedures were complex, (ii) interest rates were not favourable, (iii) collateral requirements were too high, (iv) size of loan and maturity were insufficient, (v) it was necessary to make informal payments to get bank loans, (vi) did not think it was approved, and finally, (vii) other (not specified). In contrast, establishments face no other financial constraints if there was no need for a loan since the establishment had sufficient own capital.

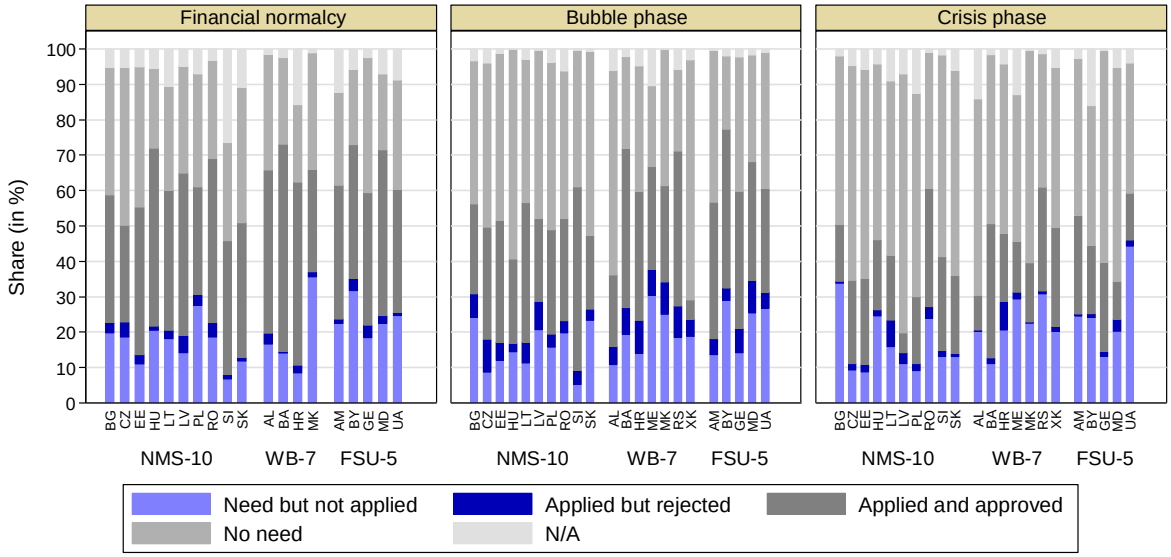
Figure 1 points to a number of interesting findings: First, irrespective of the country and the particular economic period considered, credit constraints (i.e. constraints generated by banks which reject credit or loan applications) were of little importance only. In contrast, constraints of establishments that would have needed external funds but refrained from applying for bank loans or credits dominated. Interestingly, however, during the bubble phase the frequency of credit constraints increased significantly in all countries considered but Romania and Belarus where slight reductions were

observable. The increase in credit constraints was most dramatic in Bosnia and Herzegovina, Macedonia, Moldova, Ukraine and Croatia but smallest in Poland and Latvia.

Second, the prevalence and extent of funding constraints varies widely across countries. For instance, during the financial normalcy phase, funding constraints were lowest in Slovenia and Croatia, where only 8 and 10 per cent, respectively, of all establishments experienced obstacles when attempting to access external funds. Hence, only around every 10th establishment encountered funding constraints. In contrast, it was highest in Macedonia (with 37 per cent), followed by Belarus (with 35 per cent) and Poland (with 30 per cent), where, on average, every third establishment encountered funding constraints. The extent and range of funding constraints were similar during the bubble phase, ranging between 9 per cent (in Slovenia) and 37 per cent (in Montenegro). During the crisis phase, the extent and range of funding constraints were considerably higher. Funding constraints were lowest in Estonia, Poland and the Czech Republic, where only every 10th establishment encountered difficulties accessing external funds. In contrast, funding constraints were highest in Ukraine, where almost every second establishment encountered funding constraints, followed by Bulgaria, Serbia and Montenegro, where every third establishment faced funding constraints.

Third, Figure 1 also highlights that the majority of establishments had their bank loan and credit applications approved, rendering a rejection a rare incident.

Figure 1 / Prevalence of different types of financing constraints



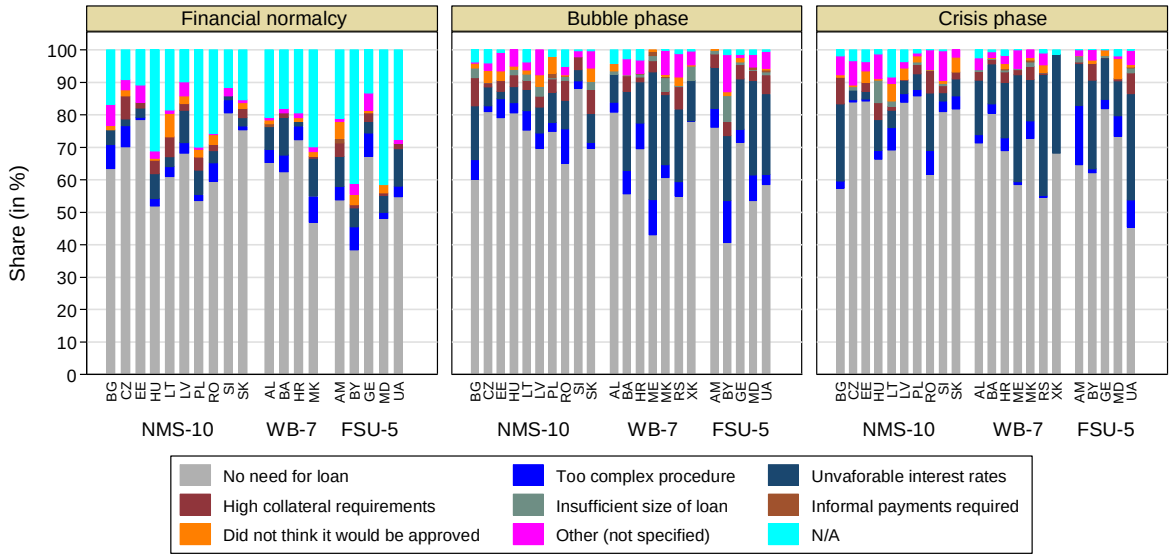
Source: BEEPS, own calculations.
Note: NMS-10 comprises all new Member States (but Cyprus and Malta), WB-7 comprises all Western Balkan countries (Albania, Bosnia and Herzegovina, Croatia, Montenegro, FYR Macedonia, Serbia and Kosovo) and FSU-5 comprises Armenia, Belarus, Georgia, Moldova and Ukraine.

Finally, it also points to important and interesting crisis effects. Firstly, during the crisis phase, the share of establishments that applied for a loan dropped considerably, pointing to a strong discouragement effect of the crisis. Secondly, during the crisis phase, a substantial drop in approval rates is observable in all countries analysed. Thirdly, the share of establishments which had no need for external funds increased considerably. This may be the result of a substantial shake-out of economically and financially

less viable establishments during the crisis, which left financially relatively healthier establishments with, however, lower or no need for external funds due to still stifling demand.

Furthermore, Figure 2 shows different reasons why establishments did not apply for bank loans, despite the need for funds. It highlights that irrespective of economic phase considered, entrepreneurs are predominantly discouraged by unfavourable interest rates, complex procedures and high collateral requirements.

Figure 2 / Different reasons for not applying for bank loans



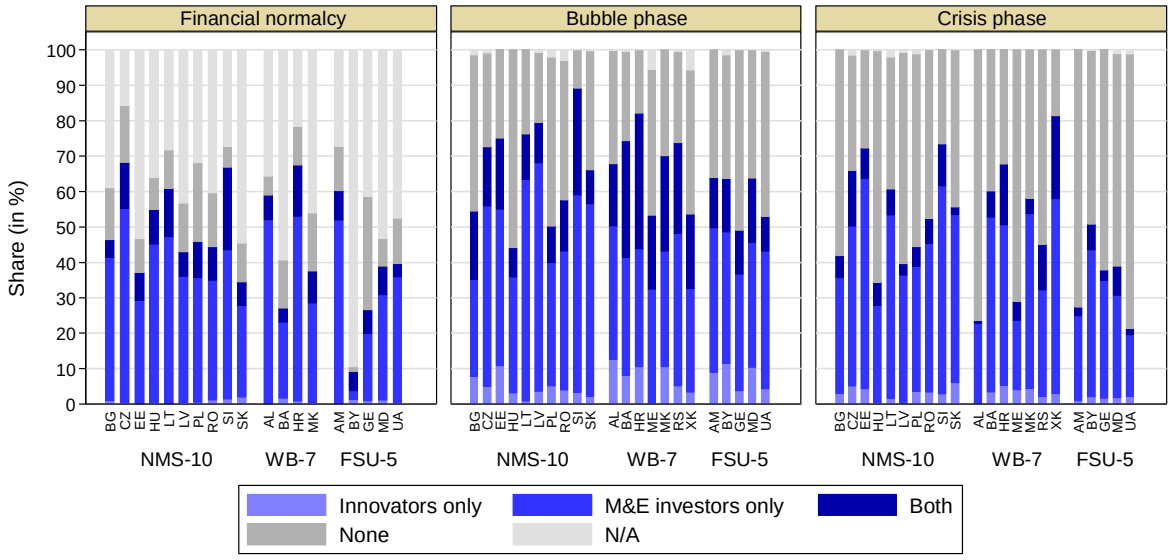
Source: BEEPS, own calculations.
Note: NMS-10 comprises all new Member States (but Cyprus and Malta), WB-7 comprises all Western Balkan countries (Albania, Bosnia and Herzegovina, Croatia, Montenegro, FYR Macedonia, Serbia and Kosovo) and FSU-5 comprises Armenia, Belarus, Georgia, Moldova and Ukraine.

4.2. INNOVATION STRATEGIES

The frequency of different innovation strategies is depicted in Figure 3. In particular, as highlighted by Veugelers and Cassiman (1999), establishments pursue different innovation strategies determined by their level of technological development and distance to the technological frontier. Hence, establishments may (i) either invest in R&D to 'make' innovations in-house or indigenously if they are close to or at the technological frontier or (ii) may source externally and invest in machinery and equipment (M&E) and 'buy' technology and know-how embodied in machinery and equipment from the original innovator if they lag further behind the technological frontier but possess the necessary technological capabilities to absorb new embodied technological knowledge which they can transform into new or modified products or services. Hence, three different innovation strategies can be differentiated: (i) the 'make only' strategy for establishments that invest in R&D only (referred to as *innovators only*), (ii) the 'buy only' strategy for establishments that invest in machinery and equipment only (referred to as *M&E investors only*) and (iii) 'both' for establishments that pursue a mix of both strategies and invest in both R&D and M&E acquisition (referred to as *both*).

Figure 3 highlights that the prevalence of innovators varies across economic periods. During the financial normalcy phase, the majority of establishments did not pursue any kind of innovation strategies. The exception is establishments located in the Czech Republic, Hungary, Lithuania, Slovenia, Albania, Croatia and Armenia. However, during the bubble phase, the opposite was observable: the majority of establishments pursued innovation strategies (except for those located in either Hungary or Georgia). During the crisis phase, the frequency of innovators sank again, falling below 50 per cent in half of all countries analysed. Furthermore, with respect to different types of innovation strategies, irrespective of economic phase considered, *M&E investors only* dominate, rendering the 'buy only' strategy the dominant innovation strategy in the region. In contrast, *innovators only* are a very rare breed. The frequency of *innovators only* was particularly low in the financial normalcy phase but stronger during the subsequent economic phases. The frequency of *innovators only* was particularly high in the run-up to the global financial crisis: with more than 10 per cent, the frequency of innovators only was highest in Albania, Belarus, Estonia, Macedonia, Croatia and Moldova and with less than 1 per cent is was lowest in Montenegro and Lithuania. In the aftermath of the crisis, however, the frequency of *innovators only* dropped again in all but three countries, namely Montenegro, Slovakia and Lithuania where the frequency of *innovators only* increased.

Figure 3 / Types of innovation strategies



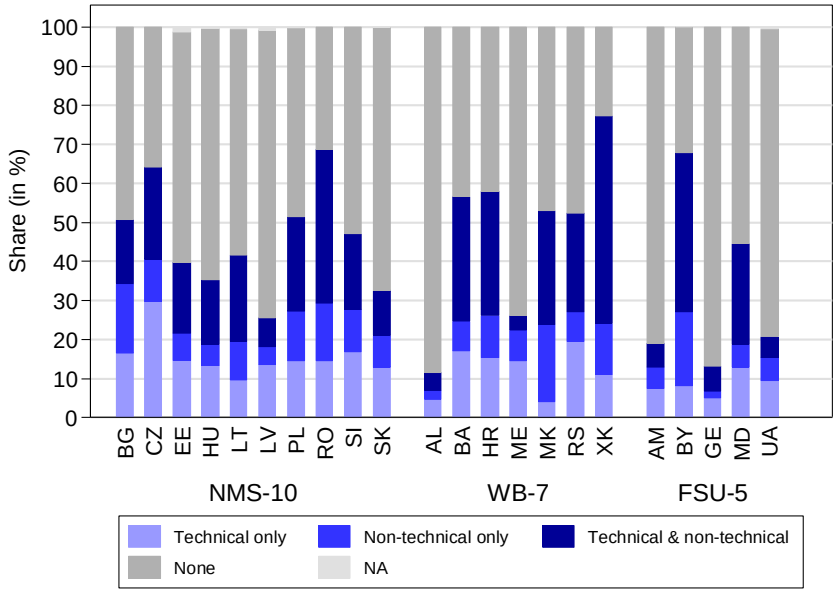
Source: BEEPS, own calculations.
Note: NMS-10 comprises all new Member States (but Cyprus and Malta), WB-7 comprises all Western Balkan countries (Albania, Bosnia and Herzegovina, Croatia, Montenegro, FYR Macedonia, Serbia and Kosovo) and FSU-5 comprises Armenia, Belarus, Georgia, Moldova and Ukraine.

Hence, given the strong prevalence of the buy-innovation strategy in the group of CESEE and FSU countries, the ensuing analysis focuses on the M&E-based innovation strategy and establishes its role for innovation success and performance improvements.

4.3. SPECIAL FEATURE: THE 2013 INNOVATION MODULE

As highlighted above (see section 3.1), in the course of the 2013-BEEPs wave, a special Innovation Module was also conducted which provides more detailed information on the nature and determinants of four different types of innovations, namely product, process, marketing and organisational innovations. Although this information will not be used in the econometric analysis, it is highly informative and insightful. Hence, in what follows, some particularly relevant aspects from the Innovation Module will be discussed in more detail to provide a more comprehensive picture of the nature and success of different innovation strategies in the group of CESEE and FSU countries.[2]

Figure 4 / Prevalence of technical and non-technical innovations



Source: BEEPS, own calculations.
Note: NMS-10 comprises all new Member States (but Cyprus and Malta), WB-7 comprises all Western Balkan countries (Albania, Bosnia and Herzegovina, Croatia, Montenegro, FYR Macedonia, Serbia and Kosovo) and FSU-5 comprises Armenia, Belarus, Georgia, Moldova and Ukraine. Technical innovations refer to product and process innovations while non-technical innovations refer to organisational and marketing innovations.

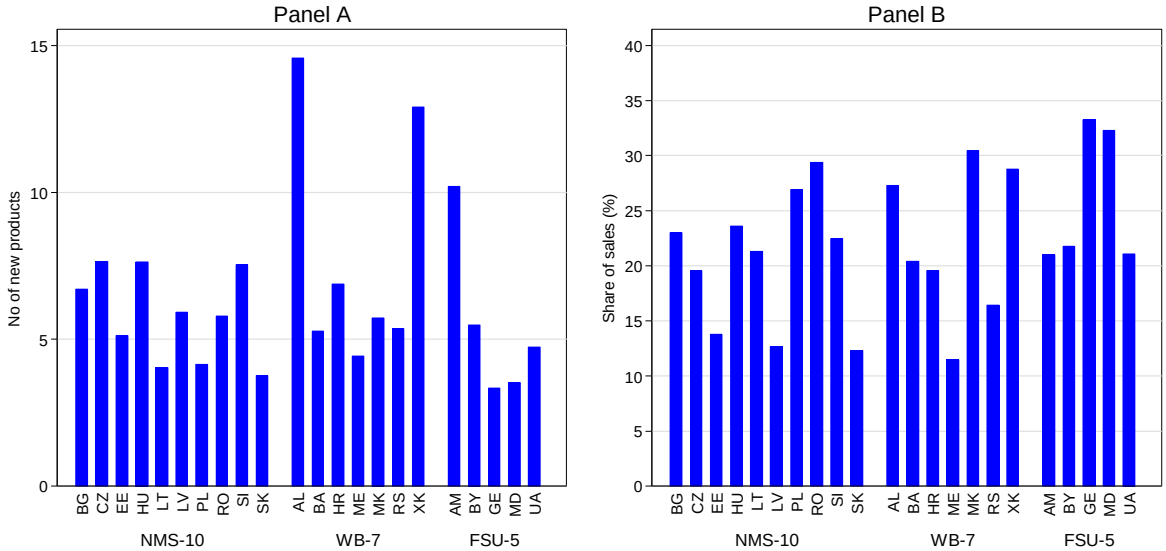
In this respect, Figure 4 sheds light on the prevalence of innovations. More specifically, it captures whether over the previous three years, an establishment introduced an innovation, differentiating between technical and non-technical innovations, where technical innovations refer to product and process innovations and non-technical innovations to organisational and marketing innovations. It differentiates between three types of innovation strategies: (i) 'technical only' for establishments that only introduced technical innovations over the previous three years (i.e. new or significantly improved products and/or processes), (ii) 'non-technical only' for establishments that only introduced non-technical innovations over the previous three years (i.e. new or significantly improved organisational practices and/or marketing methods) and (iii) 'technical and non-technical' for establishments that introduced both, technical and non-technical innovations to also show whether technical and non-technical innovations are introduced jointly. Figure 4 demonstrates that, as highlighted by the relatively low share of

[2] Annex Figures A.1 to A.5 provide similar graphs by individual industry and country group. To conserve space, these graphs are, however, not discussed in the text.

establishments that introduced non-technical innovations only, non-technical innovations only are of minor importance only. The only notable exception is Bulgaria, where establishments predominantly introduced non-technical innovations only. Instead, the majority of innovative establishments introduces technical and non-technical innovations jointly which suggests that the introduction of technical innovations also renders non-technical innovations necessary, as new products or processes also call for (or allow) new organisational practices or marketing methods.

The average number of new products per establishment as well as the average percentage of sales accounted for by a new or significantly improved product are depicted in Panels A and B, respectively, of Figure 5. Panel A demonstrates that the average number of new or significantly improved products per establishment exceeds 5 in the majority of countries analysed. In some countries, the average number of new or significantly improved products even exceeds 10, such as in Albania, Kosovo or Armenia. In contrast, the average number of new or significantly improved products is lowest in Georgia, followed by Moldova and Slovakia. Furthermore, Panel B highlights that the average percentage of sales accounted for by a new or significantly improved product exceeds 10 per cent in all countries, even exceeds 20 per cent in the majority of countries but exceeds 30 per cent in only a few countries, namely Georgia, Moldova and Macedonia. Hence, new or significantly improved products account for a non-negligible share of total sales, rendering them important sources of additional sales.

Figure 5 / Average number (Panel A) and average percentage (Panel B) of sales accounted for by new or significantly improved products per establishment



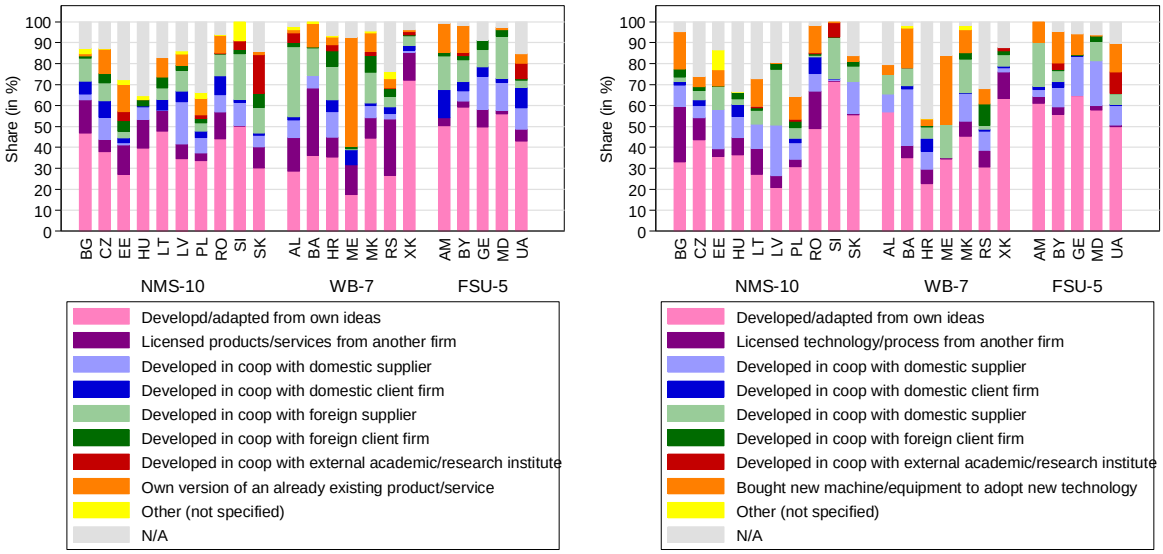
Source: BEEPS, own calculations.
Note: NMS-10 comprises all new Member States (but Cyprus and Malta), WB-7 comprises all Western Balkan countries (Albania, Bosnia and Herzegovina, Croatia, Montenegro, FYR Macedonia, Serbia and Kosovo) and FSU-5 comprises Armenia, Belarus, Georgia, Moldova and Ukraine.

Moreover, the BEEPS Innovation Module also covers information concerning the main new or significantly improved product or process. For instance, different ways of introduction of the main new or significantly improved product (Panel A) or process (Panel B) are shown in Figure 6 below. It differentiates between 9 ways that best describe the way in which the main new or significantly improved product (or process) was introduced by the establishment: either (i) developed or adapted by the

establishment from own ideas, (ii) licensed from another firm, developed in cooperation with (iii) domestic supplier, (iv) domestic client firms, (v) foreign suppliers, (vi) foreign client firms, (vii) external academic or research institute, or (viii) introduced as an establishment's own version of a product or service already supplied by another firm and (ix) other.

Panel A stresses that own ideas were of great importance in the majority of countries, particularly in Kosovo, where over 70 per cent of establishments stressed that the main new product was developed or adapted from own ideas, followed by Belarus, where almost 60 per cent of all product innovators highlight that their main new product was developed or adapted from own ideas. Interestingly, all product innovators located in the FSU-5 economies consider own ideas of utmost importance. In contrast, own ideas were least important in Montenegro or Serbia, where only between 20 and 30 per cent of all product innovators considered own ideas important. In contrast, other firms (in terms of licensers) were of lesser importance for product innovators, but most important in Belarus and Serbia and least important in Slovenia, Moldova and Belarus. Furthermore, a non-negligible share of product innovators pursued cooperative strategies to introduce their main new or significantly improved product. For instance, cooperations with domestic suppliers and client firms were important in Latvia or Ukraine, while cooperations with foreign suppliers and client firms were important in Albania, Slovenia or Macedonia while cooperations with external academic or research institutes were or particular importance in Slovakia, but also in Ukraine, Albania or Estonia. Finally, an own version of an already existing product was a relatively unimportant way to introduce the main new or significantly improved product, particularly in Bulgaria, Albania, Croatia, Moldova or Kosovo but was the main strategy among product innovators located in Montenegro.

Figure 6 / Main new or significantly improved product (Panel A) or process (Panel B): ways of introduction

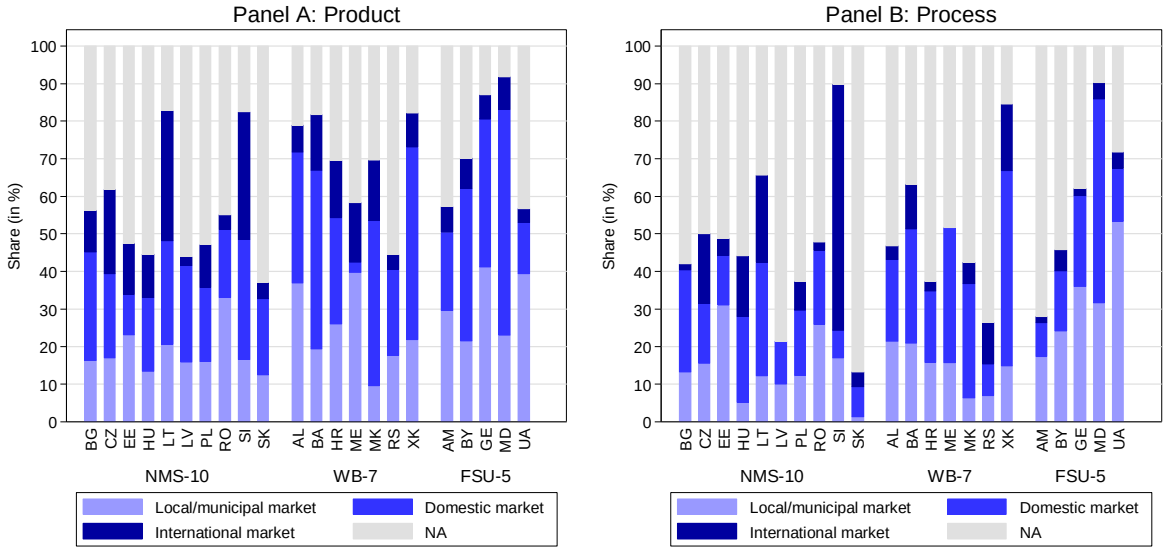


Source: BEEPS, own calculations.
Note: NMS-10 comprises all new Member States (but Cyprus and Malta), WB-7 comprises all Western Balkan countries (Albania, Bosnia and Herzegovina, Croatia, Montenegro, FYR Macedonia, Serbia and Kosovo) and FSU-5 comprises Armenia, Belarus, Georgia, Moldova and Ukraine.

Panel B draws a similar picture for the main process innovation. It again points to the rather dominant role of own ideas (particularly in the FSU-5 countries or Kosovo), the non-negligible importance of cooperations – particularly with domestic and foreign suppliers and client firms such as in Latvia or Bosnia and Herzegovina – and the minor role of machinery and equipment acquisitions to adopt the new technology (particularly in Latvia, Moldova, Slovakia or Croatia), with the exception of Montenegro. However, it also demonstrates that licensing arrangements were generally of lesser importance for the main new process compared to the main new product.

Figure 7 shows the degree of novelty of the *main* new or significantly improved product (Panel A) or process (Panel B). It captures whether at the time of introduction, the main new product or process was new to other firms operating either in the establishment's (i) local market (i.e. same municipality), (ii) domestic market or (iii) international market. Panel A of Figure 7 shows that the majority of product innovators considered their main new or significantly improved product new to either the local or the domestic market. Specifically, product innovators located in Armenia, Montenegro, Romania, Ukraine or Georgia considered their main new product predominantly new to the local market while those located in Bulgaria, Latvia, Slovakia, Bosnia and Herzegovina, Macedonia, Serbia, Kosovo, Belarus and Moldova considered their main new product predominantly new to the domestic market. In contrast, the degree of novelty of the main new product was particularly high in Lithuania and Slovenia, where around 35 per cent of all product innovators reported that their main new product was new to the international market.

Figure 7 / Main new or significantly improved product (Panel A) or process (Panel B): degree of novelty to other firms



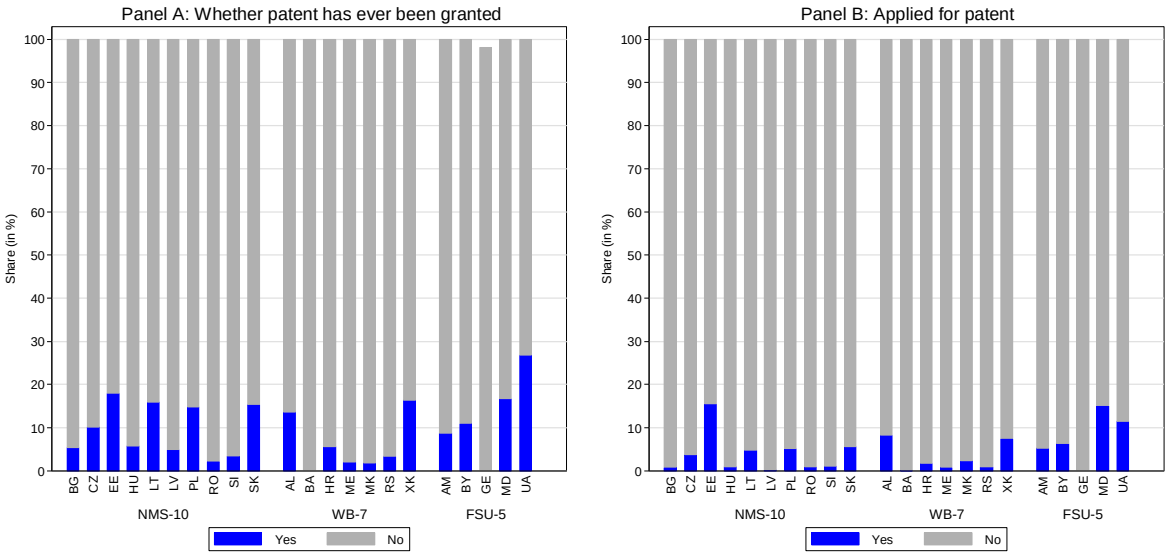
Source: BEEPS, own calculations.
Note: NMS-10 comprises all new Member States (but Cyprus and Malta), WB-7 comprises all Western Balkan countries (Albania, Bosnia and Herzegovina, Croatia, Montenegro, FYR Macedonia, Serbia and Kosovo) and FSU-5 comprises Armenia, Belarus, Georgia, Moldova and Ukraine.

Panel B of Figure 7 again points to the limited degree of novelty of the main new process. In particular, it highlights that process innovators in Estonia and Romania and in almost all FSU-5 countries (namely in Armenia, Belarus, Georgia or Ukraine) considered their main new process predominantly new to the

local market only. Process innovators in almost all WB-7 countries (except for Serbia) and the majority of NMS-10 countries considered their main new process predominantly new to the domestic market. In contrast, the degree of novelty of the main new process was highest in Slovenia, the Czech Republic and Serbia, where the majority of process innovators considered their main new process new to the international market.

Finally, Figure 8 shows the prevalence of patenting activities pursued in the region, in terms of either the share of establishments that have ever been granted a patent (Panel A) and the share of establishments that applied for a patent during the last three years (Panel B). It highlights that, in general, patenting of innovations is not a widely applied strategy among establishments to protect their intellectual property. In particular, as is visible in Panel A of Figure 8, the share of establishments that have ever been granted a patent is below 20 per cent for all countries considered except Ukraine, where almost 30 percent of establishments have ever received a patent in the past. And with less than 5 per cent, previous experience with patents is particularly low among establishments in Georgia, Macedonia, Montenegro, Romania, Serbia, Slovenia and Latvia.

Figure 8 / Protection of innovation: prevalence of establishments that have ever been granted a patent in the past (Panel A) and that have applied for a patent in the last three years (Panel B)



Source: BEEPS, own calculations.
Note: NMS-10 comprises all new Member States (but Cyprus and Malta), WB-7 comprises all Western Balkan countries (Albania, Bosnia and Herzegovina, Croatia, Montenegro, FYR Macedonia, Serbia and Kosovo) and FSU-5 comprises Armenia, Belarus, Georgia, Moldova and Ukraine.

Furthermore, Panel B of Figure 8 highlights that only very few firms applied for patents in the previous three years. More specifically, with few exceptions only (i.e. Estonia, Moldova and Ukraine), the share of establishments that recently applied for a patent is below 10 per cent. With less than 1 per cent, it is particularly low in Georgia, Bosnia and Herzegovina, Latvia, Bulgaria, Montenegro, Serbia, Romania and Hungary.

5. A modified CDM model

Generally, the CDM model is a structural econometric model which summarises '*the process that goes from the firm decision to engage in research activities to the use of innovations in its production activities*' (Crépon et al., 1998, p 2), explicitly accounting for econometric issues that arise from the nature of the data used in the analysis or the model itself, such as selection bias or endogeneity.

5.1. NEW ELEMENT: FINANCING CONSTRAINTS

In the face of insufficient own internal resources, entrepreneurs often resort to capital markets to raise the much-needed funds to finance their investment projects. Here, however, they often face non-negligible and insurmountable financing constraints, potentially forcing them to postpone, scale down or altogether abandon their investment projects. This, in turn, not only undermines their own future innovation potentials and growth prospects but also affects the economy as a whole in terms of underinvestment in R&D, and consequently, unexploited economic growth and development potentials and retarded catching-up processes of lagging economies.

Theoretically, the presence of financing constraints is typically ascribed to capital market imperfections such as information asymmetries between entrepreneurs and uninformed outside investors. For instance, in the model of credit rationing developed by Stiglitz and Weiss (1981), imperfect information induces banks to resort to rationing credits to maximise profits instead of increasing the interest rate. In particular, since the interest rate banks charge for credits also affects the riskiness of their pool of loans through adverse selection and a negative incentive effect, higher interest rates both attract riskier projects (resulting in a 'lemons problem' according to Akerlof, 1970) as well as induce debtors to realise projects with a generally lower probability of success but higher returns when successful (moral hazard). Therefore, the on average higher riskiness of potential borrowers lowers overall profits for the banks and induces profit-maximising banks to ration credits.

Empirically, evidence is quickly mounting that prevailing financing constraints strongly deter investment activities, either in terms of R&D projects or tangible investment projects. For instance, with respect to R&D investments, Álvarez and Crespi (2011) analyse a comprehensive sample of Chilean firms and emphasise that financially constrained firms are less likely to pursue innovative activities, while Mancusi and Vezzulli (2010) conclude that financially constrained entrepreneurs in Italy were around 23 per cent less likely to pursue R&D activities and had around 11 per cent lower R&D investment levels, on average. In a similar vein, Hajivassilou and Savignac (2008) demonstrate for a sample of French firms that binding financing constraints curtail innovation and that, simultaneously, innovative firms are also more likely to encounter binding financing constraints. Empirical evidence also suggests that effects of financing constraints differ by level of economic development, leaving innovative firms in economically lagging economies more exposed and affected by credit-constraints than those located in economically more advanced economies (see, e.g., Männasoo and Meriküll, 2011). Additionally, evidence is mounting that financial constraints are also critical in an entrepreneur's decision to abandon, prematurely stop, seriously slow down or not start an innovative project. For instance, Mohnen et al. (2008) highlight that

financing constraints significantly increased the probability of prematurely stopping, seriously slowing down or not starting any innovation project at all, while Segarra et al. (2013) emphasise that the probability of abandoning an innovation project differs by the particular stage of the innovation project and matters the most during the concept stage of a project.

Similarly consistent evidence of the detrimental effect of financing constraints is also observable for tangible investment projects. For instance, Hasan (2013) shows for a Latin American firm sample that investments in capital goods such as plant, machinery and equipment are less likely in the face of credit constraints while Hetland and Mjos (2012) stress that the negative effects of financing constraints differ by type of fixed asset considered, affecting investments in plant, machinery and equipment more than in buildings. Related to that, empirical evidence suggests that financing constraints also severely affect technology adoption of firms located in technologically lagging economies. In this respect, Fauceglia (2013) highlight that credit constrained firms see their probability of importing capital goods fall almost to zero, suggesting that in the face of credit constraints, technology-adoption almost comes to a standstill.

Hence, given the critical role played by financing constraints for both the decision to conduct innovative and investment activities as well as the decision on how much to spend on such activities, the baseline CDM model is extended to explicitly also account for financing constraints. In particular, the first stage of the model is extended to establish whether and how prevailing financing constraints affect entrepreneurs in their initial key decisions.

5.2. THE DECISION TO INVEST AND THE LEVEL OF INVESTMENT IN THE PRESENCE OF BINDING FINANCING CONSTRAINTS

Traditionally, the first stage of the CDM model deals with the establishment's decision to conduct innovative activities. In particular, at this initial stage, an establishment must decide whether to engage in innovative activities or not and if so, how much to spend on these activities. As highlighted above, at this stage firms often lack sufficient own resources to fund their innovative activities and often turn to capital markets to raise them. However, due to partly strong information asymmetries between debtors and outside investors, establishments often face insurmountable financing constraints which force them to downgrade, postpone or altogether abandon their innovative projects (Mohnen et al., 2008; Segarra et al., 2013).

Methodologically, the initial stage is traditionally modelled via a Heckman selection model to account for the non-random sampling of the data that results from the focus on M&E investors only. However, to also account for the role of binding funding constraints, a particular two-step approach is applied in the initial stage which addresses firstly, whether and how funding constraints affect an establishment's decision to pursue M&E investment activities and secondly, whether and how such funding constraints also affect an establishment's decision on how much to spend on M&E investment projects.

In particular, in order to shed light on the role of prevailing funding constraints for an establishment's decision to pursue M&E investment strategies in the first place, a recursive bivariate probit model with endogenous funding constraints is applied. This particular approach assumes that the probability of being credit constraint, on the one hand, and the decision to pursue M&E investment strategies, on the other, are related or correlated and should therefore be considered jointly. This assumption will be tested

empirically also. The potential endogeneity of the funding constraint indicator stems from two different sources: Firstly, latent heterogeneous factors (such as entrepreneurial behaviour) may affect both the probability of being financially constrained and the probability of being an M&E investor. Secondly, the decision to pursue M&E investment activities and how to finance them – i.e. by means of internal or external sources – may be simultaneous.

Hence, the following recursive bivariate system is specified:

$$MEI_{ijt} = \begin{cases} 1 \;\; if \;\; MEI^*_{ijt} = \alpha_1 fc_{ijt} + \beta_1 FC_{ijt} + \beta_2 ID_{jt} + \beta_3 C_t + \epsilon_{ijt} > \bar{a} \\ 0 \;\; if \;\; MEI^*_{ijt} = \alpha_1 fc_{ijt} + \beta_1 FC_{ijt} + \beta_2 ID_{jt} + \beta_3 C_t + \epsilon_{ijt} \leq \bar{a} \end{cases} \quad (1a)$$

$$fc_{ijt} = \begin{cases} fc^*_{ijt} = \gamma_1 FC'_{ijt} + \gamma_2 ID_{jt} + \gamma_3 C'_t + u_{ijt} & if \;\; fc^*_{ijt} > 0 \\ 0 & if \;\; fc^*_{ijt} = 0 \end{cases} \quad (1b)$$

where equation (1a) is the outcome equation that explains the probability that an establishment is an M&E investor while equation (1b) is the structural equation that defines the probability that an establishment is financially constrained.

Generally, MEI^*_{ijt} and fc^*_{ijt} are latent variables, while MEI_{ijt} and fc_{ijt} are dichotomous variables. MEI_{ijt} is a binary variable that takes the value 1 if establishment i in country j at time t decides to invest in M&E (i.e. reports positive M&E expenditures), provided its expenditure exceeds a particular threshold $\bar{a}$ and 0 otherwise. Moreover, $fc_{ijt} = 1$ if $fc^*_{ijt} > 0$ and $fc^*_{ijt} = 0$, otherwise. As highlighted above (section 4.1), the analysis uses a self-reported funding constraint indicator which considers establishments to be financially constrained if (i) due to generally unfavourable terms and conditions, entrepreneurs in need of loans constrain themselves from applying for bank loans or if (ii) entrepreneurs apply for loans but receive a rejection from the bank. In particular, fc_{ijt} is equal to 1 if at time t establishment i in country j did not apply for loans or lines of credit since either (i) application procedures were considered too complex, (ii) interest rates were considered too unfavourable, (iii) collateral requirements were unattainable, (iv) the size of the loan and maturity were insufficient, (v) they did not think the credit line would have been approved, or (vi) due to other reasons not specified in the survey. Furthermore, fc_{ijt} is equal to 1 if the establishment applied for a bank loan but received a rejection. fc_{ijt} is equal to 0 if none of the above applies. As highlighted above, the analysis looks at three different economic phases ($t = 1, 2, 3$), where $t = 1$ refers to the '*financial normalcy'* phase (for the period between 2000 and 2004), $t = 2$ refers to the phase of the *'housing bubble'* (for the period between 2005 and 2008), and $t = 3$ refers to the *'crisis phase'* (for the period immediately after the onset of the global financial crisis of 2008/09).

For the purpose of identification, the error terms are assumed to be independently and identically distributed as bivariate normal as follows:

$$\begin{pmatrix} \epsilon_{ijt} \\ u_{ijt} \end{pmatrix} \sim IID \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix},$$

where $\rho = Cov(\epsilon_{ijt}, u_{ijt})$.

FC_{ijt} in equation (1a) is a vector of relevant firm characteristics, comprising:

› ***Establishment size*** is defined by the log of the number of employees. To also account for the non-linear effect of firm size, its square is also included.

› ***Establishment age*** is defined as the log of firm age, calculated as the difference between the year of establishment of the firm and the current fiscal year. Similarly, to account for the non-linear effect of firm age, its square is also included.

› ***Part of a group*** is a dummy variable that is equal to 1 if a firm is part of a larger firm, and 0 otherwise.

› ***Foreign share*** refers the percentage of an establishment that is owned by private foreign individuals, companies or organisations. The percentage of an establishment owned by private domestic individuals, companies or organisations serves as reference group.

› ***State share*** refers to the percentage of an establishment that is owned by the government or state. The percentage of an establishment owned by private domestic individuals, companies or organisations serves as reference group.

› Three different dummies are included that capture an establishment's trading status: ***exporter only*** refers to establishments that report positive sales from direct exports only, ***importer only*** refers to establishments that report positive expenditures from direct imports of material inputs and supplies only while ***exporter and importer*** refers to establishments that engage in both direct exports and imports. Establishments that cater to and source from domestic markets only serve as reference group.

› ***Female*** is a dummy variable that is equal to 1 if the principal owner of the establishment is female, and 0 otherwise.

› ***Subsidy*** is a dummy variable that is equal to 1 if over the previous three years the establishment received any subsidies from national, regional or local governments or from any EU sources, and 0 otherwise.

› ***University degree*** refers to the percentage of an establishment's labour force with a university degree.

Moreover, C_t is a vector of country characteristics including:

› Log of real GDP per capita
› Real GDP growth rate

Furthermore, ID_{jt} is a vector of different industry dummies included to account for cross-industry differences. The analysis differentiates between 8 different industries, namely manufacturing (as reference group), construction, transport, wholesale and retail trade, real estate, hotels and restaurants and, other services.

A similar set of control variables in included in structural equation (1b) which determines an establishment's probability of being financially constrained. In particular, FC'_{ijt} is a vector of the following firm characteristics:

› ***Establishment size and its square*** (as defined above) are included to test whether larger firms are less credit constrained (as suggested by e.g. Álvarez and Crespi, 2011 or Beck et al., 2006) but also whether this negative size effect decreases and eventually even reverses as establishments become larger.

› ***Establishment age and its square*** (as defined above) is included to test whether younger establishments that lack reputation and experience with banks, suppliers, customers and competitors and are therefore more prone to failure, face higher funding constraints (as suggested by , e.g., Beck et al., 2006; Winker, 1999 or Ferrando and Mulier, 2013).

› ***Part of a group***, ***foreign share*** and ***state share*** (all as defined above) to test the hypotheses that the existence of internal funds or capital markets renders access to financing easier for firms that are either part of a group or foreign-owned (as e.g. suggested by Álvarez and Crespi, 2011; Shin and Park, 1999 or Beck et al., 2006) or that state-owned establishment are less financially constrained due to the potential for preferential treatment from state-owned financial institutions or because they are potential recipients of budgetary support from the government (see, e.g., Héricourt and Poncet, 2007).

› ***Exporter only***, ***importer only*** and ***exporter and importer*** (as defined above) are included to test whether exporters face lower funding constraints (as suggested by Greenaway et al., 2007 or Silva, 2012) since once the initial sunk cost of foreign market entry is covered, exporters experience significant improvements in their financial health, rendering them more credit-worthy.

› ***Female*** (as defined above) is included to test whether, as a result of discrimination, female owners are more likely to face funding constraints than their male counterparts.

› ***Subsidy*** (as defined above) is included to test whether in the face of binding funding constraints, subsidies are preferred as upfront project funding (Busom et al., 2012)

› ***University degree*** (as defined above) is a proxy for an establishment's skill composition and productivity which may prove helpful in credit application processes.

› ***Sales per employee*** refers to the log of sales per employee three years before and serves as exclusion restriction. It is a proxy for the availability of internal resources (and collateral) which facilitate access to external funds such as bank loans and credits.

Furthermore, the set of (above-mentioned and defined) country characteristics (C_t) are included plus a number of variables that capture the state of the banking sector and are considered pivotal for an establishment's access to bank loans:

› ***NPLs*** refers to the ratio of bank non-performing loans to total gross loans. It is included to capture that unhealthy banking sectors that are strongly burdened by non-performing loans are more reluctant to grant loans, therefore imposing funding constraints on credit applicants. This indicator is lagged once

to capture that the extent of previous year's non-performing loans affects current lending activities of banks.

› ***Domestic credit*** is the share of domestic credit approved by the banking sector. It is also lagged by a year to test whether access to finance is easier if the banking sector was less restrictive and provided a high share of domestic credit a year ahead of the firm's credit application.

› ***Bank outreach*** is defined as number of branches of commercial banks per 100,000 adults and reflects the average number of people served by each branch and is used to capture the ease with which banking services can be physically accessed. It tests whether a higher bank outreach is conducive to establishments seeking bank loans.

› ***Foreign banks*** refers to the share of foreign-owned banks in total banks and accounts for the growing importance and impact of foreign-owned banks on domestic financial sector development and lending stability, proving beneficial to establishments seeking access to bank loans (as, e.g., suggested by Clarke et al., 2001).

Also, the vector of industry dummies (ID_{jt}) (as defined above) is included.

However, financing constraints not only affect an establishment's decision to pursue M&E investment activities in the first place, but subsequently also its decision on how much to spend on these activities. In this respect, financially constrained establishments may still be able to proceed with their investment projects but probably at a smaller scale.

Hence, for those establishments that pursue M&E investment activities, the observed level of investment is identified as follows:

$$lnM\&Einv_{ijt} = \begin{cases} M\&Einv^{*}_{ijt} = \alpha_1 fc_{ijt} + \delta_1 FC_{ijt} + \delta_2 ID_{jt} + \delta_3 C_t + e_{ijt} & if \quad MEI_{ijt} = 1 \\ 0 & if \quad MEI_{ijt} = 0 \end{cases} \tag{1c}$$

where $M\&Einv^{*}_{ijt}$ is a latent variable corresponding to the M&E investment level of establishment i in country j at time t. It is equal to $M\&Einv_{ijt}$ if $ME_{ijt} = 1$ (i.e. the establishment is an M&E investor) and equal to 0 if $MEI_{ijt} = 0$ (i.e. the establishment is not an M&E investor). The level of investment (intensity) is measured by the logarithm of M&E spending (in Euro) per employee.

As above, FC_{ijt} in equation (1c) is a vector of diverse establishment characteristics, comprising: ***establishment age and its square*** as well as ***establishment age and its square*** to test whether larger and older establishment spend more on M&E acquisitions and how M&E spending changes as establishments become larger or older, ***part of a group***, ***foreign share*** and ***state share*** to shed light on the role of business-group affiliation and ownership structure for the level of M&E investments, ***exporter only***, ***importer only*** and ***exporter and importer*** to identify how M&E investments vary by particular trading status of establishments, ***female*** to test whether M&E investments are different in establishments where the principal owner is female, ***subsidy*** to identify whether recipients of subsidies (from national, regional or local governments or from any EU sources) are induced to spend more on M&E and, ***university degree*** to test how an establishment's higher human capital endowment affects its M&E investment levels. In addition, a dummy for ***innovators*** is included to identify potential

complementarities between M&E and R&D activities, highlighting that both activities are pursued jointly. It is equal to 1 if an establishment is also an R&D innovator (as determined by positive expenditures on R&D activities), and 0 otherwise.

C_t is again a vector of country characteristics comprising the log of real GDP per capita and the real GDP growth rate while ID_{jt} is a vector of industry dummies (all as defined above).

Methodologically, in order to account for the endogeneity of fc_{ijt} (as specified above) and the inherent selection bias, the two-step Newey approach is applied.

5.3. THE INNOVATION OUTCOME

The second stage of the model focuses on the innovation production function, i.e. an establishment's innovation output and its determinants.

In particular, the innovation production function is specified as follows:

$$INNOV_{ijt} = \theta_1 ln\widehat{M\&Einv}_{\imath jt} + \theta_2 FC_{ijt} + \theta_3 ID_{jt} + \theta_4 C_{jt} + \upsilon_{ijt} \quad (2)$$

where $INNOV_{ijt}$ refers to the innovation output of establishment i in country j at time t ($t = 1, 2, 3$). It is a dummy variable that is equal to 1 if during the previous three years, the establishment introduced new or significantly improved products or service, and 0 otherwise. $ln\widehat{M\&Einv}_{\imath jt}$ refers to the latent M&E effort, proxied by the predicted value of M&E investment intensities derived from equation (1c) above.

Again, FC_{ijt} in equation (2) is a vector of different establishment characteristics, comprising: ***establishment age and its square*** as well as ***establishment age and its square*** to test whether larger and older establishment are more likely to be product innovators and how that changes with size and age, ***part of a group***, ***foreign share*** and ***state share*** to shed light on the role of business-group affiliation and ownership structure for an establishment's probability to be a product innovator, ***exporter only***, ***importer only*** and ***exporter and importer*** to test how a particular trading status affects an establishment's ability to introduce new or significantly improved products or services, ***university degree*** to identify whether an establishment's higher human capital endowment affects its probability to be a product innovator.

C_t is again a vector of country characteristics comprising the log of real GDP per capita and the real GDP growth rate while ID_{jt} is a vector of industry dummies (all as defined above). υ_{ijt} refers to the error term.

5.4. PRODUCTIVITY EFFECTS

The third and final stage of the model determines the effects of innovation success on establishment productivity. Based on an extended simple Cobb-Douglas production function, labour productivity is determined as follows:

$$LP_{ijt} = \phi_1 \widehat{INNOV}_{\imath jt} + \phi_2 FC_{ijt} + \phi_3 ID_{jt} + \phi_4 C_{jt} + \vartheta_{ijt} \quad (3)$$

where LP_{ijt} refers to logarithm of labour productivity, defined as the logarithm of total annual sales per employee and $\widehat{INNOV}_{ijt}$ is the predicted probability of product and services innovations as derived from equation (2) above.

FC_{ijt} in equation (3) is a vector of different establishment characteristics, such as: ***establishment size,*** defined as the log of the number of employees, ***university degree*** as the percentage of an establishment's labour force with a university degree to also account for the role of skill composition for labour productivity, ***physical assets per employee***, defined as the logarithm of the net book value of machinery, vehicles, equipment, land and buildings per employee and ***capacity utilisation*** defined as output produced as percentage of maximum output possible.

C_t captures country characteristics refers to the real GDP growth rate while ID_{jt} is a vector of industry dummies (all as defined above). ϑ_{ijt} refers to the error term.

6. Findings

6.1. THE DECISION TO INVEST IN M&E AND THE LEVEL OF M&E INVESTMENT IN THE FACE OF BINDING FINANCING CONSTRAINTS

Results of the first stage are presented in Table 2 and Table 3 below, for each economic phase separately. More specifically, Table 2 sheds light on the particular set of determinants that render an establishment more likely to invest in machinery and equipment (M&E), explicitly accounting for the endogenous nature of financing constraints. More specifically, columns (1), (3) and (5) identify firm and country characteristics that render an establishment more likely to be an M&E investor while columns (2), (4) and (6) identify determining factors of prevailing financing constraints. Generally, test statistics (rho and p-values) reported in Table 2 support the hypothesis that financing constraints are endogenous, rendering the recursive bivariate probit approach the appropriate approach to study the effects of financing constraints on the decision to engage in M&E investment activities.

Columns (1), (3) and (5) in Table 2 consistently demonstrate that financial constraints were detrimental to an entrepreneur's decision to invest in M&E, irrespective of economic phase considered. The effect, however, slightly differs across phases: during the financial normalcy phase, financially constrained establishments were around 31 percentage points less likely to invest in M&E, during the bubble phase, they were only around 28 percentage points while during the crisis phase, they were even 34 percentage points less likely to invest in M&E. Pairwise t-tests, however, reveal that these differences are not statistically significant.

Furthermore, Table 2 shows that, in line with related empirical evidence, the probability of investing in M&E increased with establishment size: an increase in size by another employee rendered an establishment between 8 and 9 percentage points more likely to invest in M&E. However, during the financial normalcy phase, there is evidence of a non-linear relationship between size and the probability to invest in M&E: while larger establishments were more likely to invest in M&E, the effect tended to decrease and even reverse as establishments grew larger. Similarly, as suggested by Griffith et al. (2006), Janz et al. (2003) or Lööf et al. (2001), the probability of investing in M&E is affected by an establishment's particular trading status, particularly during the bubble and crisis phases. Specifically, during the bubble phase, relative to establishments that source from or cater to domestic markets only, exporters only were around 9 percentage points more likely to invest in M&E while importers only as well as importers and exporters were even 16 percentage points more likely to invest in M&E. During the crisis phase, exporters only were around 10 percentage points more likely to invest in M&E while importers only were even around 12 percentage points more likely to invest in M&E. In contrast, exporters and importers were only around 9 percentage points more likely to invest in M&E. Moreover, similar to Griffith et al. (2006) or Hall et al. (2009), subsidies are found to matter during the bubble and crisis phases, rendering establishments that received any subsidies from either the national, regional or local government or the EU around 10 to 11 percentage points more likely to invest in M&E.

Table 2 / Probability of facing financing constraints and the probability of being an M&E investor

	Financial normalcy		*Bubble phase*		*Crisis phase*	
	M&E investor	Financial constraints	M&E investor	Financial constraints	M&E investor	Financial constraints
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Financial constraints	-0.306***		-0.275***		-0.341***	
	(-10.690)		(-3.618)		(-6.654)	
Log size	0.094***	-0.057***	0.075***	-0.097***	0.080***	-0.055**
	(5.765)	(-3.592)	(2.953)	(-5.566)	(3.109)	(-2.521)
Log size²	-0.005**	-0.002	-0.002	0.008***	-0.002	0.001
	(-2.463)	(-0.633)	(-0.521)	(3.363)	(-0.729)	(0.426)
Log age	0.000	-0.014	0.051	-0.024	-0.070*	0.002
	(0.001)	(-0.351)	(1.363)	(-0.678)	(-1.674)	(0.062)
Log age²	-0.006	0.003	-0.010	0.007	0.009	-0.001
	(-0.919)	(0.453)	(-1.426)	(1.079)	(1.037)	(-0.117)
Part of a group	0.057**	-0.114***	-0.042*	-0.010	-0.018	-0.022
	(2.011)	(-3.565)	(-1.849)	(-0.447)	(-0.676)	(-0.800)
Foreign share	-0.001***	-0.000	0.000	-0.000	0.000	-0.000
	(-2.644)	(-0.014)	(1.473)	(-0.377)	(0.512)	(-0.382)
State share	-0.001***	0.001***	-0.001	0.001	-0.002**	0.001
	(-3.780)	(4.325)	(-1.228)	(1.144)	(-2.339)	(0.876)
Exporter only	0.030	-0.000	0.087***	-0.029	0.095***	-0.017
	(1.477)	(-0.010)	(4.443)	(-1.588)	(4.856)	(-0.900)
Importer only	0.022	-0.054***	0.156***	-0.037	0.116***	-0.019
	(1.219)	(-2.609)	(3.789)	(-1.021)	(3.424)	(-0.624)
Exporter & importer	0.014	-0.063***	0.162***	-0.058**	0.087***	-0.044
	(0.691)	(-2.824)	(5.126)	(-2.216)	(3.039)	(-1.627)
Female	-0.034**	0.013	-0.026	0.016	-0.039**	-0.018
	(-2.495)	(0.849)	(-1.620)	(1.084)	(-2.454)	(-1.220)
Subsidy	0.036	-0.019	0.096***	0.015	0.106***	-0.071***
	(1.538)	(-0.755)	(4.193)	(0.712)	(4.853)	(-3.329)
Share university degree	0.000	-0.000	0.000	-0.000	-0.000	-0.000
	(0.564)	(-1.112)	(1.612)	(-0.486)	(-1.357)	(-1.345)
Log sales/employee (t-3)		-0.050***		-0.024***		-0.023***
		(-7.232)		(-5.250)		(-6.049)
Log real GDP/capita	0.039***	0.036***	0.043***	-0.071***	0.054***	-0.066***
	(4.190)	(2.835)	(3.674)	(-6.243)	(4.189)	(-4.809)
Real GDP growth	0.005	-0.006	0.007***	0.007**	-0.003	-0.011***
	(1.616)	(-1.498)	(3.221)	(2.444)	(-1.514)	(-5.665)
Bank outreach		-0.001**		0.001***		-0.001
		(-2.389)		(3.222)		(-1.372)
NPLs (t-1)		0.003***		0.012***		0.007***
		(4.327)		(3.605)		(4.455)
Domestic credit (t-1)		-0.003***		0.002***		0.002***
		(-4.078)		(3.147)		(3.613)
Foreign bank share		-0.000		-0.000		-0.001***
		(-0.501)		(-0.090)		(-4.086)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
No of observations	4,463	4,463	4,540	4,540	4,529	4,529
Rho	0.625	0.625	0.411	0.411	0.464	0.464
p-value	0.000	0.000	0.022	0.022	0.000	0.000
Log likelihood	-4498	-4498	-4929	-4929	-5095	-5095

Note: Average marginal effects are reported; z-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1.

In contrast, the probability of investing in M&E decreases with age. In particular, during the crisis phase, another year of age rendered an establishment around 7 percentage points less likely to invest in M&E. Furthermore, the probability of investing in M&E decreases with foreign ownership share – but only during the financial normalcy phase – and state ownership share – during both the financial normalcy phase and the crisis phase. Moreover, it is also significantly lower among female owners by around 3 to 4 percentage points, during both the financial normalcy phase and the crisis phase. Interestingly, the effect of business-group affiliation differs across economic phases considered: during the financial normalcy phase, establishments that were part of a group were more likely to invest in M&E (by around 6 percentage points) while during the bubble phase, they were less likely to invest in M&E (by around 4 percentage points).

Interestingly, no significant effect emerges for an establishment's skill composition: while the coefficient on the share of university degree is positive, suggesting that establishments with a higher share of employees with a university degree are more likely to invest in M&E, the effect is, however, statistically not significant.

As regards determinants of financial constraints, columns (2), (4) and (6) highlight that, in line with related empirical evidence (e.g. Álvarez and Crespi, 2011 or Beck et al., 2006), the probability of an establishment of facing financing constraints decreases with establishment size, irrespective of economic phase considered. In particular, an increase in size (by another employee) renders an establishment between 6 and 10 percentage points less likely to face financing constraints. Furthermore, for the bubble phase, there is evidence of a non-linear size effect, suggesting that the negative size-constraint effect decreases with size and eventually even reverses if a particular size threshold is exceeded. Additionally, in line with related empirical evidence, results also suggest that establishments that are part of a group (during the financial normalcy phase only), importers only or importers and exporters (during the financial normalcy phase only) or establishments that received subsidies were less likely to face financing constraints. As expected, average sales three years ahead of the application process also renders establishments less likely to face funding constraints.

In contrast, results in Table 2 show that a higher state ownership share renders establishments more likely to face financing constraints, contradicting the hypothesis that due to preferential treatment from state-owned financial institutions or because they are recipients of budgetary support from the government (see, e.g., Héricourt and Poncet, 2007), state-owned establishment are less financially constrained. However, this effect is restricted to the financial normalcy phase only.

However, no evidence is found in support of a negative age-constraint effect, or that due to the existence of internal funds or capital markets access to financing was easier for establishments that were foreign-owned. Similarly, we also fail to find that female-owned establishments faced discrimination when attempting to access external funds or that a better endowment with human capital proved conducive to establishments seeking external resources.

Additionally, results point to the importance of the state of the economy in general and the state and structure of the banking sector in particular for the prevalence of funding constraints. In this respect, during the financial normalcy phase, funding constraints were significantly higher in wealthier economies. However, during the bubble and crisis phases, they were significantly lower in wealthier economies. A similarly mixed picture emerges for the role of real GDP growth: during the bubble phase,

funding constraints were significantly higher in faster growing economies, however, during the crisis phase, the opposite was observable, with faster growing economies showing significantly lower funding constraints. In the same way, the state and structure of the banking sector is pivotal for the prevalence of funding constraints. Concerning the state of the banking sector, results consistently demonstrate that funding constraints were significantly higher in countries with banking sectors that were more strongly burdened by non-performing loans, rendering banks more reluctant to approve loan applications. In contrast, domestic credit approved by the banking sector a year ahead played a mixed role: during the financial normalcy phase, funding constraints were significantly lower if banking sectors approved a high share of domestic credit, pointing to persistent loan approval policies pursued by banks since easy access to bank loans in the past carried over to the present. However, during the bubble and crisis phases, funding constraints turned out to be significantly higher if banking sectors approved a high share of domestic credit in the past. With respect to the structure of the banking sector, bank outreach, which reflects the physical accessibility of banks and banking services, was associated with higher funding constraints during the pre-crisis bubble phase but with lower funding constraints during the crisis phase. Hence, during the crisis phase, stronger bank outreach proved beneficial to entrepreneurs seeking access to external resources. A similarly positive role is attributable to the presence of foreign banks: during the crisis phase only, funding constraints were less likely in economies characterised by a higher foreign bank share. Hence, during the crisis period, foreign banks helped stabilise the banking sector in CESEE.

Furthermore, Table 3 identifies determinants of M&E investment intensities, again separately for each individual economic phase analysed. It consistently demonstrates that financial constraints were detrimental to the size of M&E investments also, the exact effects, however, differed by phase. In particular, financial constraints were most detrimental during the crisis phase, where financially constrained entrepreneurs spent, on average, around 9 per cent less on the acquisition of M&E. With only around 4 per cent lower M&E investments, the effect was more muted during the financial normalcy and bubble phases though.

Table 3 also demonstrates that M&E investments were significantly higher among innovators, particularly during the pre-crisis bubble phase and the crisis phase, suggesting that M&E and R&D investment activities were complementary and conducted jointly. Similarly, as suggested by Griffith et al. (2006) or Mairesse and Robin (2009), the particular trading status matters for an establishment's size of M&E investments: during the bubble phase, internationally trading establishments generally also had higher M&E investments, the exact amount of M&E investments, however, differed by particular trading status. In this respect, M&E investments were highest among establishments that imported only, followed by those that both exported and imported. Establishments that exported only were characterised by comparatively low M&E investments only.

In contrast, results emphasise that M&E investment intensities are smaller in larger establishments, irrespective of economic phase analysed or that M&E investment intensities are lower in older establishments. The latter, however, only holds for the bubble phase. However, the negative size and age effects were characterised by non-linearities, suggesting that the negative effects of size and age decrease and eventually even reverse as establishments grow larger.

However, the analysis fails to find evidence that foreign ownership share, business-group affiliation, receipt of subsidies or the skill composition of an establishment's labour force significantly mattered for the level of M&E investments.

Table 3 / Extent of M&E investments

DepVar.: lnM&Einv per employee	***Financial normalcy***	***Bubble phase***	***Crisis phase***
Variables	(1)	(2)	(3)
Financial constraints	-4.274***	-4.155***	-8.666***
	(-5.255)	(-3.883)	(-4.991)
Product innovator	0.145	0.441***	0.553**
	(1.201)	(4.538)	(2.492)
Log size	-0.868***	-0.772***	-1.110***
	(-6.622)	(-4.785)	(-3.378)
Log size²	0.033**	0.049***	0.053
	(2.041)	(2.746)	(1.347)
Log age	-0.186	-0.352	0.111
	(-0.684)	(-1.447)	(0.219)
Log age²	0.042	0.078*	-0.062
	(0.836)	(1.733)	(-0.607)
Part of a group	0.055	0.110	0.147
	(0.325)	(0.764)	(0.446)
Foreign share (%)	0.001	0.002	0.003
	(0.555)	(1.595)	(0.993)
State share (%)	0.002	0.001	0.026*
	(1.008)	(0.265)	(1.905)
Exporter only	0.096	0.229**	-0.059
	(0.682)	(2.027)	(-0.258)
Importer only	0.150	0.440**	-0.387
	(1.040)	(1.973)	(-0.925)
Exporter & importer	0.058	0.399**	-0.172
	(0.399)	(2.447)	(-0.531)
Female	-0.113	-0.176	-0.353
	(-0.989)	(-1.642)	(-1.607)
Subsidy	0.172	0.116	0.119
	(1.231)	(0.971)	(0.522)
Share university degree (%)	-0.002	-0.003	-0.004
	(-0.915)	(-1.610)	(-1.109)
Log real GDP per capita	0.321***	0.272***	0.067
	(4.106)	(3.361)	(0.491)
Real GDP growth	0.022	-0.005	-0.097***
	(0.814)	(-0.343)	(-3.361)
Industry dummies	Yes	Yes	Yes
Constant	7.087***	7.593***	11.550***
	(6.651)	(6.600)	(6.489)
No of observations	2,017	2,795	1,869
Wald test of exogeneity (chi2)	76.31	27.18	108.3
p-value	0.000	0.000	0.000

Note: *** p<0.01, ** p<0.05, * p<0.1.

As regards the state of the economy, results show that average M&E investments were significantly higher in wealthier economies (particularly prior to the onset of the global financial crisis) but significantly lower in faster growing economies. This latter phenomenon was, however, restricted to the crisis phase

only, indicating that M&E investors were more cautious in relatively faster growing CESEE and FSU countries.

6.2. THE INNOVATION OUTCOME

Results concerning the determinants of an establishment's innovation output are reported in Table 4 below, for each individual economic period separately, where innovation output is proxied by an establishment's probability of being a product innovator. It shows that an establishment with higher M&E investment intensity was also more likely to be a product innovator, emphasising that M&E investment activities are important drivers of successful innovation activities. However, this effect only applies to the crisis phase, where a one per cent increase in M&E investment intensity increased the probability of being a product innovator by 0.6 per centage points.

Furthermore, results point to positive size and age effects, indicating that the probability of being a product innovator was significantly higher among larger or older establishments. This, however, was only observable during the financial normalcy phase, where an increase in size (by another employee) increased the probability of being a product innovator by 5 percentage points while an increase in age by another year increased the probability of being a product innovator by 10 percentage points. However, concerning age, a non-linear relationship is observable, indicating that the negative effect of age decreases and eventually even reverses as establishments grow older. Moreover, during the crisis phase only, the probability of being a product innovator is found to increase with foreign ownership share, suggesting that – probably as a result of internal knowledge and technology sharing – establishments with a higher foreign ownership share were also more likely to introduce new or significantly improved products or services. Results also consistently show that due to the need to withstand fiercer competitive pressures in international markets paired with better access to foreign knowledge and technology and the resulting technology transfer trading establishments were more likely to introduce new or significantly improved products or services and that the particular trading status mattered for the exact effect: during the financial normalcy phase, exporters only were most likely to introduce new or significantly improved products or services, followed by importers only and, finally, exporters and importers. However, during the bubble and crisis phases, a different ranking emerged with exporters and importers as the most likely to introduce new or significantly improved products or services, followed by importers only and, finally, exporters only. Similarly, as highlighted by, e.g., Lööf et al. (2001), the skill composition of an establishment's workforce matters for its ability to introduce new or significantly improved products or services. This finding holds irrespective of economic phase analysed and suggests that skills strongly matter for an establishment's innovation success. The role of business group affiliation was less consistent and differed strongly by economic phase analysed: during the financial normalcy phase, innovation success was more likely among establishments that were part of a group and therefore profited from internal knowledge transfer, while during the bubble phase, innovation success was less likely among establishments that were part of a group.

In contrast, Table 4 demonstrates that innovation success was negatively related to state ownership share, suggesting that a higher state ownership was obstructive to innovation success. But this effect was only observable during the financial normalcy phase.

Table 4 / Innovation outcome – the probability of being a product innovator

DepVar.: Product innovator (yes=1)	***Financial normalcy***	***Bubble phase***	***Crisis phase***
Variables	(1)	(2)	(3)
Log M&E spending intensity	0.007	0.001	0.006*
	(1.166)	(0.207)	(1.721)
Log size	0.050*	0.015	-0.008
	(1.943)	(0.734)	(-0.191)
Log size²	-0.002	-0.000	0.001
	(-0.519)	(-0.086)	(0.141)
Log age	0.104*	0.039	0.024
	(1.678)	(1.052)	(0.340)
Log age²	-0.020*	-0.003	0.003
	(-1.777)	(-0.450)	(0.192)
Part of a group	0.149***	-0.050**	-0.021
	(3.563)	(-2.347)	(-0.461)
Foreign share	-0.000	0.000	0.001**
	(-0.129)	(0.434)	(2.248)
State share	-0.001**	0.001	-0.002
	(-2.342)	(1.376)	(-0.932)
Exporter only	0.142***	0.049***	0.077**
	(4.146)	(2.889)	(2.560)
Importer only	0.092***	0.074*	0.146***
	(3.007)	(1.927)	(2.876)
Exporter & importer	0.106***	0.104***	0.148***
	(3.386)	(3.699)	(3.672)
Share university degree	0.001***	0.001***	0.001***
	(3.188)	(2.669)	(3.092)
Log real GDP/capita	-0.022	0.005	0.005
	(-1.274)	(0.557)	(0.300)
Real GDP growth	0.031***	0.005**	-0.006
	(4.808)	(2.126)	(-1.547)
Industry dummies	Yes	Yes	Yes
Constant	-0.413	-0.013	-0.698
	(-0.677)	(-0.029)	(-1.347)
No of observations	2,017	2,794	1,865
Log likelihood	-1138	-1013	-1219

Note: Average marginal effects are reported; z-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1.

6.3. LABOUR PRODUCTIVITY EFFECTS

Finally, determinants of labour productivity, in general, and the effects of innovation success on firm labour productivity, in particular, are reported in Table 5 below. In line with related empirical evidence, it consistently highlights that product innovators, i.e. establishments that introduced new or significantly improved products in the past, were also more productive. However, the exact labour productivity effect of successful product innovations differed across economic phases: the effect was strongest during the pre-crisis bubble phase, where successful product innovators had around 6.8 per cent higher labour productivity levels than non-innovators. The effect was lower during the crisis phase, where successful product innovators had only around 4.7 per cent higher labour productivity levels than non-innovators. In contrast, the effect was weakest during the financial normalcy phase, where successful product innovators only had around 0.9 per cent higher labour productivity levels than non-innovators.

Similarly, results demonstrate that an establishment's labour productivity increased with an establishment's assets (per employee) (see also, e.g., Griffith et al., 2006), rendering physically larger establishments also more productive. In contrast, a negative size-effect emerges, indicating that larger establishments (in terms of employment) were less productive. But this negative size-productivity nexus was only observable during the pre-crisis bubble phase but absent during the remaining phases. Furthermore, in contrast to results from similar analyses (see, e.g., in Goya et al., 2013; Brown and Guzmán, 2014 or Benavente, 2003), an establishment's labour productivity increased with the share of university graduates in its workforce. But this negative effect is very small and only holds for the crisis phase where an increase in the share of an establishment's workforce with university degree by 1 percentage point was associated with 0.3 per cent lower labour productivity levels. A mixed picture emerges for the role of capacity utilisation: during the financial normalcy phase, establishments with higher capacity utilisation were characterised by significantly lower labour productivity levels while, during the pre-crisis bubble phase, the opposite was observable, rendering establishments with higher capacity utilisation also significantly more productive.

Table 5 / Labour productivity effects

DepVar.: log labour productivity	**Financial normalcy**	**Bubble phase**	**Crisis phase**
Variables	(1)	(2)	(3)
Product innovator	0.852***	6.826***	4.730***
	(4.468)	(7.108)	(7.791)
Log size	0.021	-0.141***	-0.064
	(1.569)	(-4.013)	(-1.562)
Share university degree	0.001	-0.000	-0.009***
	(1.383)	(-0.094)	(-3.392)
Log assets/employee	0.218***	0.284***	0.176***
	(18.010)	(12.459)	(7.311)
Capacity utilisation	-0.002**	0.009***	0.003
	(-2.154)	(5.200)	(1.370)
Real GDP growth	-0.221***	-0.096***	-0.021
	(-22.749)	(-6.551)	(-1.241)
Industry dummies	Yes	Yes	Yes
Constant	8.855***	2.031***	6.578***
	(48.484)	(2.755)	(17.454)
No of observations	1,771	853	526
Adjusted R^2	0.478	0.288	0.283

Note: t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Finally, the state of the economy also mattered for an establishment's labour productivity level. In this respect, labour productivity was consistently significantly lower among establishments located in faster growing economies (particularly during the financial normalcy and bubble phases).

7. Robustness analysis

In addition to the probability of being a product innovator, which served as an indicator for an establishment's innovation output in section 6.2 above, a number of additional innovation output indicators were also collected in the course of the BEEPS surveys. In particular, as outlined above (see section 4), the special Innovation Module which was conducted jointly with the most recent 5th wave collected comprehensive information on the outcome and mode of different types of innovations. Hence, in what follows, a robustness analysis is conducted which uses alternative proxies for innovation success/output to shed light on the determinants of innovation output (second stage), on the one hand, and to establish whether and how those alternative proxies affect labour productivity (third stage), on the other.

However, these alternative innovation output proxies are not available for all three economic phases of interest and either refer to the two most recent phases (i.e. bubble phase and crisis phase) or, as in the case of all proxies stemming from the 2013 Innovation Module, only refer to the most recent crisis phase.

In particular, the set of alternative innovation output/success proxies refers to the following:

› Volume of ***annual sales from new products*** is defined as the log of total annual sales (in Euro) earned from selling new or significantly improved products in the previous fiscal year per employee. This variable is only available for the bubble phase and the crisis phase.

› ***Number of new products*** is defined as the number of new or significantly improved products that were introduced over the previous three years. This variable is only available for the crisis period.

› Different technical innovation strategies were also identified and tested: ***product only*** refers to establishments that introduced new or significantly improved products only (but no process innovations), ***process only*** refers to establishments that introduced new or significantly improved production or delivery methods (but no product innovations) while ***both*** refers to establishments that introduced both, new or significantly improved products and processes jointly. The reference category refers to establishments that did not introduce any technical innovation at all. These strategies are only available for the crisis period, however.

› Finally, ***patents*** is a dummy variable that is equal to 1 if an establishment applied for a patent during the previous three years, and 0 otherwise. This variable is again only available for the crisis phase.

7.1. THE INNOVATION OUTCOME – ALTERNATIVE INNOVATION PROXIES

Results of the determinants of each individual alternative innovation output indicator are reported in Table 6. Methodologically, depending on the nature of the individual alternative innovation output indicators, different approaches were used: an OLS approach for the volume of annual sales per employee, a negative binomial model for the number of new products since significant over-dispersion (i.e. the variance considerably exceeds the mean) rendered a Poisson model inappropriate, a multinomial logit model for the three innovation strategies as well as a simple logit model for the patent variable.

Table 6 highlights that the role M&E investment intensity plays for innovation success strongly differs across alternative proxies used for innovation output. For instance, in line with above findings (section 6.2), columns (1) and (2) demonstrate that sales of new products per employee were significantly higher among establishments characterised by higher M&E investment intensities, irrespective of economic period analysed, indicating that more intense M&E investment activities were an important ingredient for successful innovation activities among establishments in CESEE and FSU countries. In particular, a one per cent increase in an establishment's M&E investment intensity was associated with an around 0.1 per cent increase in sales of new products per employee.

In contrast, results for the remaining innovation output indicators that all refer to the crisis period only are more diverse and mixed. For instance, column (3) shows that the number of new products was significantly lower among establishments with higher M&E investment intensities. In particular, an increase in an establishment's M&E intensity by 1 per cent was associated with a decrease in the number of new or significantly improved products by 0.03 units. However, columns (4) to (6) stress that an establishment's M&E investment intensity level played no statistically significant role for its decision to pursue either of the three innovation strategies: product only, process only or both. Finally, column (7) emphasises that an establishment's decision to apply for a patent was also statistically unrelated to its M&E investment intensity level.

Results are also rather mixed for the remaining determinants of an establishment's innovation outcome and vary by particular innovation output indicator considered. For instance, the probability of applying for a patent increased with size while older establishments were characterised by higher sales from new products per employee but a lower probability of applying for a patent. A higher foreign ownership share was associated with higher sales from new products per employee as well as a higher number of new or significantly improved products or services. In contrast, a higher state ownership share was associated with lower sales from new products per employee but made it more likely that an establishment pursued the 'process only' innovation strategy. Moreover, business group affiliation made a patent application more likely. Furthermore, in line with above results, trading status mattered strongly, rendering internationally trading establishments more successful in terms of sales of new products per employee, more likely to patent as well as more likely to pursue both product and process innovations. Finally, a high share of an establishment's workforce with a university degree was also conducive to innovation success, rendering more skill-intensive establishments more successful in terms of higher sales of new products per employee, but also more likely to patent or to pursue different innovation strategies (process only as well as product and process jointly).

Table 6 / Innovation outcomes

Phases	***Bubble phase***	***Crisis phase***	***Crisis phase***	***Crisis phase***	***Crisis phase***	***Crisis phase***	***Crisis phase***
DepVars	Log sales per employee	Log sales per employee	No of new products	Product only	Process only	Both	Patent application
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log M&E spending intensity	0.061***	0.070***	-0.030**	0.003	-0.003	0.003	0.002
	(2.942)	(3.828)	(-2.131)	(1.099)	(-1.477)	(0.896)	(0.969)
Log size	0.087	-0.238	0.161	-0.039	0.009	0.037	0.045*
	(0.819)	(-1.104)	(0.969)	(-1.184)	(0.376)	(1.069)	(1.823)
Log size²	-0.019	0.036	0.005	0.002	-0.000	-0.002	-0.005
	(-1.461)	(1.282)	(0.238)	(0.516)	(-0.027)	(-0.528)	(-1.641)
Log age	0.376*	0.294	-0.199	0.006	0.000	0.013	-0.052*
	(1.723)	(0.869)	(-0.727)	(0.108)	(0.009)	(0.217)	(-1.727)
Log age²	-0.094**	-0.122*	0.027	0.003	-0.001	0.001	0.012**
	(-2.357)	(-1.807)	(0.503)	(0.240)	(-0.108)	(0.080)	(2.088)
Foreign share	0.005***	0.002	0.006***	0.001	-0.000	0.000	-0.000
	(3.947)	(1.117)	(3.956)	(1.445)	(-0.142)	(1.397)	(-1.425)
State share	-0.009***	-0.000	-0.009	-0.001	0.001*	-0.001	0.001
	(-2.643)	(-0.007)	(-0.978)	(-0.336)	(1.725)	(-0.472)	(1.536)
Part of a group	0.045	0.100	-0.134	-0.022	-0.012	-0.002	0.045**
	(0.376)	(0.433)	(-0.738)	(-0.579)	(-0.442)	(-0.048)	(2.491)
Exporter only	0.333***	0.342**	0.039	0.027	0.014	0.050**	0.018
	(3.768)	(2.309)	(0.347)	(1.134)	(0.800)	(1.974)	(1.156)
Importer only	0.351**	0.249	0.232	0.056	-0.046	0.087**	0.004
	(1.989)	(1.106)	(1.308)	(1.405)	(-1.332)	(2.170)	(0.164)
Exporter & importer	0.543***	0.547***	-0.009	0.023	-0.009	0.117***	0.040**
	(4.453)	(2.966)	(-0.063)	(0.682)	(-0.384)	(3.688)	(2.233)
Share university degree	0.007***	0.005**	-0.000	0.000	0.000*	0.001***	0.000*
	(4.467)	(2.418)	(-0.103)	(1.002)	(1.652)	(2.913)	(1.955)
Log real GDP/capita	0.515***	0.386***	-0.126*	-0.000	-0.011	0.005	-0.003
	(11.354)	(4.082)	(-1.745)	(-0.027)	(-0.974)	(0.337)	(-0.284)
Real GDP growth	-0.065***	-0.035*	-0.056***	-0.008**	0.000	0.002	0.004**
	(-4.689)	(-1.847)	(-3.797)	(-2.452)	(0.056)	(0.579)	(2.484)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	3.454***	4.767***	2.997***				
	(6.722)	(4.784)	(3.937)				
No of observations	1,695	658	745	1,862	1,862	1,862	1,198

Note: t- or z-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1; average marginal effects are reported.

7.2. LABOUR PRODUCTIVITY EFFECTS – ALTERNATIVE INNOVATION PROXIES

Finally, Table 7 reports results for the determinants of labour productivity, in general, and the effects of innovation success on firm labour productivity, in particular, if the set of alternative innovation proxies available in the most recent two BEEPS survey waves is used instead.

Table 7 / Labour productivity effects

DepVar.: log sales per employee	**Bubble phase**	**Crisis phase**	**Crisis phase**	**Crisis phase**	**Crisis phase**
Variables	(1)	(2)	(3)	(4)	(5)
Log sales new products/employee	0.880***	0.924***			
	(15.329)	(10.177)			
Number of new products/employee			0.040		
			(0.184)		
Patent application				0.647	
				(0.504)	
Product only					1.443
					(0.660)
Process only					-5.718***
					(-2.876)
Product & process					3.926***
					(3.771)
Log size	0.021	0.003	0.094	0.052	-0.059
	(0.841)	(0.084)	(0.545)	(1.149)	(-0.671)
Share university degree	0.001	-0.003	-0.002	-0.003	-0.004
	(0.827)	(-1.428)	(-0.901)	(-0.965)	(-1.161)
Log assets/employee	0.229***	0.176***	0.223***	0.221***	0.172***
	(10.899)	(7.685)	(8.998)	(8.818)	(7.197)
Capacity utilisation	0.003	-0.001	0.003	0.002	0.003
	(1.581)	(-0.564)	(0.976)	(0.972)	(1.146)
Real GDP growth	-0.012	-0.008	-0.069***	-0.074***	-0.043**
	(-0.877)	(-0.526)	(-3.582)	(-4.257)	(-1.965)
Industry dummies	Yes	Yes	Yes	Yes	Yes
Constant	0.329	1.059	8.096***	8.193***	8.101***
	(0.662)	(1.390)	(17.562)	(23.775)	(11.048)
No of observations	853	526	526	524	525
Adjusted R^2	0.410	0.333	0.198	0.200	0.299

Note: t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

In line with above findings (see section 6.3), results demonstrate that innovation success was conducive to labour productivity. In particular, columns (1) and (2) show that a one per cent increase in the log of sales of new products per employee was associated with around 0.9 per cent higher labour productivity levels, in both the bubble as well as the crisis phase. However, no significant labour productivity effect was observable once the number of new or significantly improved products per employee is used as an indicator for an establishment's innovation success (results in column (3)) or among innovators that applied for a patent (column (4)). A more nuanced and mixed picture emerges for the role of different technical innovation strategies for labour productivity (presented in column (5)): while establishments that introduced new products only were unable to achieve significantly higher labour productivity levels, those that introduced new products and new production processes or delivery methods jointly had (around 3.9 per cent) higher labour productivity levels. In contrast, establishments that introduced new

production processes or delivery methods only suffered from lower labour productivity levels (by around 5.7 per cent), pointing to strong temporary disruptive effects and adjustment costs associated with a change or upgrade in production processes.

Concerning the remaining determinants of labour productivity, results in Table 7 are qualitatively similar to above results (see section 6.3). In particular, irrespective of economic phase analysed, labour productivity levels were also higher in more capital-intensive establishments.

Finally, the state of the economy mattered, rendering establishments located in faster growing economies during the crisis less productive.

8. Summary and conclusion

Understanding innovation processes, in general, and the complex relationships between innovation and productivity, in particular, has been a major concern for economists and policy-makers alike, concerned with developing and implementing effective policies that help economically and technologically lagging economies develop their growth potentials and initiate quicker technology-driven growth and catching-up with richer economies. Increasingly and consistently so, in this context, the detrimental role of non-negligible financing constraints for innovation processes has been highlighted.

Against this backdrop, the analysis addresses the role prevailing financing constraints play for innovation processes. It uses firm-level data taken from the Business Environment and Enterprise Performance Survey (BEEPS) for a large set of Central Eastern and South Eastern European countries (CESEE) and Former Soviet Union countries (FSU) to shed light on the relationship between different stages of the innovation process: (i) the drivers and determinants of innovation inputs, explicitly accounting for the effects of financing constraints for an entrepreneur's decision on whether and how much to spend on innovation; (ii) the relationship between innovation input and innovation output; and (iii) the relationship between innovation output and firm productivity. It takes a comparative approach and studies innovation processes during three different economic phases, namely (1) the phase of *'financial normalcy'* referring to the period between 2000 and 2004; (2) the '*bubble phase'* for the period between 2004 and 2008; and (3) the *'crisis phase'* for the brief period following the global financial crisis of 2008. Methodologically, it uses a modified CDM model (Crépon et al., 1998), extended by the role of binding financing constraint that have so far been widely neglected in this particular line of research. The analysis looks at the most dominant innovation strategy pursued in the region – i.e. the 'buy' strategy (Veugelers and Cassiman, 1999; Cassiman and Veugelers, 2006) – where entrepreneurs invest in machinery and equipment (M&E) to buy embodied technology and know-how from the original innovator which helps them to either develop new products or services or modify existing ones.

Results of the analysis reveal that prevailing financial constraints were non-negligible and very harmful, inducing entrepreneurs to be both, less likely to invest in M&E as well as to invest less in the acquisition of M&E. Observable effects were, however, most pronounced during the crisis phase. All in all, given the dominance of the M&E-based innovation strategy among CESEE and FSU countries, these findings call for quick policy intervention aimed at reducing or altogether dismantling prevailing financing constraints to help innovators increase their participation in innovative activities as well as their innovation efforts and to accelerate technology-induced catching-up of lagging economies.

Additionally, the analysis identifies particular establishment characteristics that render an establishment more likely to invest in M&E and highlights that, in line with related empirical evidence, larger establishments, internationally trading establishments as well as establishments that received subsidies were more willing to invest in M&E. In contrast, the probability of acquiring M&E decreased with age, foreign and state ownership share. Similarly, M&E investment efforts turn out to be higher among internationally trading firms that need to withstand fiercer global competition, tend to be conducted jointly

with R&D activities, pointing to the complementarity between M&E and R&D investment strategies, and increased with state ownership share. In contrast, M&E efforts decreased with size and age.

Moreover, results shed light on the relationship between M&E investment efforts and innovative outcome. In particular, results point to some weak evidence of the important role of M&E investment efforts for an establishment's innovation success, suggesting that establishments with higher M&E investment efforts are also more likely to become successful product innovators. This particular effect, however, was rather weak and restricted to the crisis phase only. In a similar vein, successful product innovators tend to have a better educated workforce that is pivotal to their innovation success, trade internationally and are therefore forced to innovate to stay competitive or have a higher foreign ownership share which facilitates internal knowledge and technology sharing and proves beneficial to product innovations.

Finally, the analysis sheds light on the relationship between innovation output and an establishment's labour productivity. It demonstrate that, irrespective of economic period considered, successful innovative activities pay off, enhancing innovators' labour productivity levels.

All in all, the analysis points to the need for policy intervention in reducing or entirely dismantling existing financing constraints to spur investments in machinery and equipment and to accomplish better economic performance.

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10. Annex

Table A.1 / List of variables

Variable	Definition	Source
M&E investor	Dummy=1 if establishment purchased fixed assets like machinery, vehicles or equipment	BEEPS
Innovator	Dummy=1 if establishment reports positive R&D expenditures (in-house or outsourced)	BEEPS
Product innovator	Dummy=1 if establishment introduced new or significantly improved products or services during the last three years	BEEPS
Process innovator	Dummy=1 if establishment introduced new or significantly improved methods for the production or supply of products or services during the last three years	BEEPS
Innovation sales (%)	Percentage of establishment's total annual sales accounted for by products that were introduced or significantly improved over the last three years	BEEPS
Innovation sales/employee	Total sales accounted for by products that were introduced or significantly improved over the last three years per employee (in Euro)	BEEPS
Number of new products	Number of new or significantly improved products an establishment introduced in the market over the last three years	BEEPS
Product only	Dummy=1 if establishment only introduced new or significantly improved products over the last three years	BEEPS
Process only	Dummy=1 if establishment only introduced new or significantly improved processes over the last three years	BEEPS
Product & process	Dummy=1 if establishment introduced new or significantly improved products and processes over the last three years	BEEPS
Labour productivity	Total sales per employee (in Euro)	BEEPS
Funding constraint	Dummy=1 if establishment is financially constrained: did not apply for bank loan despite the need; bank loan application was rejected	BEEPS
Log size	Log of number of employees	BEEPS
Log size²	Log size squared	BEEPS
Log age	Log age (age=fiscal year-year establishment began operations)	BEEPS
Log age²	Log age squared	BEEPS
Part of a group	Dummy=1 if establishment is part of a larger firm	BEEPS
Foreign share	Per cent of establishment owned by private foreign individuals, companies or organisations	BEEPS
State share	Per cent of establishment owned by the government or state	BEEPS
Exporter only	Dummy=1 if establishment is exporter only (and reports positive sales from direct exports)	BEEPS
Importer only	Dummy=1 if establishment is importer only (and reports positive imports of material inputs and supplies)	BEEPS
Exporter & importer	Dummy=1 if establishment both exports and imports	BEEPS
Female	Dummy=1 if Top Manager is female	BEEPS
Subsidy	Dummy=1 if establishment received any subsidies from the national, regional or local government or the EU	BEEPS
University degree	The percentage of an establishment's labour force with a university degree	BEEPS
Log sales (t-3)	Log of sales (in Euro) three years before	BEEPS
Log assets/employee	Log of net book value of machinery, vehicles, equipment, land and buildings	BEEPS
Capacity utilisation	Capacity utilisation: output produced as proportion of maximum output possible	BEEPS
Log real GDP/capita	Log of real GDP per capita	WDI
Real GDP growth rate	Real GDP growth rate	WDI
Bank outreach	Number of branches of commercial banks per 100,000 adults	WDI
NPLs	Bank nonperforming loans to total gross loans (%)	WDI
Domestic credit	Domestic credit provided by banking sector (% of GDP)	WDI
Share foreign banks	Foreign ownership share (%)	ECB

Table A.2 / List of countries and number of firms studied in the analysis, by period

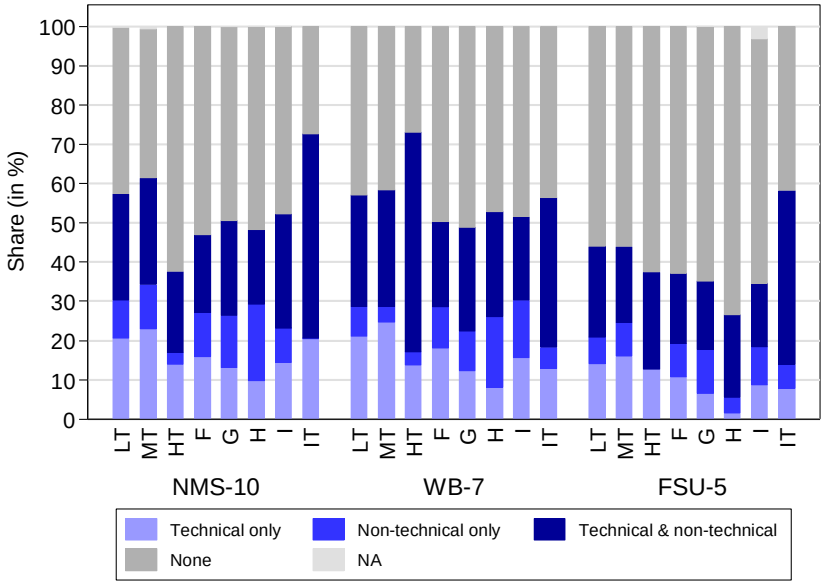
Country	Code	Waves used	Financial Normalcy	Bubble phase	Crisisphase	Total
Albania	AL	2005, 2009, 2013	204	175	360	739
Armenia	AM	2005, 2009, 2013	351	374	360	1,085
Bosnia and Herzegovina	BA	2005, 2009, 2013	200	361	360	921
Bulgaria	BG	2005, 2009, 2013	300	288	293	881
Belarus	BY	2005, 2009, 2013	325	273	360	958
Czech Republic	CZ	2005, 2009, 2013	343	250	254	847
Estonia	EE	2005, 2009, 2013	219	273	273	765
Georgia	GE	2005, 2008, 2013	200	373	360	933
Croatia	HR	2005, 2009, 2013	236	159	360	755
Hungary	HU	2005, 2009, 2013	610	291	310	1,211
Lithuania	LT	2005, 2009, 2013	205	276	270	751
Latvia	LV	2005, 2009, 2013	205	271	336	812
Moldova	MD	2005, 2009, 2013	350	363	360	1,073
Montenegro	ME	2009, 2013	0	116	150	266
FYR Macedonia	MK	2005, 2009, 2013	200	366	360	926
Poland	PL	2005, 2009, 2013	975	455	542	1,972
Romania	RO	2005, 2009, 2013	600	541	539	1,680
Serbia	RS	2005, 2009, 2013	0	388	360	748
Slovenia	SI	2005, 2009, 2013	223	276	270	769
Slovakia	SK	2005, 2009, 2013	220	275	268	763
Ukraine	UA	2005, 2008, 2013	594	851	1,002	2,447
Kosovo	XK	2009, 2013	0	270	202	472
	Total		6,560	7,265	7,949	21,774

Source: WB BEEPS.

Table A.3 / Summary statistics

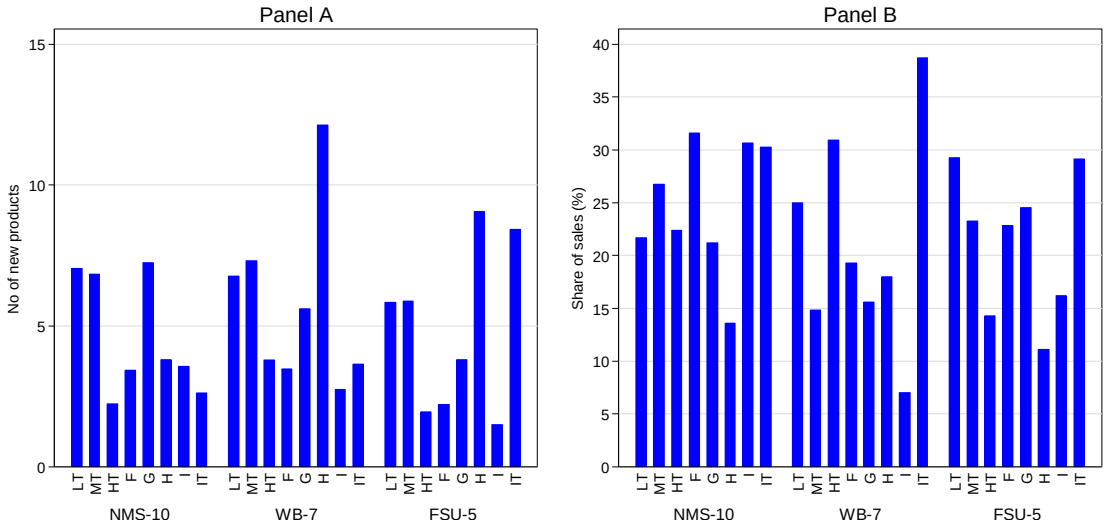
	Financial normalcy	Bubble phase	Crisis phase
Variables	Mean *(Std.Dev.)* [Min; Max]	Mean *(Std.Dev.)* [Min; Max]	Mean *(Std.Dev.)* [Min; Max]
	0.25 *(0.25)*	0.24 *(0.43)*	0.25 *(0.43)*
Financial constraints	[0; 1]	[0; 1]	[0; 1]
	0.60 *(0.49)*	0.79 *(0.41)*	0.28 *(0.45)*
Product innovator	[0; 1]	[0; 1]	[0; 1]
	0.74 *(0.44)*	0.62 *(0.49)*	0.43 *(0.50)*
M&E investor	[0; 1]	[0; 1]	[0; 1]
	1188.55 *(291.63)*	4156.14 *(0.65)*	5006.60 *(0.26)*
M&E spending/employee	[0; 75568.78]	[0; 1250000]	[0; 2039984]
	9.93 *(1.01)*	10.11 *(1.45)*	10.11 *(1.54)*
Log sales/employee	[1.51; 16.17]	[1.10; 17.11]	[2.65; 24.38]
	2.93 *(1.67)*	3.42 *(0.45)*	2.91 *(0.24)*
Log size	[0.69; 9.16]	[0; 9.81]	[0; 9.20]
	2.34 *(0.80)*	2.33 *(0.84)*	2.40 *(0.77)*
Log age	[1.10; 5.19]	[0; 5.20]	[0; 5.08]
	0.06 *(0.24)*	0.10 *(0.30)*	0.08 *(0.27)*
Part of a group	[0; 1]	[0; 1]	[0; 1]
	9.10 *(26.65)*	8.90 *(0.64)*	6.95 *(0.65)*
Foreign ownership share	[0; 100]	[0; 100]	[0; 100]
	8.06 *(26.42)*	1.57 *(0.01)*	0.76 *(0.52)*
State ownership share	[0; 100]	[0; 99]	[0; 99]
	0.10 *(0.30)*	0.16 *(0.37)*	0.14 *(0.35)*
Exporter only	[0; 1]	[0; 1]	[0; 1]
	0.13 *(0.34)*	0.03 *(0.18)*	0.04 *(0.19)*
Importer only	[0; 1]	[0; 1]	[0; 1]
	0.15 *(0.36)*	0.08 *(0.27)*	0.07 *(0.25)*
Exporter & importer	[0; 1]	[0; 1]	[0; 1]
	0.21 *(0.41)*	0.20 *(0.40)*	0.21 *(0.41)*
Female	[0; 1]	[0; 1]	[0; 1]
	0.09 *(0.28)*	0.10 *(0.30)*	0.11 *(0.32)*
Subsidy	[0; 1]	[0; 1]	[0; 1]
	26.34 *(29.04)*	21.41 *(0.62)*	26.65 *(0.67)*
Share university degree	[0; 100]	[0; 100]	[0; 100]
	8.94 *(1.44)*	8.72 *(1.86)*	8.56 *(2.16)*
Log assests/employee	[1.90; 18.06]	[0.81; 16.62]	[7.86; 14.91]
	82.15 *(19.53)*	75.57 *(1.94)*	74.56 *(0.69)*
Capacity	[5; 100]	[1; 100]	[0; 100]
	8.41 *(0.83)*	8.41 *(0.80)*	8.48 *(0.75)*
Log real GDP/capita	[6.65; 9.75]	[6.80; 9.90]	[7.08; 9.86]
	7.05 *(2.52)*	7.35 *(2.89)*	4.35 *(3.70)*
Real GDP growth	[4.13; 12.10]	[0.11; 13.75]	[-0.01; 18.65]
	22.69 *(17.23)*	23.30 *(17.14)*	22.23 *(13.47)*
Bank outreach	[3.72; 84.30]	[3.86; 88.39]	[1.60; 58.61]
	9.79 *(8.88)*	3.86 *(2.59)*	10.84 *(4.63)*
Non-performing loans	[0.40; 28.30]	[0.20; 11.20]	[3.00; 21.00]
	34.63 *(14.39)*	41.99 *(20.82)*	63.74 *(20.42)*
Domestic credit	[5.56; 57.49]	[7.03; 89.70]	[17.58; 98.78]
	60.31 *(25.85)*	66.60 *(28.61)*	69.64 *(23.34)*
Foreign bank share	[12.07; 97.96]	[0; 99.04]	[22.56; 94.53]

Figure A.1 / Prevalence of technical and non-technical innovations, by industry



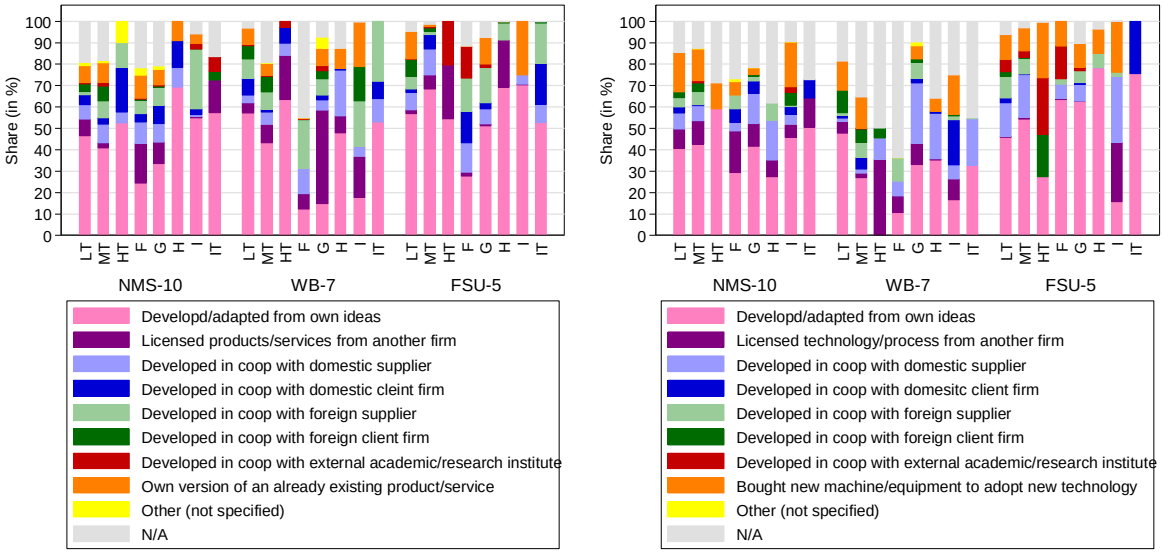
Note: NMS-10 comprises all new Member States (but Cyprus and Malta), WB-7 comprises all Western Balkan countries (Albania, Bosnia and Herzegovina, Croatia, Montenegro, FYR Macedonia, Serbia and Kosovo) and FSU-5 comprises Armenia, Belarus, Georgia, Moldova and Ukraine. LT refers to the low-tech sectors, comprising food (ISIC 15), tobacco products (ISIC 16), textiles (ISIC 17), garments (ISIC 18), tanning & leather (ISIC 19), paper & paper products (ISIC 21), publishing & printing (ISIC 22), furniture (ISIC 36) and recycling (ISIC 37). MT refers to medium-tech sectors, comprising coke & refined petroleum (ISIC 23), chemicals (ISIC 24), plastics & rubber products (ISIC 25), non-metallic mineral products (ISIC 26), basic metals (ISIC 27), fabricated metal products (ISIC 28), machinery and equipment (ISIC 29), electronics (ISIC 31), motor vehicles (ISIC 34) and other transport equipment (ISIC 35). HT refers to high-tech sectors, comprising office machinery (ISIC 30), communication equipment (ISIC 32) and precision instruments (ISIC 33). F refers to construction (ISIC 45), G to wholesale and retail trade (ISIC 50 - 52), H to hotel & restaurant (ISIC 55), I to transport & communication (ISIC 60) and IT to IT (ISIC 72).
Source: BEEPS, own calculations.

Figure A.2 / Average number (Panel A) and average percentage (Panel B) of sales accounted for by new or significantly improved products per establishment, by industry



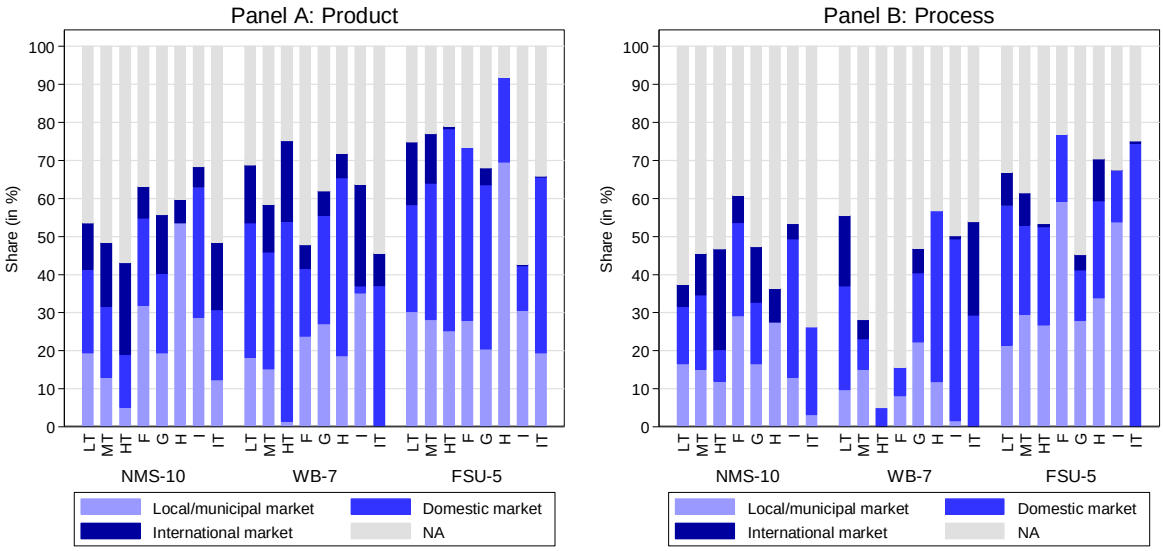
Note: See note Figure A.1.
Source: BEEPS, own calculations.

Figure A.3 / Main new or significantly improved product (Panel A) or process (Panel B): ways of introduction, by industry



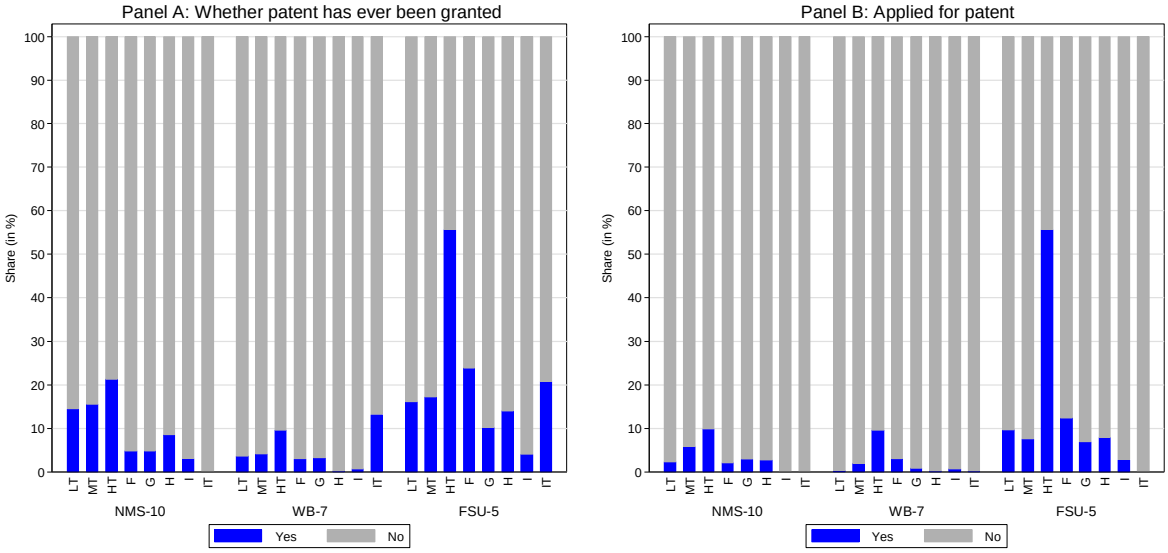
Note: See note Figure A.1.
Source: BEEPS, own calculations.

Figure A.4 / Main new or significantly improved product (Panel A) or process (Panel B): degree of novelty to other firms, by industry



Note: See note Figure A.1.
Source: BEEPS, own calculations.

Figure A.5 / Protection of innovation: prevalence of establishments that have ever been granted a patent in the past (Panel A) and that have applied for a patent in the last three years (Panel B), by industry



Note: See note Figure A.1.
Source: BEEPS, own calculations.

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