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Innovation and Economic Crisis in Transition Economies

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Abstract

Based on Schumpeterian theoretical considerations, this paper investigates the innovation behavior of firms during the severe economic crisis of the year 2008/2009. It focuses on transition countries of Central and Eastern Europe and Central Asia, which have completely restructured their innovation systems through the course of transformation from planned to market economies a relatively short time ago. As a result of the crisis, we observe a strong decline of innovation activity in all transition economies. In line with the literature, there is, however, empirical evidence for both creative destruction as well as creative accumulation. This underlines two key findings: firstly, the universality and durability of Schumpeterian assumptions, and secondly, a call for anti-cyclical innovation policy.

Keywords

Innovation behavior, economic downturn, transition countries

JEL Classifications

O12; O14; O30; O31; O57

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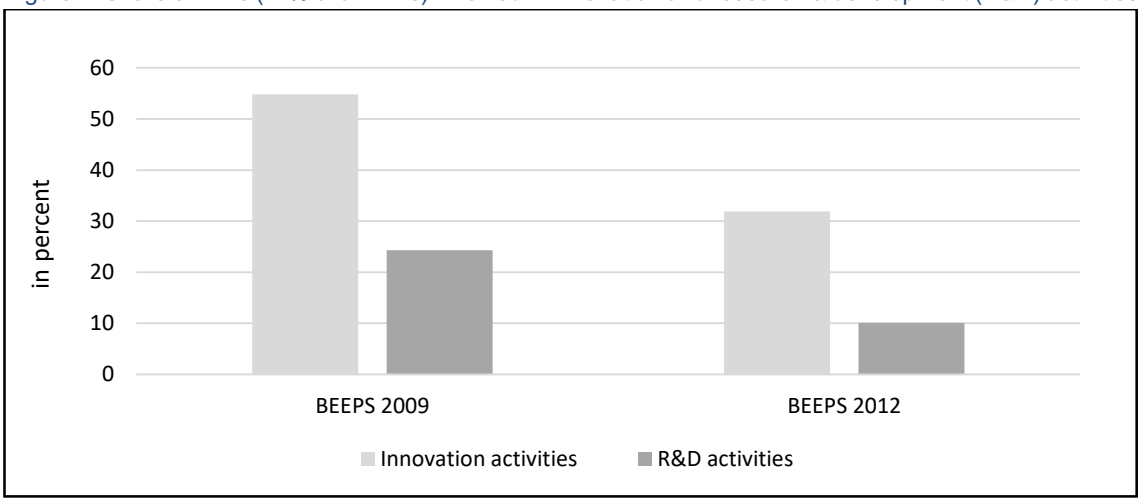
1 Introduction

The global financial crisis (GFC) of 2008/2009 had catastrophic repercussions on individual countries as well as on the international economy (Crotty, 2009; Obstfeld and Rogoff, 2009). It was rooted in the subprime mortgage crisis of 2007, which emerged due to the collapse of the housing market in the United States. The GFC found its peak with the bankruptcy of the investment bank Lehman Brothers in September 2008, shocking the global economy. As a result, companies had to struggle with this sharp economic plunge. Like many developed and emerging economies, Central and Eastern Europe (CEE) were hit hard by the GFC (Fagerberg and Srholec, 2016).

Using firm level data of the Business Environment and Enterprise Performance Surveys (BEEPS), we can see that the economic crisis in Central and Eastern Europe was also accompanied by a strong reduction of research and innovation activities. Considering 29 economies in Central Eastern Europe and the Commonwealth of Independent States (CIS) and comparing 2005-2007 and 2009-2011, we observe a significant drop in research and innovation activities[1] (see Figure 1). Figure 2 illustrates that this strong decline in R&D and innovation activities appears in all three country groups (former Soviet Union (SU) countries, EU transition countries and other former communist countries such as Mongolia or Albania). Countries of the former Soviet bloc are stronger affected than EU transition countries.

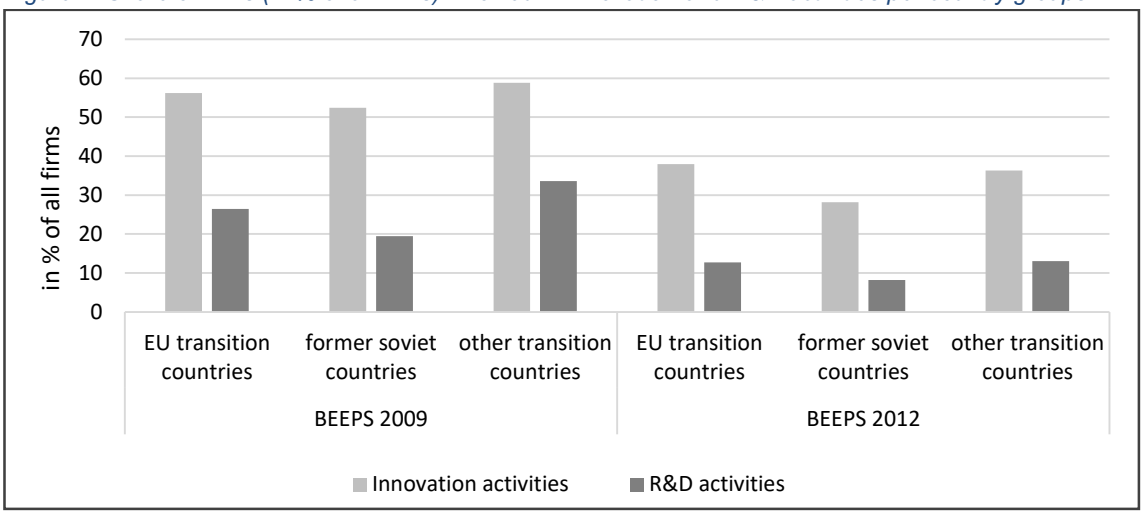
Figure 1: Share of firms (in % of all firms) involved in innovation and research & development (R&D) activities



Source: BEEPS surveys 2009 and 2012
Note: Data includes 29 transition economies. The BEEP survey 2009 refers to innovation / R&D activities during the time period 2005-2007; the BEEPS survey 2012 refers to innovation / R&D activities during the time period 2009-2011.

[1] The term 'innovation' refers here to the introduction of new products/services or process technologies and research activities to R&D activities performed in- or out-house.

Figure 2: Share of firms (in % of all firms) involved in innovation and R&D activities per country groups



Source: BEEPS surveys 2009 and 2012
Note: EU transition economies: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic and Slovenia; Former Soviet Union: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Ukraine, and Uzbekistan; Other transition economies: Albania, Bosnia and Herzegovina, Kosovo, FYR Macedonia, Montenegro, Serbia and Mongolia.

Descriptive statistics give a first impression about innovation and research activities before and after the economic crisis. Overall, it seems that innovation appears more cyclical rather than anti-cyclical in these countries. However, the reaction of individual firms may be different depending on their economic and financial situation as well as business strategy and other firm specific circumstances. Therefore, this paper will empirically investigate the determinants of firms' innovation and research activities in times of a deep economic crisis. In this context, we also scrutinize how economic crisis in the year 2008/2009 shifted the innovation behavior of companies in the sense of creative destruction or accumulation in transition economies. The subject of the paper – innovation behavior under conditions of an economic crisis –is of very high importance, given the fact that the world economy is again experiencing an economic crisis that is now being triggered by the COVID-19 pandemic. Continuous innovation efforts are not only crucial for a company's long-term economic performance but also for a country's knowledge base and its long-term growth (Grossman and Helpman, 2001; Romer, 1986, 1990). Schumpeter and the Schumpeterian literature suggest that innovative activities and innovative organizations can be revamped by economic crises through the effects of creative accumulation and destruction (Schumpeter, 1934, 1939). Despite a rise in risks and uncertainty during a crisis, some firms see the advantage of lower opportunity cost and the forgone of achieving productivity growth during a recession. Thus, these firms shift their resources and increase their innovation activities to launch their novelties with an economic upswing (Barlevy, 2007; Arvanitis and Woerter, 2014, Fernandes and Paunov, 2012).

Whilst there exist several studies for European Union and Latin American economies on innovation behavior during the 2008/2009 crisis, no empirical insights are available for transition economies so far. We use the term "transition economies", referring to the formerly planned economies in CEE. We acknowledge that transition in

the sense of institutional change from a planned to a market economy has formally been completed in many of these countries, and that the group of all 29 transition economies today is quite heterogeneous. Conversely, these countries share the common experience of system break and complete restructuring of their economic and technological system. Moreover, these relatively young market-based innovation systems may be more vulnerable compared to established market economies. Hence, it is possible and indeed likely that the economic crisis 2008/2009 had a stronger impact on these countries' innovation activity. Harmonized company survey allows a comprehensive analysis in which heterogeneity will be taken into consideration. Our paper is not focusing on a specific industry sector or technology, but how an economic crisis affects firms' innovation performance in general in these countries.

According to our findings, the crisis leads to an overall decline in innovation activities. Moreover, a shift of innovation activities from small to large firms occurs which indicates creative accumulation. However, we also observe that young firms increase their likelihood to innovate after the crisis which gives some weak indication for creative destruction as well. Further, our results show firms engaged in R&D activities innovate more persistent and thus are less affected by the GFC. Additionally, firms with access to financial resources such as loans and subsidies have a higher likelihood to innovate after the crisis.

The paper is organized as follows: section two provides the theoretical framework and literature review as well as the hypotheses. In section three, a descriptive foundation of the following empirical analysis is laid through illustration of the data samples, and the econometric model is presented. The empirical results are presented in section four. Finally, section five provides a brief summary, dealing with study's limitations and finally, a conclusion.

2. Theoretical considerations, literature review and hypotheses

In the 2008/2009 crisis, innovation activities overall declined significantly because of low demand expectations and increased uncertainty (OECD, 2009, 2012; Paunov, 2012; Kanerva and Hollanders, 2009; Archibugi *et al.*, 2013a, 2013b). However, it is important to innovate counter-cyclically to keep up with future innovation rates (Paunov, 2012). Further, innovative capabilities help firms to respond to economic downturns and increases their likelihood of survival (Cefis and Marsili, 2019; Amore, 2015; Antonioli *et al.*, 2011); and there are some firms that continue to invest in innovation during an economic crisis to build or reinforce competitive advantages. Schumpeter argued that an economic turmoil could provide the chance for firms to become more efficient and innovative through creative destruction, allowing them to even gain competitive advantage (Schumpeter, 1911, 1934). *Creative destruction* is characterized by low learning cumulativeness, high technological opportunities and a dynamic environment with higher entry and exist rates (Archibugi *et al.*, 2013a; Malerba and Orsenigo, 1995; Francois and Lloyd-Ellis, 2003). These more agile and flexible structures within new

entrants and small companies allow them to better adapt to an economic downturn in the business cycle, challenging incumbent firms by gaining advantages of changing environments and new market opportunities. Incumbent firms, though, perform research and development (R&D) and innovation as routine activities because they build on their previous knowledge in specific (technological) areas (Schumpeter, 1942).This innovation process is called *creative accumulation* and is characterized by path-dependent patterns, high (technological) knowledge accumulation, low opportunities and high entry barriers which lead to a more stable environment (Breschi *et al.*, 2000; Nelson and Winter, 1982; Archibugi *et al.*, 2013a, 2013b; Archibugi, 2017; Schumpeter, 1942). Hence, established companies, which are generally older and larger firms, benefit from their path-dependent patterns and cumulative learning processes and innovate continuously unaffected by economic fluctuations in the business cycle. These two innovation scenarios have been labelled Schumpeterian models Mark I and Mark II (Barlevy, 2007; Cefis, 2003; Freeman *et al.*, 1982).

The most recent literature investigated the firms' innovation behavior during the global economic crisis 2008/2009 (Archibugi *et al.*, 2013a, 2013b; Filippetti and Archibugi, 2011; Paunov, 2012; Antonioli and Montresor, 2019; Antonioli *et al.*, 2011). Archibugi et al. (2013a) examining panel data from the UK, found evidence for both creative destruction and creative accumulation during the economic crisis 2008/2009. Firms classified as great innovator are more likely to increase innovation during the crisis (but not before) and thus supporting the case of creative accumulation. At the same time, their results also show that new fast-growing firms are as well more likely to expand their innovation investment, indicating a process of creative destruction during the crisis. However, the empirical evidence is not yet conclusive. Archibugi et al. (2013b) analyzing European survey data from 2009, find that small or new firms are more likely to increase their investment in innovation during the economic downturn 2008, while before the crisis larger firms are more likely to increase or maintain their investment in innovation. Thus, the authors conclude that even though before the crisis creative accumulation prevailed, during the recension firms' innovation behavior converge towards creative destruction. Findings from other studies, however, display the opposite. Teplykh (2018) finds that in three Western European countries larger firms innovate more during the crisis whilst small firms were seen to struggle the most, indicating a stronger tendencies towards creative accumulation. This is in line with the results of Correa and Iootty (2010), they found that in six Eastern European countries young and innovative firms are more affected by the economic crisis in 2008. Paunov (2012) confirms this for the case of eight Latin American countries which are also examples of young firms being less likely to innovate in time of a crisis. In these studies, liquidity constraints are a listed reason for the innovation weakness of small firms during an economic slump because smaller or younger companies have more difficulties to access external finance due to small credit history (Paunov, 2012; Correa and Iootty, 2010; Teplykh, 2018). In fact, getting access to external finance during an economic downswing becomes difficult for firms because banks, markets and investors are more risk averse in recessions (Paunov, 2012; OECD,

2009, 2012). These financial constraints detain innovation during recessions (Stiglitz, 1993; Hyytinen and Toivanen, 2005; Aghion *et al.*, 2012).

The most recent empirical literature based on studies of European and Latin American countries indicates that there is no pure cyclical or anticyclical innovation behavior (Archibugi *et al.*, 2013a, 2013b; Paunov, 2012; Filippetti and Archibugi, 2011). Further it demonstrates that creative destruction and creative accumulation co-exists. However, in transition countries not much is yet known about the impact of the GFC on innovation behavior. All transition economies experienced a system break with heavy losses of their scientific and industrial research and development (Meske, 2000). Since the 1990s, they have tried to build-up and modernize their innovation systems to re-engage in original technological activities within networks of innovators (Günther, 2015; Varblane *et al.*, 2007; Dyker, 2010). The economic crisis 2008/2009 puts these efforts and achievements at risk. Using firm level data for a large number of transition economies and referring to Schumpeterian theoretical thought, we will test the following hypotheses about the firm behavior in transition economies for the time before and after the crisis.

According to the literature, incumbent firms in general profit from their established resources and are more robust in innovating during an economic crisis (Archibugi *et al.*, 2013a; Paunov, 2012; Teplykh, 2018). In transition economies, it must also be accounted for that the institutional environment often fosters the success of large firms while the opportunities for small and medium companies are restricted (Golikova and Kuznetsov, 2017). Therefore, the first hypothesis is:

H1: The crisis leads to a shift of innovation activities across firms towards larger or older firms (in the sense of creative accumulation)

However, a crisis can provide chances for small and new firms to emerge and gain market power through creative destruction (Archibugi *et al.*, 2013a; Malerba and Orsenigo, 1995; Francois and Lloyd-Ellis, 2003). Thus, the second hypothesis is formulated as follows:

H2: The crisis leads to a shift of innovation activities across firms towards small or younger firms (in the sense of creative destruction).

Furthermore, R&D projects are normally a long-term commitment. Thus, in times of crisis, it is not profitable for companies to postpone or abandon innovation projects, which passed the initial phase because it is costly for them to give up the benefits from these projects (Paunov, 2012, Arvantis and Woerter, 2014). Recent results of Knudsen et al. (2019) confirm this. Their findings show that Norwegian firms are less likely to cut off R&D investments compared to investments in physical assets. Moreover, Archibugi et al.(2013a) found that companies involved in R&D innovate more persistently during the economic crisis. For these reasons, our third hypothesis is:

H3: Firms engaged in R&D activities are less likely to cut back their innovation activities during the crisis.

Financial constraints are one of the main reasons to cut back innovation during an economic downturn (Stiglitz, 1993; Hyytinen and Toivanen, 2005; Spatareanu *et al.*,

2019). The results of Gorodnichenko and Schnitzer (2013) and Mateut (2018) have shown that this also applies for transition countries in Eastern Europe and Central Asia. Furthermore, during a crisis banks, markets and investors become more risk averse and it is more difficult to get access to external finance (Paunov, 2012; OECD, 2009, 2012). Hence, the fourth hypothesis to be tested is:

H4: Firms with better access to finance are less likely to cut back their innovation activities during the crisis.

3. Data and Econometric Specification

3.1. Description of the data

The analysis makes use of the Business Environment and Enterprise Performance Survey (BEEPS) which is implemented by the EBRD (European Bank for Reconstruction and Development) in partnership with the World Bank. The BEEPS data set is a firm-level survey based on face-to-face interviews with managers containing information on a wide range of standard firm characteristics. BEEPS also cover a wide range of business environment topics including access to finance, corruption, infrastructure, crime, competition, and performance measure. Furthermore, it provides the advantage that firms self-report various types of their innovation activity such as: if the company introduced new products or services or did a major upgrade of existing ones or acquired a new production technology over the last three years.[2] ‚New' in this case means new to the firm, not necessarily new to the market.

We analyze the fourth and fifth wave of the BEEPS that were conducted in 30 countries[3] during 2009 and 32 countries[4] during 2012. The surveys contain answers from almost 12,000 enterprises in 2009 and 15,600 in 2012. Since our research concentrates only on transition countries we have omitted data from Turkey, Greece and Cyprus. Our final sample comprises 10,846 observations in 2009 and 14,539 in 2012 for 29 transition countries. Both surveys have a similar sampling frame and contain a wide range of identical questions. Each sample includes very small firms with a minimum of two employees as well as large firms with up to 10,000 employees. The sample does not include companies that are ruled by government price regulations such as electric power, gas and water supply and companies that are 100 percent state-owned. Overall, the

[2] A frequently used alternative in innovation research is a combination of firm and patent data. We have not taken this approach because analyzing patent activity in transition countries is less suitable since firms are likely to innovate through imitation or adaptation instead of inventing completely new (patentable) things of the existing state-of-the-art technologies (Aghion *et al.* (2002); Gorodnichenko *et al.* (2009); Gorodnichenko and Schnitzer (2013); Acemoglu *et al.* (2006).

[3] Both surveys contain 17 countries from Central and Eastern Europe including Albania, Bosnia and Herzegovina, Kosovo, FYR Macedonia, Montenegro, Serbia, and the EU member states Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic and Slovenia, further 11 countries from the former Soviet Union among them Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Ukraine, and Uzbekistan, and other countries such as Mongolia and Turkey (which is not included in our analysis).

[4] The countries Cyprus and Greece were only surveyed in BEEPS 2012 and are not included in our analysis.

sample frames have been designed by a stratified random sampling to assure a representative structure of the firms' population in each country. In each country, the sectoral composition concerning the share of manufacturing firms versus firms in services has been set by their contribution to country's GDP[5]. Furthermore, the data includes firms from different regions (rural areas just as large cities). Thus, the BEEPS data allows us to analyze the innovation behavior of heterogeneous firms in transition countries. Moreover, each questionnaire includes a question regarding the firms' innovation activities over the last three years[6]. This enables us to compare innovation behavior before and during the aftermath of the crisis.

The BEEPS data offer as well a small panel data set. However, we rely in our analysis on pooled data as our dependent variable has a retrospective component. Furthermore, small panel data set of heterogeneous firms makes it difficult to determine robust relationships (Gorodnichenko and Schnitzer, 2013).

3.2. Operationalization of key variables

To investigate our first two hypotheses, we use the following firm characteristics: firm size measures the number of full-time employees (at the end of the fiscal year) and ranges from micro, small, middle to large firms. The size categories are in accordance with the OECD's criteria.[7] Further, age is measured as the number of years since the firm is operating and coded as a categorical variable (1= start-up (1-5 years) and 4=incumbent (over 21 years)). We included the sub-categories start-up to control for newly created businesses and as the first five years are the most challenging years for a company (Fort *et al.*, 2013). Alternatively to firm age, we include categories of manager experience measured in years.

To test our third hypothesis, we include the dummy R&D (in- or out-house) which measures whether a company is involved in R&D activities or not[8].

With respect to the fourth hypothesis, the firm's financial situation is described through the dummy loan (if the firm has currently a loan from a financial institution or not). In addition, we include a subsidies dummy (if the firm received governmental subsidies over the last three years or not), as subsidies can help stimulating firm's innovation activities in times of crisis (Paunov, 2012; Brautzsch *et al.*, 2015). This is in

[5] The sector manufacturing includes manufacturing and agro-processing, but does not entail primary industries such as mining or agriculture. The service sector includes retail, wholesale, IT and repair services, hotel and restaurants as well as transportation and communication services.

[6] This three-year period covers the years 2005-2007 in BEEPS 2009 and 2009-2011 in BEEPS 2012. However, it has to be noted that in the 2012 survey Russian firms have been interviewed one year earlier. Thus, in that case the innovation period covers the years 2008-2010.

[7] According to OECD (2017) firm sizes can be subdivided into micro enterprises (fewer than 10 employees), small enterprises (10 to 49 employees), and medium-sized enterprises (50 to 249 employees). Large enterprises employ 250 or more people.

[8] Archibugi et al (2013a, 2013b) are using R&D expenditures in their analysis. Due to a large amount of missing data for R&D expenditure we do not use this indicator.

line with Mateut (2018); receiving public subsidies stimulates firms' innovation activities in transition countries, especially within financial constrained firms.

As a measure of firm financial constraints, we use the following two variables: (1) the dummy variable overdue, which indicates if the firm has overdue payments by more than 90 days or not. (2) Self-reported problematic to get access to finance, which includes availability and cost, interest rates, fees and collateral requirements. Access to finance is coded ‚1' if it is none to minor obstacle, ‚2' if it is a moderate obstacle and ‚3' if it is a very severe to major obstacle.

Consistent with the literature, the following controls have been chosen. The variable employee growth is included as firms' employment decisions can reflect the effects of an economic plunge. Moreover, a firm is foreign owned if the foreign shareholder holds more than 50 percent. Gorodnichenko and Schnitzer (2013) and Karymshakov et al. (2019) found that foreign-owned companies innovate more in transition countries than local firms. As foreign competition and exporting status can have an impact on firm behavior (Gorodnichenko *et al.*, 2009; Mateut, 2018; Paunov, 2012; Beneito *et al.*, 2015; Molodchik *et al.*, 2020) we include export defined as 1/0 if the company is doing export business. Background measures the firms' origin: 1= private from the start, 2=privatized, and 3=other (e.g. private subsidiary of a formerly state-owned firm, joint venture with foreign partner). The ordinal variable education describes the share of employees with a university degree and captures the human capital within a firm.

3.3 Summary statistics

According to the BEEPS data, the number of firms that reported an increase in sales dropped by about 15 percentage points after the GFC. The number of firms that reported a decrease in sales rose accordingly. A closer look at the firms' size categories (see Figure A1) show that the share of firms reporting an increase in sales dropped in BEEPS 2012 by 19 percent points in all size categories (from micro to large) compared to BEEPS 2009. Furthermore, in all size categories a decline in possessing a current loan is recorded after the GFC. Whilst, the share of firms having overdue payments rose in all size categories except within large firms. Furthermore, Figure A2 shows that after the GFC, a greater share of large and middle-sized firms reported to be innovative. This is a difference to that of micro and small firms with many not involving themselves in innovation activities. In comparison, before the GFC the majority of large, middle and small sized firms reported to innovate, whereas less than half of the micro firms were classified as innovative. Looking at firm age and innovation or R&D activities, we can see that before the GFC there was no big difference between age groups and innovation activities while after the GFC innovation activities increase with firm age. However, R&D activities are increasing with firm age before and after the GFC (see Figure A3). These first descriptive insights imply that the first hypothesis will be supported whereas the second one will be rejected.

Table 1 reports the summary statistics of the used variables for each survey wave. Among the central explanatory variables, the share of firms classified as micro and small

increase in Beeps 2012 compared to 2009, while the percentage of medium and large firms slightly declines. A possible explanation is that firms were forced to dismiss employees due to the GFC. Firms involved in R&D activities sink by almost 15 percent point in BEEPS 2012 compared to 2009. Other financial indicators also decrease in the 2012 survey, as expected. For instance, the percentage of firms with a current credit line drop by 10 percent point. It is surprising that 28.5 percent of firms rank access to finance as great obstacle in BEEPS 2009, while in BEEPS 2012 it is 19 percent. The share of firms with overdue payments does not change in both waves. Descriptive statistics for the other controls show, amongst others, that in BEEPS 2012 the percentage of firms having a higher percentage of employee with a university degree increases compared to the survey before.

Table 1: Summary statistics

Variable	BEEPS survey 2009		BEEPS survey 2012	
	Percent	No. obs.	Percent	No. obs.
Dependent variable				
Innovation				
Product or process: yes	54.81	5,941	31.88	4,634
Product or process: no	45.19	4,898	68.12	9,904
Central explanatory variables				
Firm size				
Micro*	22.03	2,364	31.71	4,582
small	41.44	4,446	47.26	6,828
Medium	27.02	2,899	16.68	2,410
large	9.51	1,020	4.35	629
Firm age				
Start-up (1-5 years)*	11.66	1,264	12.89	1,874
Young (6-10 years)	24.21	2,624	26.01	3,781
Middle-aged (11-20 years)	49.53	5,369	43.72	6,355
Incumbent (20+ years)	14.60	1,582	17.38	2,527
Manager experience				
1-5 years*	13.70	1,485	11.80	1,716
6-10 years	21.31	2,310	22.71	3,302
11-20 years	38.74	4,199	39.94	5,807
>20 years	26.25	2,845	25.54	3,713
R&D				
RD activities: yes	24.29	2,603	10.10	1,468

RD activities: no*	75.71	8,114	91.94	13,366
General financial situation				
Current loan: yes	45.79	4,963	35.53	4,874
Current loan: no*	54.21	5,876	66.47	9,664
Employee growth: increased	55.42	5,586	44.90	6,070
Employee growth: same*	21.13	2,130	32.19	4,352
Employee growth: decreased	23.44	2,363	21.91	3,097
Sales growth: yes	67.19	4,699	51.82	4,433
Sales growth: no*	32.81	2,295	48.18	4,122
Financial constraints				
Overdue payment: yes	63.51	6,884	63.32	9,206
Overdue payment: no*	36.49	3,955	36.68	5,332
Access finance: no/minor obstacle	46.86	4,872	62.45	8,899
Access finance: moderate obstacle *	24.60	2,557	18.38	2,619
Access finance: great obstacle	28.54	2,967	19.17	2,732
State subsidies: yes	8.50	921	8.06	1,172
State subsidies: no*	91.50	9,918	91.51	15,159
Control Variables				
Sector dummies				
Sector: manufacturing	42.08	4,561	37.00	5,379
Sector: service*	57.92	6,278	63.00	9,159
Foreign ownership				
50% or more: yes	7.31	792	4.63	673
all others: no*	92.69	10,047	95.37	13,865
Background				
Private from start	71.86	7,777	85.93	12,252
Privatization case	21.58	2,336	10.60	1,540
Other*	6.56	656	5.03	731
Human capital				
University degree: none*	10.45	1,080	8.89	1,245
University degree: up to 25%	54.56	5,639	40.28	5,582
University degree: 25-50%	20.74	2,144	24.49	3,394
University degree: more than 50%	14.25	1,473	26.24	3,637
Export				

Export: yes	23.33	2,521	19.11	2,752
Export: no*	76.67	8,285	80.89	11,651
Country				
EU transition	31.64	3,429	25.56	3,716
Others*	68.36	7,410	74.44	10,822

Note: * Reference categories.

Table 2: Summary statistics: Indicators of firm's innovative activities by country group

	BEEPS 2009		**BEEPS 2012**	
EU Countries	N	Share	N	Share
Innovation activity	3429	.562	3716	.379
R&D activities	3374	.264	3687	.129
Subsidies	3370	.161	3695	.174
Former SU Countries				
Innovation activity	5372	.524	8670	.282
R&D activities	5329	.194	8604	.083
Subsidies	5295	.044	8589	.042
Other Countries				
Innovation activity	2038	.588	2152	.363
R&D activities	2014	.336	2152	.131
Subsidies	2013	.071	2125	.08

Table 2 present additional statistics (share and number of observations) according to country groups (EU countries, former SU countries, other formerly communist countries). In BEEPS 2009 slightly more than half of the survey firms were engaged in innovation activities in each country group. Whereas, BEEPS 2012 in EU countries and other communist countries firms' innovation activities decreased to 37 percent and in former SU countries to 28 percent. A decline in R&D activities becomes also visible in all country groups when comparing both surveys. Countries that were members of the EU have the highest percentage of subsidies in both waves.

3.4. Econometric Specification

In order to examine the innovation behavior before and after the crisis, we now go into detail about our methodological approach. The dependent variable is binary and stands for product or service innovation or process innovation, with an either "yes, innovated over the last three years" or "no, did not" option. Innovation in this context is defined as the introduction of new products/services or process technologies[9]. The query of firms' innovation activities is in accordance with the Oslo Manual established by OECD and Eurostat. Due to the binary dependent variable, a logit model is employed for the estimation. We have chosen the logit approach as it facilitates the interpretation of the

[9] Since the Beeps 2009 definition of product innovation explicitly refers to changes in the process we combined this with the queries of process or product innovation in Beeps 2012 and created the dependent variable (product or process innovation).

coefficients (Archibugi et al., 2013b). The vector of explanatory and control variables encompasses firm characteristics such as size, age, employee growth over the last three years, manager experience, research & development, education, subsidies over the last three years, and foreign owned. To control for unobserved heterogeneity across countries and industry sectors we include country as well as industry dummies based on four-digit industry code.

4. Empirical results

4.1. Baseline results

The main findings of the study are presented in Table 3. Column 1 of Table 3 shows the results of the baseline model, which tests the main variables of interest (firm age, firm size and financial measures); whilst in column 2, the age variable is expressed as the manager experience instead of pure firm age (years). All specifications control for industry and country fixed effects and cluster standard errors at industry and year level.

The estimates suggest a positive and significant relationship between firm size and firm innovative activities: the odds to innovate increase with size. Large firms have 37 percent higher odds to innovate compared to micro firms, whereas the odds to innovate decrease around 21 percentage points for small firms. Looking at the marginal effects of firm size on firm's predicted innovation activities and comparing the two survey (see Figure 3), we can see that before the GFC small firms are more likely to innovate compared to micro firms, while medium-sized and large firms do not have a significant higher likelihood to innovate compared to micro firms. However, after the GFC large firms do not only show a significant difference compared to micro firms, they also have a higher predicted likelihood to innovate. Similar effects can be seen for middle-sized firms. Even though it appears that small firms were more actively innovating before the GFC, our overall results suggest a shift of innovation activities from small to large firms, indicating a process towards creative accumulation during and after the crisis. This is plausible as larger firms have more resources and are thus more resistant to a crisis and continue to innovate. Thus, we can confirm our first hypothesis.

Table 3. Logit estimation results of pooled BEEPS waves

	(1)	(2)
Size: small firm	1.160***	1.171***
	(0.0470)	(0.0475)
Size: medium firm	1.278***	1.302***
	(0.0692)	(0.0692)
Size: large firm	1.367***	1.414***
	(0.0958)	(0.102)
Age: young firm (6-10)	1.174**	
	(0.0599)	
Age: middle aged (11-20)	1.279***	
	(0.0592)	
Age: incumbent (>20)	1.304***	
	(0.0841)	
Manager exp. 6-10 years		1.079
		(0.0624)
Manager. exp. 11-20 years		1.295***
		(0.0752)
Manager. exp. >20 years		1.247**
	(0.0958)	(0.0881)
RD activities	5.340***	5.342***
	(0.348)	(0.345)
Subsidies	1.367***	1.377***
	(0.0759)	(0.0764)
Current loan	1.316***	1.317***
	(0.0451)	(0.0447)
Overdue	1.254***	1.256***
	(0.0473)	(0.0476)
Employee growth increased	1.292***	1.268***
	(0.0544)	(0.0556)
Employee growth decreased	0.999	1.002
	(0.0364)	(0.0356)
Access finance: no/minor obstacle	0.990	0.989
	(0.0445)	(0.0441)
Access finance: great obstacle	1.282***	1.277***
	(0.0584)	(0.0579)
Foreign owned	1.281***	1.275***
	(0.0839)	(0.0832)
Export	1.485***	1.482***
	(0.0902)	(0.0910)
Edu: up to 25% have university degree	1.188**	1.191**
	(0.0921)	(0.0912)
Edu: 25-50% have university degree	1.291***	1.298***
	(0.0957)	(0.0954)
Edu: more than 50%	1.396***	1.408***
	(0.0946)	(0.0948)
Private from start	1.063	1.043
	(0.0792)	(0.0750)
Privatization	0.857*	0.863*
	(0.0761)	(0.0743)
N	21395	21395

Note: The dependent variable is binary standing for process or product/service innovation activities. Reference groups: for manager experience: 1-5 years; firm size: micro firms; employee growth: unchanged; access finance: moderate obstacle; edu: no workers with university degrees. Time controls as well as country and industry fixed-effects included. Exponentiated coefficients; to better interpret our results, we transform the coefficients into odds ratio; standard errors in parentheses are clustered at sector*wave level, * p < 0.10, ** p < 0.05, *** p < 0.001

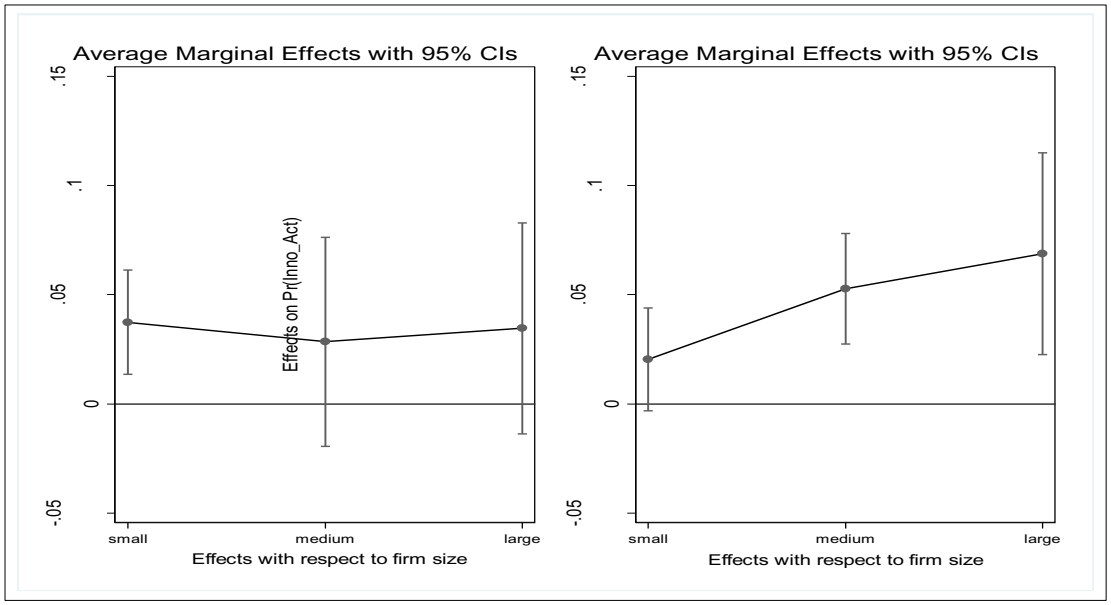


Figure 3: Marginal effects on predicted probability of firm's innovation activities with respect to firm size before (left) and after (right) the crisis. Note: Marginal effects show if the difference between subgroups of a categorical variable are significant. Here, the reference group is "micro firms".

Turning to firm age, the results similarly suggest a positive and significant relationship between firm age and innovative activities. Again, the odds to innovate increased with age. The impact is similar. Incumbent firms have 30 percent higher odds and middle-aged firms have 28 percent higher odds to innovate compared to start-up firms, while young firms have 17 percent higher odds to innovate compared to start-up firms. Figure 4 shows the marginal effects of firm age on firm's predicted innovation activities for the both surveys. According to Figure 4, in BEEPS 2009 (before the GFC) middle aged firms are more likely to innovate compared to start-up firms, while after the GFC also young firms and incumbent firms have a higher probability to innovate. These findings indicate that incumbent firms which in general perform innovation activities more routinely, innovate less affected by the crisis. Once again, this confirms our hypothesis. However, we also see a rise in the likelihood to innovate among young firms. This could indicate a behavior of creative destruction. Hence, we cannot fully rule out our second hypothesis.

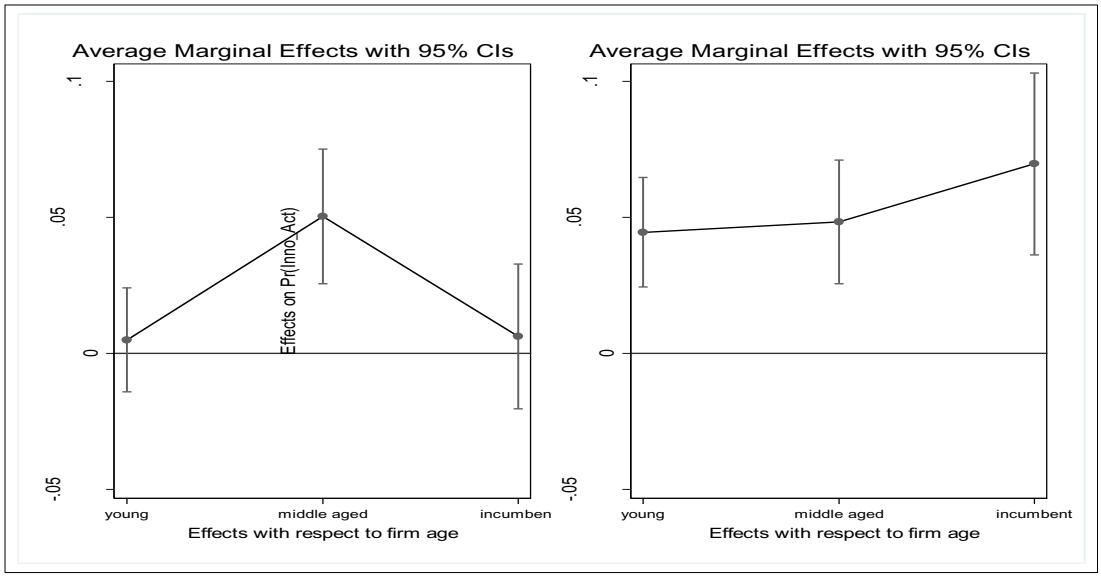


Fig. 4 Marginal effects on predicted probability of firm's innovation activities with respect to firm age before (left) and after (right) the crisis. Note: Marginal effects show if the difference between subgroups of a categorical variable are significant. Here, the reference group is "start-up firms"

With respect to our third hypothesis, our findings show that R&D activities are an important input-factor for innovation. This is in line with the results of Gogokhia and Berulava (2020). The odds to innovate are over five times higher for companies involving themselves in R&D than those that do not. These results are in line with (Archibugi *et al.*, 2013a, 2013b). Furthermore, Figure 5[10] illustrates the predicted likelihood to innovate with respect to firms' R&D activities across the two surveys: not only are firms involved in R&D activities more likely to innovate, it also appears that R&D activities stabilize innovation during times of crisis. These findings indicate that firms engaged in R&D projects are less willing to withdraw from these, as R&D projects are normally commitments made for a long period of time. Comparing firms' R&D activities across firm size before and after the GFC, shows that this stabilization effect is similar across firm sizes (see Figure 6). We see that (disregarding the firm size), firms which didn't invest into R&D have a lower level of probability to engage in innovation activity. Whereas the probability of R&D investors only decreases by 5 percent points. A similar picture appears comparing firms' R&D activities across firm age before and after the GFC (see Figure 7), also here we can see a difference between R&D investors and non-investors, but it also existed prior to crisis. Only the gap widened after the crisis. However, among non-R&D pursuing firms it appears that incumbent firms are slightly more likely to innovate after the crisis. Based on our results, we confirm our third hypothesis. Companies involving themselves in R&D activities are less likely to cut back in innovation due to an economic shock.

[10] Tables of the respective regressions with interactions for Figure 5, 6, and 7 can be found in Table A1 to A3 in Appendix.

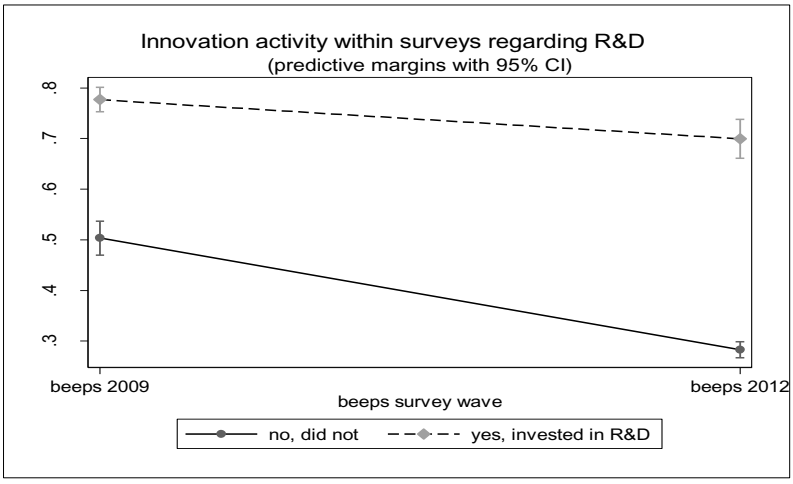


Figure 5: Predicted probability of firms' innovation activity depending on R&D activities a cross waves.

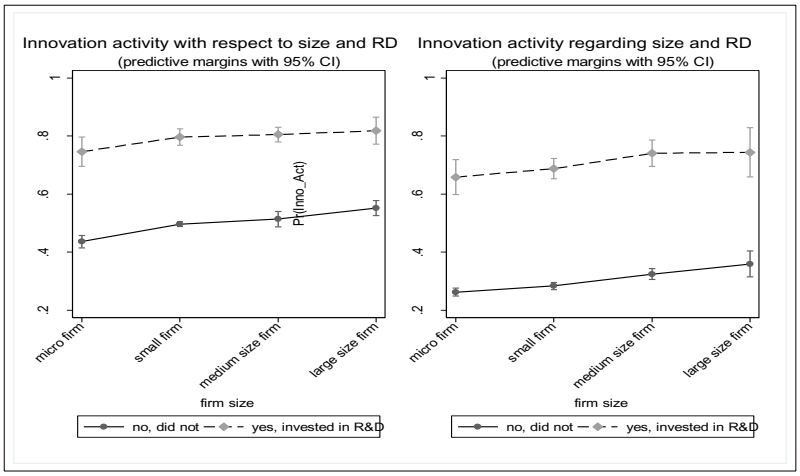


Figure 6: Predicted probability of firms' innovation activity depending on R&D activities across firm age before (left) and after (right) the crisis.

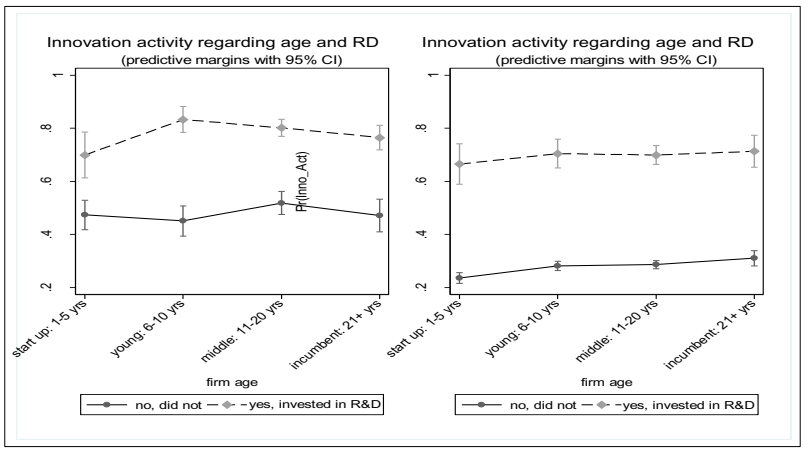


Figure 7: Predicted probability firms' innovation activity depending on R&D activities across firm size before (left) and after (right) the crisis.

Concerning our fourth hypothesis, our results indicate that firms with access to finance such as a current loan or receiving subsidies have indeed higher odds to innovate compared to firms that do not have access to these financial resources. Firms that receive governmental subsidies over the last three years have 37 percent higher odds to innovate than those that do not. As in transition economies the institutional environment often fosters the success of incumbent firms (Golikova and Kuznetsov, 2017), we compare in Figure 8 the probability to innovate of firms that are receiving governmental subsidies across firm age before and after the GFC. Before the GFC firms have (disregarding age) about the same level of likelihood to innovate. After the crisis, older subsidized companies are more likely to innovate. This result indicate that older companies may have received more governmental support. A possible reason might be that older firms have a stronger political network or on the basis of the concept 'too big to fail' incumbent firms became more public support.

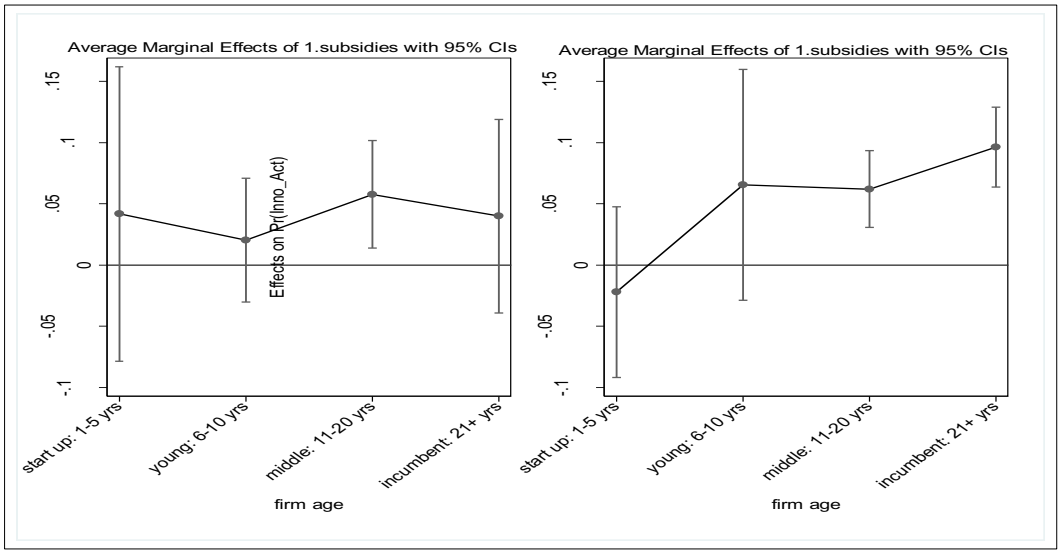


Figure 8 Marginal effects on predicted probability of firm's innovation activities with respect to receiving subsides across firm size before (left) and after (right) the crisis. Note: Marginal effects show if the difference between subgroups of a categorical variable are significant. Here, the reference group is "firm with no loan".

So far, we have looked at firms that have access to public funding, when considering firms with access to loans we can see that firms with a current loan have 32 percent higher odds than those that do not. Thus, it appears that firms with access to finance are more likely to innovate and we can confirm our fourth hypothesis. Previous findings have shown that small firms struggle more to access finance during a crisis (see e.g. Paunov, 2012; Teplykh, 2018; Correa and Iootty, 2010). Comparing firms predicted innovation activity with respect to having a loan across size groups before and after the GFC (see Figure 9, Table A4), we can see this also applies in this context. Even though, micro firms had the highest likelihood to innovate before the crisis, after the crisis medium sized and large firms (with a loan) are more likely to innovate. This again indicates a shift of innovation activities across firms towards larger companies. This shift could be caused because banks see investments in R&D and innovation as inherently risky, so they are

less likely to provide firms with important R&D activities with further financing during a crisis. This could be especially the case for smaller firms which have fewer financial collaterals compared to larger firms.

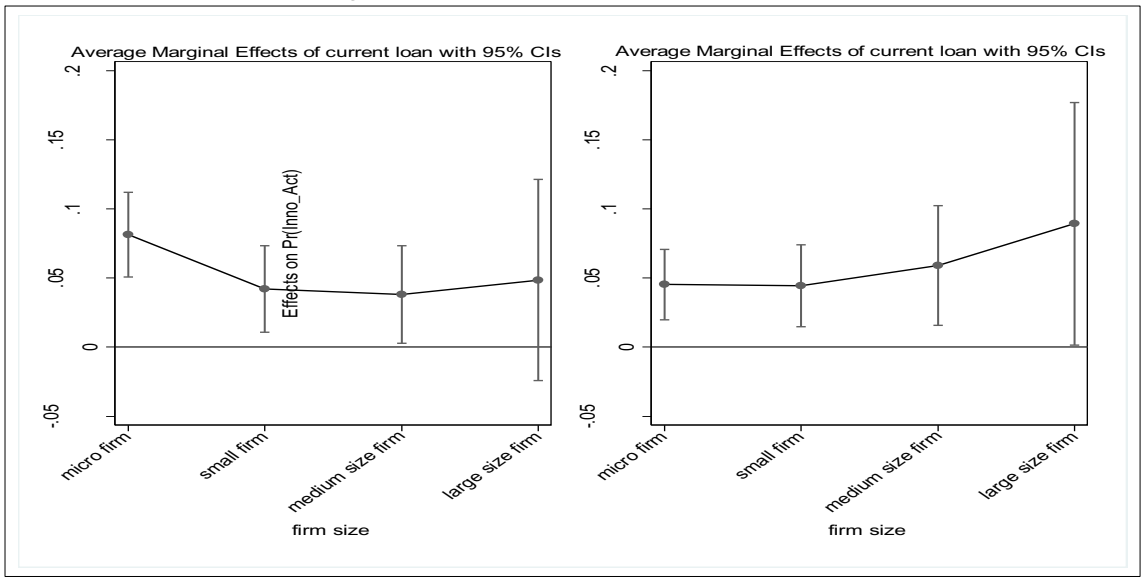


Figure 9 Marginal effects on predicted probability of firm's innovation activities with respect to having a current loan across firm size before (left) and after (right) the crisis. Note: Marginal effects show if the difference between subgroups of a categorical variable are significant. Here, the reference group is "firm with no loan".

Further, the results in column 1 of Table 3 show that firms that are doing well and increase their number of employees have 29 percent higher odds to innovate compared to those who maintain their employee number[11]. However, decreasing the number of employees does not have a significant impact. Interestingly, those firms with issues to access finance and firms with financial constraint in form of overdue payments have as well higher odds to innovate. How can this be? Companies that state accessing finance is a great obstacle have 28 percent higher odds to innovate than those with moderate difficulties. In addition, firms with overdue payments have 25 percent higher odds compared to firms that do not. What seems counterintuitive at first sight, becomes clearer on closer examination. Comparing the marginal effects of having overdue payments across firm size (see Figure 10; respective regression in Table A5), it becomes visible that after the crisis the likelihood of firms (disregarding size) with overdue payments to innovate decreases.

[11] Alternatively, to employee growth we used sales growth in our analysis. The findings are similar to employee growth. Firms that reported an increase in sales are more likely to innovate. Due to the high numbers of missing that occurred while creating this measure, we have chosen to not include sales growth in our main analysis.

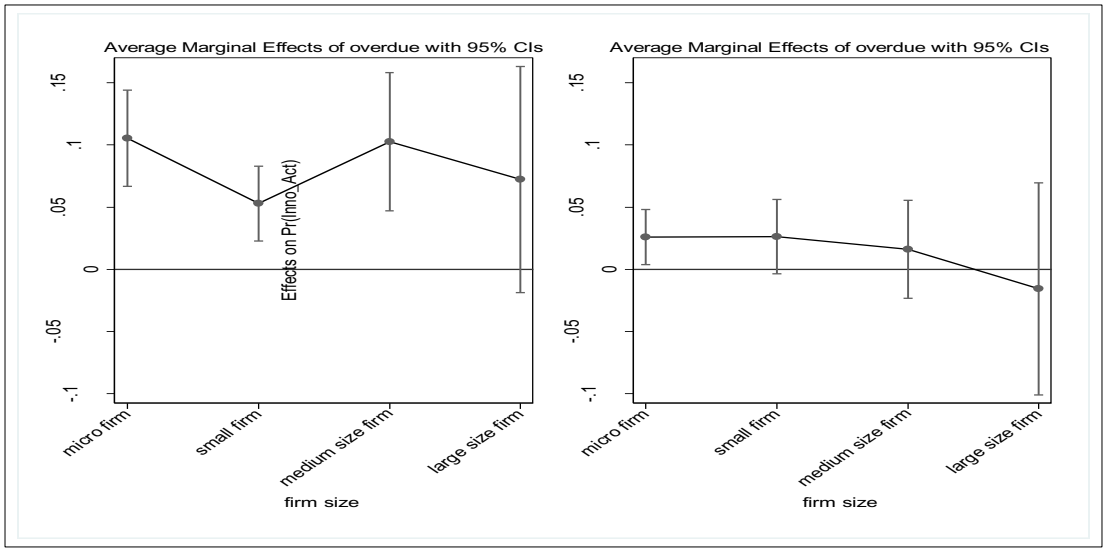


Figure 10: Marginal effects on predicted probability of firm's innovation activities with respect to overdue payments across firm size before (left) and after (right) the crisis. Note: Marginal effects show if the difference between subgroups of a categorical variable are significant. Here, the reference group is "no overdue payments".

Looking deeper into firms self-reported obstacles to access finance, Figure 11 shows that before the crisis there was no significant difference between minor and great obstacle accessing finance across firm size. However, after the crisis we see that the gap widens and the likelihood to innovate among firms with minor obstacles decreases by 15 percent points. These results indicate that innovating firms are more likely to face financial constraints than firms that do not pursue innovation activities. These findings are consistent with Mateut (2018) and Gorodnichenko and Schnitzer (2013).

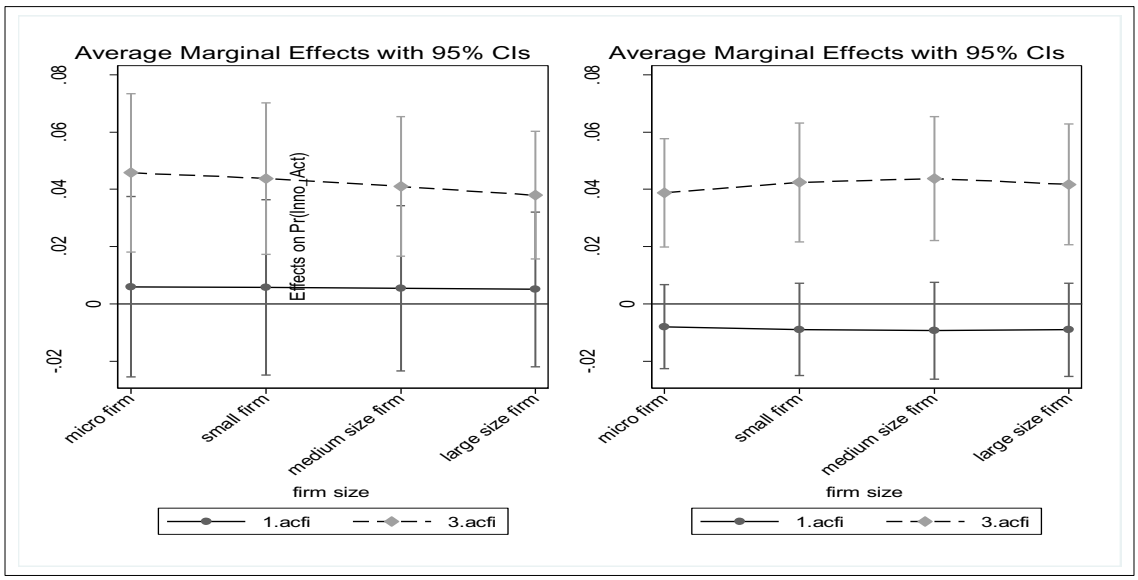


Figure 11: Marginal effects on predicted probability of firm's innovation activities with respect to obstacles accessing finance across firm size before (left) and after (right) the crisis. Note: Marginal effects show if the difference between subgroups of a categorical variable are significant. Here, the reference group is "moderate obstacle". 1.acfi refers to "minor obstacle to access finance"; 3.acfi refers to "great obstacle to access finance"

Moving to our control variables, our findings show that foreign firms have 28 percent higher odds to innovate compared to domestically owned ones. Further, companies involved in the export business have almost 50 percent higher odds to innovate than those that are not. These findings are in line with Paunov (2012) and show that internationalization (foreign ownership, export) helps to stimulate innovation.
Human capital measured as the share of employees with a university degree makes innovation activities within firms more likely. Firms where a majority of employees holds a university degree have 40 percent higher odds to innovate than firms with no university-trained employees. These results support the premise that innovation knowledge is impersonated in skilled workers and should not be dismissed due to a crisis (Paunov, 2012; Hall and Lerner, 2010). Besides, we control the firm's background whether the firm was privatized or run privately from the start. Our results suggest that privatized firms have around 20 percent fewer odds to engage in innovative activities compared to firms created by a joint venture etc., while the difference between joint ventures and private firms since their start is not significant. This could imply that privatized firms maybe offer a less creative environment and, thus, have less odds to innovate.

4.2 Robustness checks

Although firm age is a good measure for a firm's experience and knowledge base, it does not necessarily mean that the firm's manger is as experienced as firm age implies. Furthermore, Amore (2015) demonstrated that past experience shapes firms' innovation decisions during crises. Therefore, we additionally use an alternative measure of manager experience.

We present the robustness checks in column 2. Overall, our findings still hold. Of particular note is the difference in the odds for firm size. The odds to innovate increase by 2 percent points for medium sized firms and by 4 percent points for large firms compared to the baseline estimations. Firms run by managers with eleven to twenty years of experience have 30 percent higher odds compared to firms with unexperienced managers. Though, the odds to innovate decrease by 5 percent points for firms that employ managers with over twenty years of experience. This indicates that with higher age managers are getting less eager to innovate. Nevertheless, it supports our findings above. Figure 12 shows the predicted likelihood to innovate among firm age for both surveys. According to Figure 12, again before the GFC firms run by advanced experienced manager (11-20 years) have an increased probability to innovate compared to inexperienced companies, while after the GFC firms led by managers with more than 20 years of experience are more likely to engage in innovation activities. This indicates that during and after the crisis innovation activities across firms shifted and became more concentrated in experienced firms.

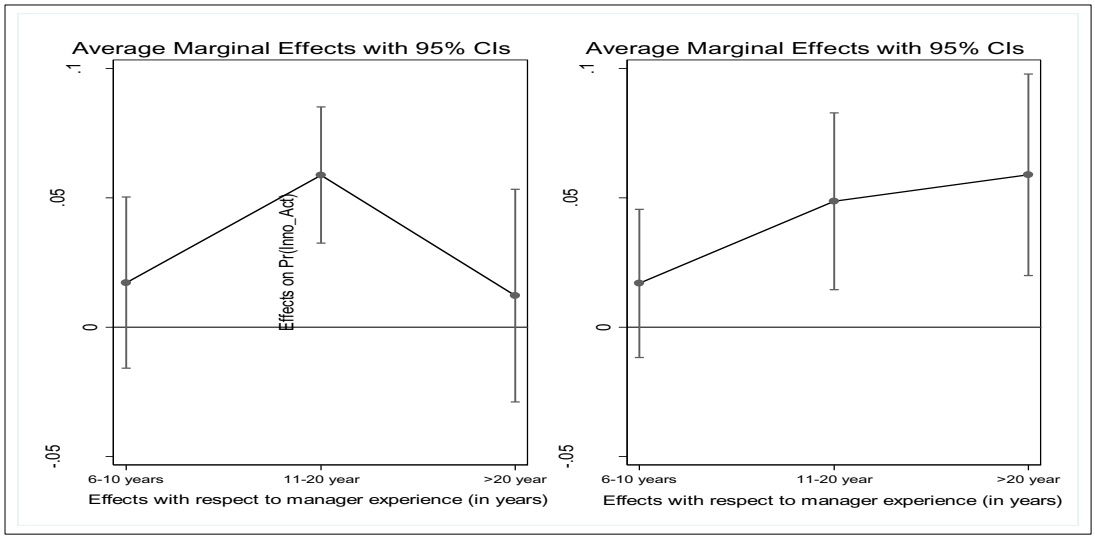


Figure 12: Marginal effects on predicted probability of firm's innovation activities with respect to manager experience before (left) and after (right) the crisis. Note: Marginal effects show if the difference between subgroups of a categorical variable are significant. Reference group is manager experience of 1-5 years.

So far, we have focused on product or process innovation as well as on pooled wave. Table 4 shows the results in column (1) of the pooled analysis only focusing on product or service innovation and in column (2) to (4) the surveys are analyzed separately referring to product/service innovation or in case of column (4) to process innovation. Overall, our findings remain similar. Slight differences appear when analyzing Beeps 2009 individually. Differences within the categories firm size and age are less significant. However, this confirms the results of the marginal plots presented before. Before the crisis, small firms as well as middle aged firms were more likely to innovate. However, after the crisis a shift of innovation activities happens towards large and incumbent firms having the highest odds to innovate which can be seen in the results of column (3). This is indicating a process towards creative accumulation. When only focusing on process innovation, we can see that the odds to innovate increase even more with age and size. This makes sense as process innovation conducted to reduce costs, to increase output or quality is more common among larger firms. This is in line with the results of (Paunov, 2012).

Table 4. Logit estimation results of BEEPS waves separately

	(1) Product pooled	(2) product_2009	(3) product_2012	(4) process_2012
Size: small firm	1.091**	1.198**	1.042	1.261***
	(0.0467)	(0.0711)	(0.0653)	(0.0889)
Size: medium firm	1.140*	1.147	1.247**	1.469***
	(0.0773)	(0.139)	(0.0891)	(0.113)
Size: large firm	1.195*	1.193	1.354**	1.746***
	(0.109)	(0.143)	(0.200)	(0.198)
Age: young firm (6-10)	1.163**	1.023	1.313***	1.379***
	(0.0541)	(0.0491)	(0.0887)	(0.131)
Age: middle aged (11-20)	1.280***	1.274***	1.298***	1.397***
	(0.0487)	(0.0766)	(0.0735)	(0.132)
Age: incumbent (>20)	1.341***	1.029	1.524***	1.505***
	(0.0839)	(0.0694)	(0.124)	(0.183)
RD activities	4.770***	4.355***	5.405***	5.651***
	(0.224)	(0.219)	(0.320)	(0.376)
Subsidies	1.376***	1.248**	1.409***	1.412***
	(0.0760)	(0.120)	(0.0721)	(0.124)
Current loan	1.276***	1.277***	1.274**	1.352***
	(0.0539)	(0.0585)	(0.0944)	(0.0716)
Overdue	1.280***	1.466***	1.150**	1.190**
	(0.0675)	(0.0887)	(0.0816)	(0.0729)
Employee growth increased	1.342***	1.387***	1.283***	1.161**
	(0.0601)	(0.0864)	(0.0739)	(0.0606)
Employee growth decreased	1.022	0.979	1.069	0.915
	(0.0475)	(0.0437)	(0.0741)	(0.0868)
Access finance: no/minor obstacle	0.973	1.026	0.911	1.067
	(0.0430)	(0.0759)	(0.0614)	(0.0741)
Access finance: great obstacle	1.202***	1.235***	1.142**	1.423***
	(0.0507)	(0.0775)	(0.0722)	(0.102)
N	21512	9092	12420	12499

Note: The dependent variable is binary standing for process or product/service innovation activities. Reference groups are as follows: for manager experience: 1-5 years; firm size: micro firms; employee growth: unchanged; access finance: moderate obstacle; edu: no workers with uni degrees. Same further controls included as in Table 3. Time controls, sector, and country fixed-effects included. Exponentiated coefficients; to better interpret our results, we transform the coefficients into odds ratio; standard errors in parentheses are clustered at the sector*wave level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$

4.3. Further analysis: subsamples

The post-socialist economies of Central and Eastern Europe and Central Asia are far from being a homogenous group. An advantage of the BEEPS data is, that it is possible to compare cross-country variations. To investigate possible heterogeneity on innovation activities across country groups, we estimate two subsamples with respect to EU-membership (see Table 5)[12]. Among countries with an EU membership, young firms have with 34 percent the highest odds to innovate compared to start-up firms. While in non-EU countries middle-aged firms have the highest odds to innovate. Once again, the difference in odds regarding firm size is noticeable. In transition countries without an EU

[12] As the group "other former communist countries" is a collection of a number of small, crisis-ridden countries, we decided to not include it in a separate estimation.

membership odds increase much more with firm size compared to EU transition countries. This could be related to the institutional environment in these countries which often fosters the success of larger firms. Moreover, we find that being involved in R&D activities increases the likelihood in both country groups. Although the impact is higher in non-EU countries. Consistent with the summary statistics showing that in EU countries more firms receive subsidies, the odds to innovate are in these countries 20 percent point higher than in non-EU countries. In both country groups, having a current loan increases the likelihood to innovate. However, the odds to innovate are 30 percent point higher among non-EU members. Hence, it appears that in these countries access to finance has a higher importance to innovating firms.

Table 5. Logit estimations of pooled subsamples with respect to EU-membership

	(1) EU transition countries	(2) None-EU countries
Size: small firm	1.078	1.204***
	(0.0678)	(0.0542)
Size: medium firm	1.186**	1.347***
	(0.0998)	(0.0830)
Size: large firm	1.237*	1.468***
	(0.139)	(0.139)
Age: young firm (6-10)	1.349**	1.137**
	(0.156)	(0.0631)
Age: middle aged (11-20)	1.187*	1.326***
	(0.111)	(0.0695)
Age: incumbent (>20)	1.260*	1.258***
	(0.162)	(0.0868)
RD activities	4.654***	5.808***
	(0.387)	(0.562)
Subsidies	1.517***	1.309**
	(0.131)	(0.130)
Current loan	1.148**	1.417***
	(0.0711)	(0.0625)
Overdue	1.270**	1.248***
	(0.109)	(0.0534)
Employee growth increased	1.124**	1.388***
	(0.0651)	(0.0746)
Employee growth decreased	0.964	1.015
	(0.0633)	(0.0543)
Access finance: no/minor obstacle	1.041	0.976
	(0.0889)	(0.0455)
Access finance: great obstacle	1.241**	1.266***
	(0.123)	(0.0710)
N	5901	15426

Note: The dependent variable is binary standing for process or product/service innovation activities. Reference groups are as follows: for manager experience: 1-5 years; firm size: micro firms; employee growth: unchanged; access finance: moderate obstacle; edu: no workers with uni degrees. Same further controls included as in Table 3. Time controls, sector, and country fixed-effects included. Exponentiated coefficients; to better interpret our results, we transform the coefficients into odds ratio; standard errors in parentheses are clustered at the sector*wave level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$

5. Conclusion

This study has investigated the innovation behavior of companies in 29 transition countries within Central Eastern Europe and the Commonwealth of Independent States and compares their innovation activities before and after the global financial crisis of the year 2008/2009. In our analysis, we make use of a broad definition of innovation activities including the introduction of new products/services or process innovations. The focus on these activities is due to their relevance towards these emerging and catching-up countries. Using BEEPS data, we investigated over 25,000 firms in two pooled surveys conducted in 2009 and 2012. Overall, we find strong empirical support for a shift of innovation activities from small to incumbent and large companies, indicating the Schumpeterian phenomenon of creative accumulation after the crisis. This is in line with our first hypothesis. However, young firms also have a higher likelihood to innovate after the crisis, whereas we cannot say the same regarding small firms. Thus, we cannot fully accept our second hypothesis. Furthermore, our findings highlight the importance of R&D activities within companies as these have a significant stabilization effect on firms' innovation behavior in times of crisis. This confirms our third hypothesis. Regarding financial measures, as already assumed, we find that firms that have access to finances in form of a loan or subsidies are more likely to innovate.

The countries under investigation have gone through a radical transformation process from a planned to a market economy and have reached different degrees of modernization and technological capability. The market-based innovation systems, even in EU transition economies, are relatively young and still developing a technological profile, networks between actors, and institutions. It is plausible to assume that an external shock hits these countries' innovation activity stronger as compared to established market economies. In the light of these considerations, it is insightful to observe that a major Schumpeterian theoretical prediction, creative accumulation, holds true. Creative destruction – small and young firms' innovation dynamics within/after a crisis – is not fully confirmed, probably an indication for the still weak or emerging start-up milieus in transition economies. Policy makers should be encouraged by our findings to support research and development activities in firms, which is a basis for innovative activities and helps firms to weather the crisis.

Our findings mostly align with what is found in the empirical literature. Creative destruction and creative accumulation are two co-existing scenarios and a clear distinction between those two is not possible. This is also reflected in the findings of the empirical literature. While some studies show a stronger tendency to creative destruction during the economic crisis 2008/2009 in Europe (Archibugi *et al.*, 2013a, 2013b), most findings suggest that established companies are more likely to innovate during this economic downturn which points to creative accumulation (Correa and Iootty, 2010; Paunov, 2012; Teplykh, 2018). In this respect, our paper supports these findings.

As every empirical analysis, our investigation is not without limitations. Firstly, companies that did not survive the crisis are not in the data set. However, we are mainly interested in the innovation behavior of companies that survived the crisis or were created during the crisis. Thus, this limitation does not undermine our results; it is just

that we cannot say anything about the firms that dropped out of the market. Hence, we cannot answer the question whether non-surviving firms left the market because they were less innovative and thus less successful or they might have exited because innovation activities depleted their financial resources. Looking deeper into this controversial connection between innovation and survival in the context of transition countries would complement this research area. Secondly, due to data restrictions, we cannot control for the differences of maintaining, increasing or decreasing innovation activities only for the type of firms that do innovate in times of crisis. Therefore, we are only able to observe the aggregated shifts in firms' innovation behavior. This limitation stresses the need of further research on this matter. Given the overall decline in innovation activities during the GFC, the question remains whether this decline in innovation and R&D activities is less pronounced for larger firms or whether larger firms are using innovation as a coping strategy to get through the crisis. Thirdly, even though we are not able to show a causal relationship, through the variety of controls this paper attempts to established as best as possible how size, age, R&D activities and financial measures affect innovation. Finally, even though self-reported measurements provide in our case earlier mentioned advantages, we are aware that self-reported data are more vulnerable to measurement error and cultural bias.

Our paper contributes to the strand of literature dealing with the Schumpeterian models of creative destruction and creative accumulation in times of crisis. Given the important link between innovation and long-term economic growth this topic is of great importance and research on it should be deepened and expanded. As we only compare two points within one business cycle (before and after the crisis), it would be interesting to expand our analysis with panel data which covers more cycles and would allow us to get deeper insights in this topic.

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Appendix

*Table A1. Logit estimation results of pooled BEEPS waves: Interaction R&D*wave*

	(1)
Size: small firm	1.160***
	(0.0471)
Size: medium firm	1.279***
	(0.0687)
Size: large firm	1.385***
	(0.0985)
Age: young firm (6-10)	1.175**
	(0.0603)
Age: middle aged (11-20)	1.280***
	(0.0597)
Age incumbent (>20)	1.304***
	(0.0854)
Subsidies	1.363***
	(0.0760)
Current loan	1.318***
	(0.0447)
Overdue	1.261***
	(0.0479)
Access finance: no/minor obstacle	0.994
	(0.0449)
Access finance: great obstacle	1.283***
	(0.0587)
1.RD_activities	4.026***
	(0.235)
2.wave#1.RD_activities	1.853***
	(0.154)
N	21395

Note: The dependent variable is binary standing for process or product/service innovation activities. Reference groups are as follows: firm size: micro firms; access finance: moderate obstacle. Other controls included as well as time controls, sector, and country fixed-effects included. Exponentiated coefficients; to better interpret our results, we transform the coefficients into odds ratio; standard errors in parentheses are clustered at the sector*wave level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$

*Table A2. Logit estimation results of pooled BEEPS waves: Interaction R&D*age*

	(1) BEEPS 2009	(2) BEEPS 2012
Size: small firm	1.330***	1.132*
	(0.0810)	(0.0809)
Size: medium firm	1.437***	1.432***
	(0.113)	(0.114)
Size: large firm	1.675***	1.673***
	(0.149)	(0.204)
Age: young firm (6-10)	0.903*	1.311***
	(0.0551)	(0.103)
Age: middle aged (11-20)	1.197**	1.330***
	(0.0842)	(0.0947)
Age: incumbent (>20)	0.985	1.512***
	(0.0764)	(0.126)
Subsidies	1.317**	1.449***
	(0.122)	(0.0840)
Current loan	1.290***	1.381***
	(0.0593)	(0.0701)
Overdue	1.468***	1.167***
	(0.0842)	(0.0544)
Access finance: no/minor obstacle	1.014	0.971
	(0.0836)	(0.0433)
Access finance: great obstacle	1.229***	1.323***
	(0.0747)	(0.0820)
young#1.RD_activities	1.756**	1.097
	(0.427)	(0.237)
Middle aged#1.RD_activities	1.092	1.024
	(0.234)	(0.175)
Incumbent#1.RD_activities	1	1
	(.)	(.)
N	8978	12428

Note: The dependent variable is binary standing for process or product/service innovation activities. Reference groups are as follows: firm size: micro firms; access finance: moderate obstacle. Other controls included as well as time controls, sector, and country fixed-effects included. Exponentiated coefficients; to better interpret our results, we transform the coefficients into odds ratio; standard errors in parentheses are clustered at the sector*wave level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$

*Table A3. Logit estimation results of pooled BEEPS waves: Interaction R&D*size*

	(1) BEEPS 2009	(2) BEEPS 2012
Size: small firm	1.321***	1.130*
	(0.0665)	(0.0745)
Size: medium firm	1.432***	1.415***
	(0.109)	(0.109)
Size: large firm	1.707***	1.692***
	(0.144)	(0.222)
Age: young firm (6-10)	1.034	1.315***
	(0.0543)	(0.0877)
Age: middle aged (11-20)	1.281***	1.327***
	(0.0833)	(0.0913)
Age: incumbent (>20)	1.032	1.503***
	(0.0695)	(0.140)
Subsidies	1.310**	1.448***
	(0.123)	(0.0863)
Current loan	1.291***	1.380***
	(0.0587)	(0.0698)
Overdue	1.456***	1.167***
	(0.0825)	(0.0543)
Access finance: no/minor obstacle	1.011	0.971
	(0.0839)	(0.0431)
Access finance: great obstacle	1.233***	1.324***
	(0.0761)	(0.0821)
small#1.RD_activities	1.104	1.085
	(0.255)	(0.321)
medium#1.RD_activities	1.083	1.174
	(0.273)	(0.406)
large#1.RD_activities	1	1
	(.)	(.)
N	8978	12428

Note: The dependent variable is binary standing for process or product/service innovation activities. Reference groups are as follows: firm size: micro firms; access finance: moderate obstacle. Other controls included. Time controls, sector, and country fixed-effects included. Exponentiated coefficients; to better interpret our results, we transform the coefficients into odds ratio; standard errors in parentheses are clustered at the sector*wave level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$

*Table A4. Regression results of pooled waves: Interaction loan*size*

	(1) BEEPS 2009	(2) BEEPS 2012
Size: small firm	1.276***	1.136
	(0.0849)	(0.102)
Size: medium firm	1.234**	1.317**
	(0.113)	(0.116)
Size: large firm	1.219	1.281
	(0.199)	(0.296)
Age: young firm (6-10)	1.026	1.301***
	(0.0488)	(0.0815)
Age: middle aged (11-20)	1.285***	1.331***
	(0.0775)	(0.0906)
Age: incumbent (>20)	1.033	1.495***
	(0.0684)	(0.143)
Subsidies	1.259**	1.420***
	(0.120)	(0.0795)
Overdue	1.467***	1.143**
	(0.0868)	(0.0639)
Access finance: no/minor obstacle	1.028	0.953
	(0.0773)	(0.0435)
Access finance: great obstacle	1.235**	1.257***
	(0.0816)	(0.0714)
1.current_loan	1.452***	1.310***
	(0.106)	(0.0994)
small#1.current_loan	0.842*	0.973
	(0.0846)	(0.104)
medium#1.current_loan	0.835	1.042
	(0.113)	(0.145)
large#1.current_loan	0.896	1.246
	(0.185)	(0.318)
N	9110	12452

Note: The dependent variable is binary standing for process or product/service innovation activities. Reference groups are as follows: firm size: micro firms; access finance: moderate obstacle. Other controls included as well as time controls, sector, and country fixed-effects included. Exponentiated coefficients; to better interpret our results, we transform the coefficients into odds ratio; standard errors in parentheses are clustered at the sector*wave level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$

*Table A5. Regression results of pooled waves: Interaction overdue*size*

	(1) BEEPS 2009	(2) BEEPS 2012
Size: small firm	1.379***	1.133
	(0.0986)	(0.103)
Size: medium firm	1.111	1.414**
	(0.111)	(0.150)
Size: large firm	1.253	1.739**
	(0.229)	(0.369)
Age: young firm (6-10)	1.025	1.301***
	(0.0492)	(0.0810)
Age: middle aged (11-20)	1.276***	1.330***
	(0.0765)	(0.0920)
Age: incumbent (>20)	1.025	1.497***
	(0.0688)	(0.144)
Subsidies	1.251**	1.422***
	(0.123)	(0.0809)
Current loan	1.277***	1.317***
	(0.0588)	(0.0656)
Access finance: no/minor obstacle	1.026	0.951
	(0.0762)	(0.0438)
Access finance: great obstacle	1.233**	1.255***
	(0.0793)	(0.0720)
1.overdue	1.622***	1.175**
	(0.149)	(0.0814)
small#1.overdue	0.793**	0.986
	(0.0841)	(0.0930)
medium#1.overdue	1.031	0.927
	(0.144)	(0.112)
large#1.overdue	0.907	0.782
	(0.230)	(0.200)
N	9110	12452

Note: The dependent variable is binary standing for process or product/service innovation activities. Reference groups are as follows: firm size: micro firms; access finance: moderate obstacle. Other controls included as well as time controls, sector, and country fixed-effects included. Exponentiated coefficients; to better interpret our results, we transform the coefficients into odds ratio; standard errors in parentheses are clustered at the sector*wave level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$

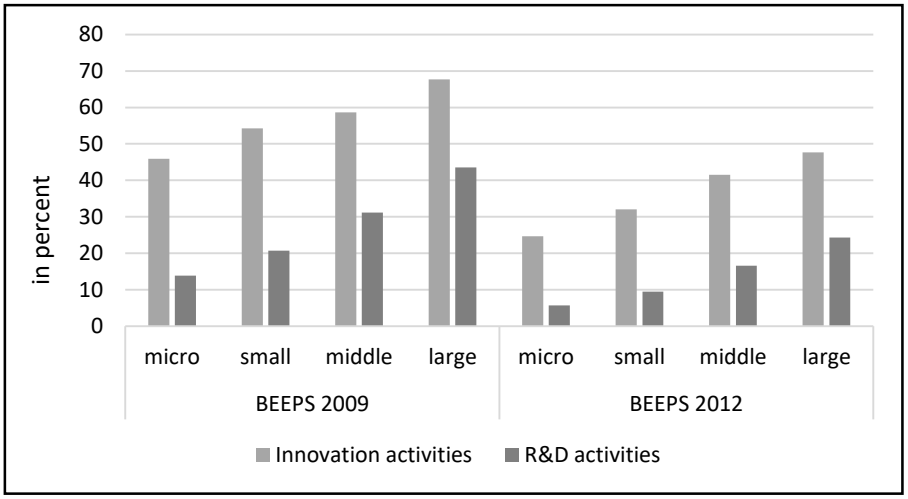

Figure A1: Share of firms (in % of all firms) involved in innovation and R&D activities per firm size category. Source: BEEPs surveys 2009 and 2012

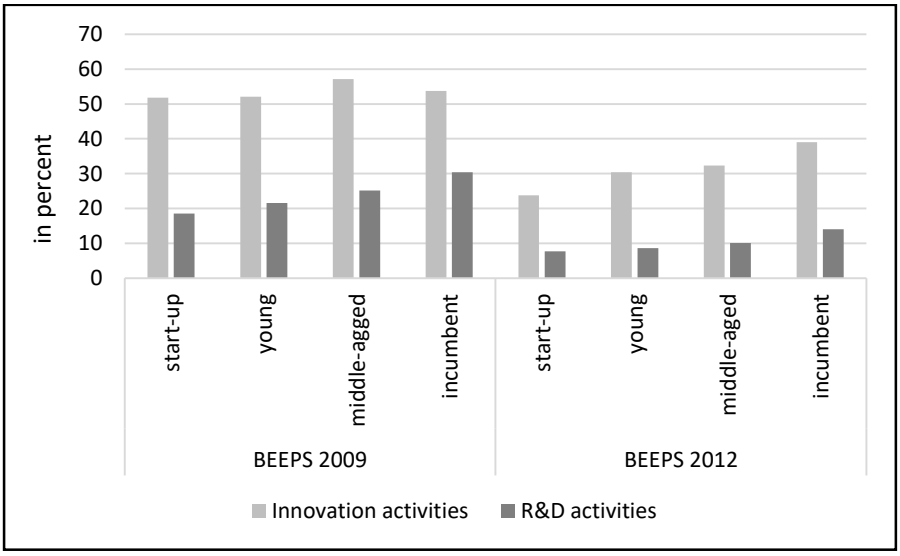

Figure A2: Share of firms (in % of all firms) involved in innovation and R&D activities per firm age category. Source: BEEPs surveys 2009 and 2012

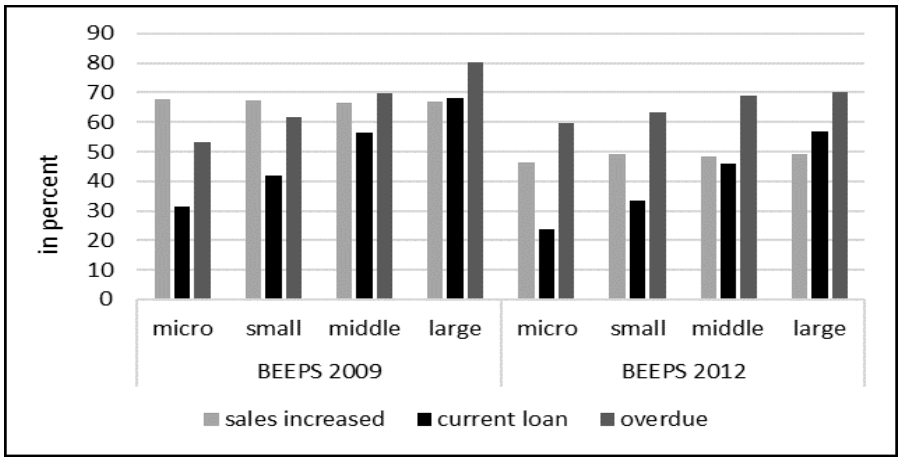

Figure A3: Share of firms (in % of all firms) within financial categories per firm size category. Source: BEEPs surveys 2009 and 2012

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