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Oxana Babecká Kucharčuková, Renata Pašalićová

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An Investigation with Czech Firm-Level Data

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Reviewed by: Diana Žigraiová (IES Charles University)
Filip Novotný (Czech National Bank)

Project Coordinator: Jan Babecký

Firm Investment, Financial Constraints and Monetary Transmission: An Investigation with Czech Firm-Level Data

Oxana Babecká Kucharčuková and Renata Pašalićová [*]

Abstract

This project investigates the effect of financial constraints and monetary policy on firms' investment behaviour using Czech firm-level data. The empirical specification is based on the dynamic neoclassical investment model, which explains investment by sales and cash flow. In addition, it includes financial constraints and other factors. We differentiate firms according to their size and type of economic activity. We find that indebtedness and availability of liquidity have significant effects on investment. In the post-crisis period firms obtained less additional credit due to greater riskiness and tended to accumulate more liquidity. Expectations about future GDP growth and business sentiment are positively related to investment. At the same time, we observe considerable heterogeneity of the results across sectors. The impact of the short-term real interest rate is highly significant for firms of all sizes and in all important sectors of the Czech economy, reflecting monetary policy effectiveness.

Abstrakt

Tato analýza zkoumá vliv finančních omezení a měnové politiky na investiční rozhodování českých podniků. Použitá empirická specifikace je založená na dynamické verzi neoklasického modelu investic, vysvětlujícího intenzitu podnikových investic vývojem tržeb a cash flow. Dále je rozšířená o finanční omezení a jiné faktory. Podniky rozlišujeme podle jejich velikosti a typu ekonomické aktivity. Výsledky ukazují, že podnikové investice jsou významně ovlivňovány zadlužeností a dostupností likvidity. Zejména v pokrizovém období podniky čerpaly méně úvěrů v důsledku zvýšené rizikovosti a více akumulovaly likviditu. Pozitivní očekávání budoucího růstu HDP a sentimentu podniků příznivě ovlivňují vývoj investic. Současně je pozorována významná heterogenita uvedených výsledků napříč jednotlivými odvětvími. Dopad krátkodobé úrokové sazby na investiční rozhodování je velmi signifikantní, a to u všech podniků z hlediska jejich velikosti a ve všech významných odvětvích, což odráží účinné působení měnové politiky.

JEL Codes: D22, E5, E22, G3, G32.

Keywords: Financial constraints, firms, indebtedness, investment, liquidity, monetary policy.

[*] Oxana Babecká Kucharčuková, External Economic Relations Division, Monetary Department, Czech National Bank, Na Příkopě 28, 115 03 Praha 1, Czech Republic; oxana.babecka-kucharcukova@cnb.cz.
Renata Pašalićová, Monetary Policy and Fiscal Analysis Division, Monetary Department, Czech National Bank, Na Příkopě 28, 115 03 Praha 1, Czech Republic; renata.pasalicova@cnb.cz.
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Nontechnical Summary

Investment activity was significantly affected by the last financial crisis and remains below its pre-crisis level in the euro area and other EU countries, including the Czech Republic. Weak aggregate demand is the most likely explanation of this phenomenon. Other factors, however, can also influence the dynamics of investment, most notably financial constraints and uncertain economic conditions.

In the past, research in this area often used national accounts data and other macroeconomic indicators or data aggregated by economic sectors. Nowadays, it tends to focus more and more on firm-level data. We follow this second approach, which we believe complements macroeconomic analysis. The ultimate advantage of disaggregated data is that it allows us to capture heterogeneity among businesses and test whether the impacts of key variables such as monetary policy differ across various types of firms.

In this paper, we analyse the effect of financial limitations and monetary policy on investment. Our empirical specification is based on the dynamic neoclassical investment model derived from the CES production function and augmented by proxies for financial constraints and the monetary policy stance. We also include macroeconomic control variables such as uncertainty and expectations. We use the balance sheet data of Czech firms over 2003–2015. The data come from the dataset harmonised by the CNB for the ECB Competitiveness Network database. Although our initial aim was to compare the periods before and after the crisis, the low number of observations in the first period forced us to focus mainly on recent years and distinguish firms by size and type of economic activity. Indeed, recent years are the most interesting for the analysis. It is widely documented in the literature that financial constraints became a decisive factor in firms' investment decisions mainly in the post-crisis period.

Our results confirm that corporate investment is influenced by financial variables and expectations about future economic prospects as well as by the monetary policy stance. Furthermore, our analysis shows that indebtedness and the availability of liquidity have significant effects on investment as well. Slightly higher indebtedness might have caused Czech firms to obtain less additional credit due to greater riskiness in the post-crisis period. At the same time, firms have tended to accumulate more liquidity due to uncertainty about the economic conditions and future profitability. The highest elasticity to debt is found in industry and services, while industry as a whole and wholesale and retail trade are the most sensitive to liquidity. Second, expectations about domestic GDP growth one year ahead and business sentiment are positively related to investment. This result is robust to alternative measures of expectations and uncertainty. Finally, the coefficient on the real interest rate is mostly negative and significant, indicating that monetary policy tightening increases the costs of financing and reduces investment.

1. Introduction

Investment by non-financial corporations is an important driver of Czech economic growth. Investment throughout the EU was significantly affected by the last financial crisis and remains below its pre-crisis level.[1] The crucial role of investment in the past and the uncertainty about its future prospects are causing researchers and policy makers to focus on the role of macroeconomic and financial determinants of investment activity. Gürtler (2017) proves that given the high degree of Czech economic openness, foreign demand tends to be the most important factor explaining changes in capital. He additionally stresses the role of expectations about future demand and the increasing impact of expectations over time. He finds that private investment is also influenced positively by EU funds and depreciation of the real exchange rate and negatively by the real interest rate. According to Ferrara et al. (2015) factors other than aggregate demand may influence the dynamics of investment. These factors include financial variables and uncertainty of economic conditions in particular. Furthermore, the authors point out that the nature of the shock matters, as different shocks may have different implications for monetary policy.

It is widely documented in the literature that firms' financing decisions play a crucial role in determining investment. There is no unique approach to measuring firms' sensitivity to financial constraints. Some studies estimate the importance of reliance on internal financing. Others use information on financial variables or surveys, such as the financial cost differential between external financing sources or information on firms' perceptions of their access to finance (as an obstacle to growth and expansion). Furthermore, recent research tends to focus more and more on firm-level data. This approach complements macroeconomic analysis. The ultimate advantage of disaggregated data is that it allows us to capture heterogeneity among businesses and test whether the impacts of key variables such as monetary policy differ across various types of firms.

In this paper, we look at both financial constraints and monetary policy. We use firm-level data to construct proxies for firms' financial health. We then analyse the effect of these indicators on investment by firms. Studies based on firm balance sheet data are less common in this research area. To the best of our knowledge, the present research is the only study focusing on both financial constraints and Czech firms. More precisely, we estimate the sensitivity of investment to cash flow, liquidity, debt, the real interest rate and expectations. We provide results for the whole sample, then we estimate our model for individual sectors and groups of enterprises by size. Therefore, the analysis contributes to a better understanding of firms' investment behaviour observed after the last economic and financial crisis.

The rest of this paper has the following structure. The next section describes some key stylised facts relating to private investment and based on firms' balance sheet structure. The third section briefly summarises the literature on this topic. The estimation approach is explained in the fourth section. The fifth and sixth sections describe the data and results, and the seventh section concludes.

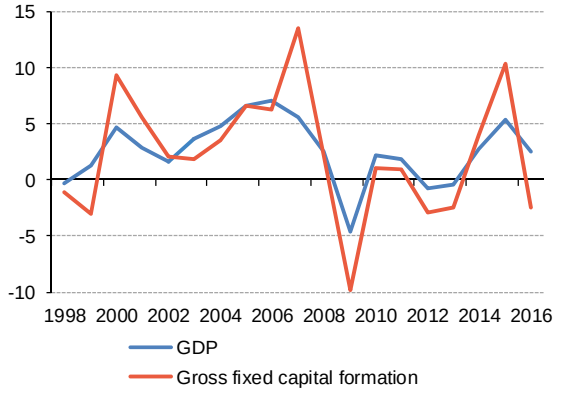
[1] According to empirical findings, financial crises generally have a long-lasting effect on investment. Evidence from previous crises shows that the decline in the investment-to-GDP ratio can last longer than expected. For instance, IMF (2014) shows that the peak effect occurs almost three years after the crisis.

2. Stylised Facts

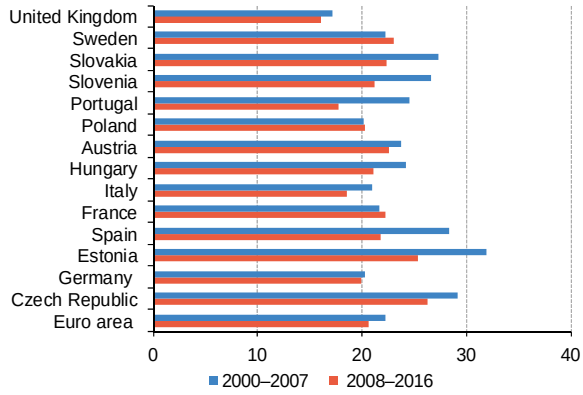
Investment in the Czech Republic slowed markedly during the last global financial crisis. The annual growth rate of investment plunged from 14% in 2007 to -10% in 2009. Investment as a share of GDP reached 25% in 2016 – a very low level compared to what was observed before, although still one of the highest figures in the EU (Figure 1). Despite the subsequent gradual recovery and easing of financial conditions, private investment rates remain below their pre-crisis levels across the EU.[2]

Figure 1: Investment and GDP Growth in the Czech Republic and International Comparison

a) Investment vs. GDP growth in %



b) Investment as a percentage of GDP



Source: CZSO and Eurostat.

Looking at Czech firms' balance sheet structure, we see a clear decrease in fixed assets. The possible explanations for this include a fall in investment in buildings (probably associated with limited foreign direct investment inflows) and a stagnating share of investment in machinery and equipment. Corporate holdings of fixed assets play a crucial role in firms' assets. The importance of cash holdings – a short-term financial asset – has simultaneously increased (Figure 2). This trend has been observed in the majority of euro area countries and can be attributed to an increased level of uncertainty about economic policy and to a continuous decline in cross-border capital flows. This has forced companies to accumulate cash in order to insure themselves against potential financial constraints.

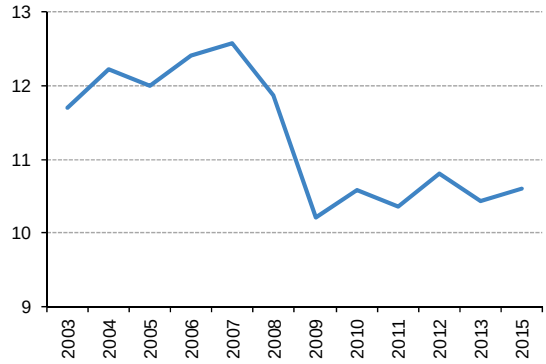
At the same time, corporate indebtedness has increased slightly in the recent period. However, it is still low compared to the euro area. According to the Bank Lending Survey, firms have borrowed less from banks and relied more on their own sources and on alternative forms of financing in the post-crisis period. Looking at Wage Dynamics Network (WDN) survey data, Babecký et al. (2015) find that for the majority of firms, the availability of credit had little or no relevance in the period 2010–2013. Moreover, since 2014, demand for loans has been driven

[2] The investment rates of Central and Eastern European countries (CEE EU) have been higher than those in the euro area since the turn of the century. This is explained by a relative scarcity of capital and an associated higher return on investment. In the aftermath of the global financial crisis, investment rates fell across the EU, but the decline was steeper in CEE EU. This reflected a sudden halt in capital inflows into CEE EU, a loss of income, higher risk premiums and deleveraging, which led to a higher saving rate.

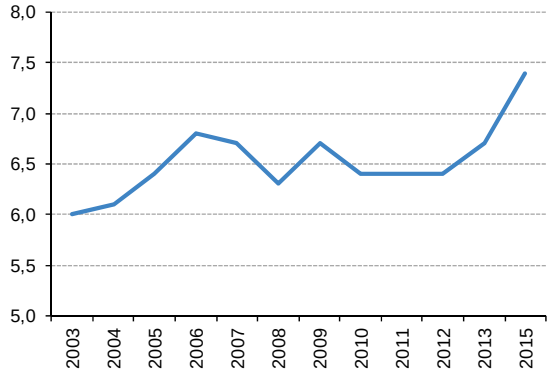
primarily by financing of mergers/acquisitions and corporate restructuring, debt restructuring and by financing of real estate activities. On the other hand, the capital market in the Czech Republic is small. As a consequence, firms have limited access to capital and need to use bank loans extensively to finance their investment.

Figure 2: Evolution of Selected Firm Balance Sheet Items over Time, Ratios in %

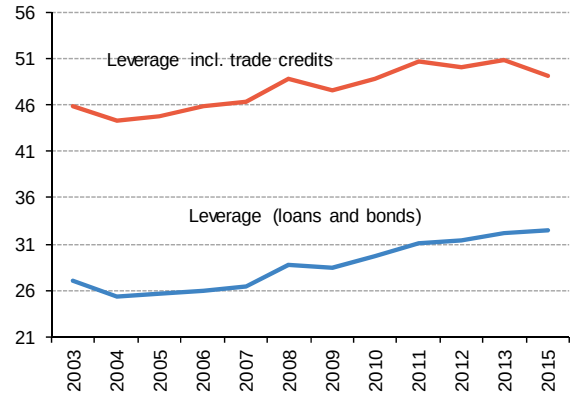
a) Cash Flow
(EBIT plus depreciation/total fixed assets)



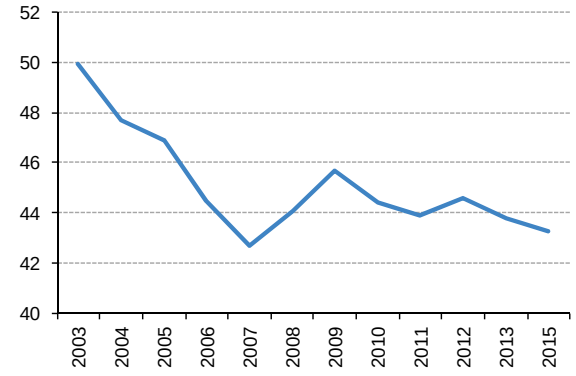
b) Liquidity
(cash holdings/total assets)



c) Debt
(debt/total assets)



d) Fixed Assets
(fixed assets/total assets)



Source: Annual balance sheet and income statement data from CZSO, CNB calculation for EC BACH database and CompNet.

3. Literature

In recent years, several empirical studies have tried to understand and explain the weakness in corporate investment. They have analysed various determinants of changes in investment, using a broad range of econometric techniques based on numerous theoretical approaches. However, no strong consensus has emerged on the specific reason for the weak business investment, although the demand factor has often been put forward (see IMF, 2015, for a summary of these approaches). IMF (2015) combines both micro- and macro-approaches. First, it studies business

investment in advanced economies and emerging markets at the aggregate level. The results suggest that falling output is the main factor behind the decline in investment. The country-specific analysis also emphasises the significant role played by financial constraints and uncertainty in the decline in business investment in stressed countries (Greece, Ireland, Italy, Portugal and Spain). Moreover, the micro-level data for advanced economies over the period 2000–2013 show that firms most dependent on external financing are those where investment has been significantly affected over the sample period, which in turn reflects the impact of financial constraints.

Another stream of empirical literature focuses on analysing the weakness in private non-residential investment in the euro area (see, for example, Barkbu et al., 2015[3]). According to these studies, declining output is the main factor behind the weak private non-residential investment. Other contributors to the weakness of investment include an increased real user cost of capital (mainly for stressed countries) as a result of financial fragmentation and, to a lesser extent, uncertainty, which was found to be significant in most countries, with the exception of the stressed economies. Moreover, the authors did not find any impact of cash flow and leverage on the macro level.

Turning to studies based on firm-level data, Chatelain et al. (2001) find investment to be sensitive to the user cost of capital and cash flow movements in major euro area countries (Germany, France, Italy and Spain). Furthermore, Mojon et al. (2002) show that the average interest on debt corresponding to investment is generally higher for small firms than for large firms in the euro area. However, there is little evidence that the effects of monetary policy on small firms are larger. On the other hand, Butzen et al. (2001), using Belgium firms' balance sheet data, note that investment by small firms is more sensitive to changes in cash flow than investment by large firms. At the same time, the user cost of capital does not seem to be important for investment in Belgium. Benito and Whitley (2003) examine this problem in the context of the UK economy. In contrast to the above-mentioned study, they find a significant negative effect of the user cost of capital. While they find that the interest paid by smaller firms is higher on average, they do not find any evidence suggesting that small firms are more sensitive with regard to monetary policy. Kátay and Wolf (2004) show that the effect of changes in the user cost of capital and cash flow on investment is significant in Hungary, which suggests that financial variables do matter for firms.

The Global Financial Stability Report (2014) concludes that firms invest when the expected marginal return on additional capital is higher than its costs. The report also finds that firms increase capital expenditure when profitability rises. Bloom et al. (2007 and 2009) focus on impact of uncertainty and cash flow on investment and find that uncertainty influences business investment in the UK and the US. Mizen and Vermeulen (2005) show that investment sensitivity in Germany and the UK to cash flow is mainly due to creditworthiness. Hobdari et al. (2009) find that investment is determined by firm profitability. They assume two groups of firms: financially constrained and financially unconstrained. The sensitivity of profitability to investment changes when a firm is assumed to operate in a financially constrained situation compared to a financially unconstrained one.

[3] This approach was first applied by Jorgenson (1971) and then developed by Bertola and Caballero (1994) and Lee and Rabanal (2010).

The recent financial crisis increased research interest in the role played by financial constraints. A substantial part of the new research in this area provides empirical evidence on the causal role of bank credit in explaining the collapse in corporate investment during the recent financial crisis. Buca and Vermeulen (2012) show that firm investment became highly sensitive to bank debt during the investment collapse of 2009. They use annual balance sheet data over the period 2000–2009 for Germany, France, Italy, Spain, Belgium and Portugal. Moreover, during the crisis, higher bank debt leverage of firms is associated with reduced investment, which is larger for small and medium-sized firms. These bank-dependent borrowers were sensitive to bank loans in 2009, whereas large firms were not.

Corporate investment dynamics, credit rationing and financial constraints in the Czech context have been tested by Lízal and Švejnar (2001). Pruteanu-Podpiera (2007) focuses on behaviour of Czech firms during 1997–2002. Horvath (2005) examines a panel of Czech firms and concludes that balance sheet indicators matter for the interest rate that banks charge firms. Galuščák and Lízal (2011) provide estimates of the production function for Czech manufacturing firms. Firm investment in our paper is analysed in a similar manner – but with differences in terms of content and aim – in Pospíšil and Schwarz (2014), who put an emphasis on bankruptcy, and in Gürtler (2017), who focuses on the determinants of firm investment.

4. Empirical Model

The economic literature explains the dynamics of fixed investment using three different theoretical approaches: the accelerator model, the neoclassical model and Tobin's q model. The accelerator and neoclassical models assume that the desired capital stock level is proportional to the level of output. More precisely, changes in the actual level of capital can be explained by changes in the desired level of capital, which in turn will be proportional to the change in output (Clark, 1917, and Jorgenson, 1971). The neoclassical accelerator model additionally explains investment by the user cost of capital (Jorgenson, 1971). The Tobin's q model of investment uses a proxy for the value of a unit of capital in place relative to its current purchase price (Tobin, 1969).

Our empirical strategy is based on the neoclassical dynamic investment equation. This equation is derived from the constant elasticity of substitution (CES) production function.[4] In its general form, the investment equation is defined for each firm's investment (*I)* to capital (*K*) ratio as a function of sales (*Y*), cash flow (*CF*), the user cost of capital (*UC*) and firm indebtedness (*DT*):

$$\frac{I}{K} = f(Y, CF, UC, DT). \qquad (1)$$

The empirical literature offers numerous versions of this equation. Some studies take the explanatory variables in growth rates (log differences), while others compute the ratio of investment to the lagged value of capital. The econometric procedure also varies across studies: error correction equation, probit regression, regime-switching regression, ADL model. In addition, substantial differences in data availability on the micro level lead to differences in the

[4] The CES production function assumes that the production technology has a constant percentage change in labour and capital proportions due to a percentage change in the marginal rate of technical substitution.

approximation of theoretically grounded variables. All this makes the results hard to compare across studies, so choosing the "true" specification is challenging. Since our main objective is to measure the sensitivity of investment to financial constraints and monetary policy before and after the last financial crisis, we split the sample into two parts, which makes the estimated period quite short for analysing long-run relations. For this reason, we do not consider the error correction model and write the investment equation in ADL form. The empirical specification follows the Hobdari et al. (2009) and Pospíšil and Schwarz (2014) approaches. We augment the baseline specification with two variables capturing financial constraints and firm indebtedness (*FIN*). We also add two macroeconomic variables measuring uncertainty and expectations of macroeconomic development (*EXP*), as well as a variable reflecting the impact of monetary policy (*MP*). After the additional variables are inserted, the estimated equation takes the form described by equation (2), which we estimate with time- and sector-specific dummies (D_k):

$$\frac{I_{it}}{K_{it-1}} = \beta_1 \cdot \frac{I_{it-1}}{K_{it-2}} + \beta_2 \cdot \left(\frac{I_{it-1}}{K_{it-2}}\right)^2 + \beta_3 \cdot \frac{Y_{it-1}}{K_{it-1}} + \beta_4 \cdot \frac{CF_{it-1}}{K_{it-1}} + \sum_{n=1}^{2} \beta_n \cdot FIN_{it-1}^n + \sum_{n=1}^{2} \beta_n \cdot EXP_{it-1}^n + \beta_7 \cdot MP_{t-1} + \sum_{k=1}^{K} \lambda_k \cdot D_k + \varepsilon_{it}. \quad (2)$$

The investment ratio is estimated as the ratio of the sum of the change in capital (Δk) and depreciation (δ) to the capital of the previous period: $\frac{\Delta k_{it} + \delta_{it}}{k_{it-1}}$. Due to the sample length, equation (2) is estimated with one lag.

Similar to Hobdari et al. (2009) and Pospíšil and Schwarz (2014) we include the square term of the lagged dependent variable, but more importantly there is no user cost of capital in either their specification or ours. Although this is a theoretically grounded variable, its computation requires a lot of assumptions, such as the use of data aggregated at the sectoral level or for the total economy as an approximation of firm-level data. More importantly, however, we were unable to obtain some of the necessary information with the database we use.[5] The user cost of capital depends on, among other things, the firm-specific interest rate (average interest paid on debt), which in turn is influenced by monetary policy – see Mojon (2002) for an example of empirical results on monetary policy transmission. Given the absence of the user cost of capital from our empirical

[5] We estimated the user cost of capital following, for instance, Mojon (2002):

$$UCC_{kt} = \frac{p^I{}_{kt}}{p_{kt}}\left[\left(\frac{D_{kt}}{D_{kt}+E_{kt}}\right) ID_{kt}(1-u_t) + \left(\frac{E_{kt}}{D_{kt}+E_{kt}}\right) i_t + \delta_{kt} + (1-\delta_{kt})\frac{\Delta p^I{}_{kt+1}}{p^I{}_{kt}}\right],$$

where p^I and p are, respectively, firm-specific prices of investment goods and prices of output (usually proxied by deflators at the sectoral level). D is total debt, ID is average interest paid on debt at firm level, E is equity, i is return on equity (approximated by the long-term interest rate), u is the corporate income tax rate (which gradually decreases from 31% in 2000 to 19% in 2010), δ is the depreciation rate and subscripts i and t denote the firm and time dimensions. The estimation of this formula requires the depreciation rate and the firm-specific interest rate, which are hard to compute using firm balance sheet data due to distorted information at firm level. For instance, the maximum depreciation rate attains extremely high values even after the outliers are removed. For this reason, the user cost of capital is not used here.

specification, we add a monetary policy variable approximated by the short-term money market rate (3M PRIBOR).

Apart from the cash flow-to-capital ratio, which is traditionally included in the investment equation and can be considered an indicator of a firm's sensitivity to the financial burden, we use two additional measures (denoted as *FIN* in equation (2)). These measures are debt and liquidity, estimated according to the following formula:

$$Leverage_{it} = \frac{Total\ Debt_{it}}{Total\ Assets_{it}}, \tag{3}$$

$$Liquidity_{it} = \frac{Cash\ Holding_{it}}{Total\ Assets_{it}}. \tag{4}$$

5. Data Description

The data are summarised in Table 1. The main data source of firm-specific variables over 2003–2015 is a CNB database. The CNB collects original data from the Czech Statistical Office (CZSO) and harmonises it as an input for the ECB Competitiveness Network (CompNet) database.[6] For a detailed description of the CompNet project and database, see its website.[7] The database is based on annual balance sheet and income statement information collected by the CZSO and compiled by the CNB according to harmonised definitions and procedures. To the best of our knowledge, the only previous study to have used this Czech dataset is Babecký et al. (2017), who applied it to the Czech labour market as part of the ECB Wage Dynamic Network 3 (WDN 3) project. The great advantage of this data source is the availability of information at firm level, which allows for estimation of the sensitivity of investment to financial characteristics for individual economic sectors and for firms of various sizes separately.

Macroeconomic variables are taken from the CZSO and the CNB. We approximate uncertainty with CZSO sentiment indicators available for four economic sectors (industry, construction, trade and services). Finally, expectations are measured by financial market expectations about GDP growth one year ahead obtained from a CNB survey. The original data are of monthly frequency. In order to be far enough from the next year while still having key macro data for the current year, we take the mid-year observation.

[6] The CNB prepares data for the European Commission's BACH database in the same way.

[7] http://www.comp-net.org/data/

Table 1: Overview of Variables and Data Sources

Variables	Definition	Source
Dependent variable: balance sheet data		
Investment ratio	Change in the capital stock (tangible and intangible fixed assets invested in buildings, machinery, equipment and other fixed assets) plus depreciation divided by lagged capital.	Authors' computation using CZSO firm data harmonised by the CNB as an input for CompNet
Explanatory variables: balance sheet data		
Sales	Operating revenue from sales.	CZSO firm data harmonised by the CNB as an input for CompNet
Cash flow	Profit/loss plus depreciation.	
Liquidity	Cash holdings – amount available in cash and cash equivalents.	
Total debt	Total loans from credit institutions and other creditors.	
Total assets	Fixed and other assets.	
Sectoral dummies (if applied)	Breakdown of firms by economic activity (NACE classification) – 18 sectors (NACE codes B–S, see Table A1 in the appendix for the NACE codes).	Authors' computation
Firm size dummies	Breakdown by number of employees: small (less than 50), medium-sized (50–250) and large (more than 250) and by turnover in CZK thousands: small (less than 250), medium-sized (250–1,250) and large (more than 1,250), see Table A2 in the appendix.	Authors' computation
Explanatory variables: macroeconomic data		
Interest rate	Nominal interest rate (3M PRIBOR) deflated by CPI.	CNB, ARAD
Confidence	Sentiment indicators available for four economic sectors (industry, construction, trade and services).	CZSO
Expectations	Expectations about GDP growth one year ahead obtained from a CNB survey – *Financial market inflation expectations*.	CNB

Note: CompNet: firm-level balance sheet and income statement data over the 2003–2015 period are collected from the CZSO by the CNB for the harmonised database of the ECB Competitiveness Network.

Turning to data preparation, we start by cleaning the dataset of outliers. First, we remove all observations with negative capital and all observations where the value of capital is smaller than the value of depreciation in a given year. Second, for the capital-to-investment ratio, we remove all observations where this ratio exceeds seven (a similar approach is used by ECB researchers – see Lopez-Garcia et al., 2015). For all other explanatory variables, we follow Babecký and Campos (2011) and drop all observations lying more than ±3 standard deviations from the mean. Descriptive statistics of the remaining data at firm level are given in Table 2.

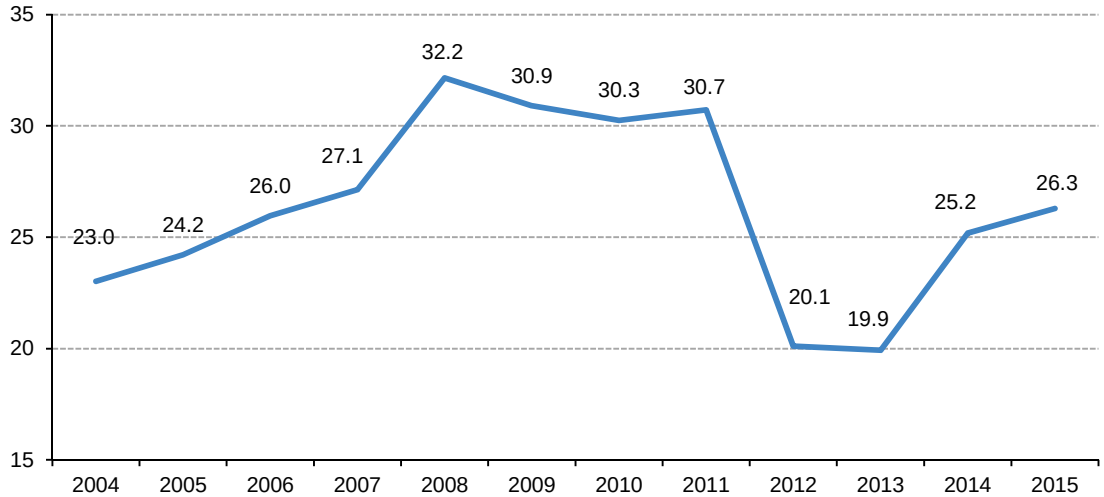
Table 2: Descriptive Statistics of Selected Balance Sheet Items, in CZK Millions/Ratios

Balance sheet items	Mean	Std. Dev.	Min	Max
Total assets	742	6,664	0.18	533,000
Tangible fixed assets	314	2,900	0	184,000
Intangible fixed assets	19	353	-51	24,000
Depreciation	36	286	0	13,900
Cash flow	79	715	-4,203	48,100
Long-term debt	31	349	0	17,200
Short-term debt	32	255	0	13,000
Investment-to-capital	0.38	1	0	7
Sales-to-capital	7.55	57	0	5,576
Cash flow-to-capital	1.57	124	-1,273	33,741
Total debt	0.09	0	0	15
Liquidity	0.02	0	0	1

Source: CNB dataset for CompNet, authors' computation.

Figures 3 and 4 show, that the outliers significantly reduce the number of observations available for the regression. For instance, if we had a balanced panel, we would have 338,000 observations between 2003 and 2015. However, the investment-to-capital ratio has well under 100,000 observations. Due to the missing values and removed outliers, the estimated sample is reduced to about 48,000 observations distributed very unequally over time. The number of records in the pre-crisis period is too small to obtain results comparable with the more recent period. For this reason, detailed results are only prepared for the period 2010–2015 (the number of firms increases considerably after 2009; given that we need a sufficient number of lagged observations as well, the second period starts in 2010). In this respect, the results for 2010–2015 are also more reliable.

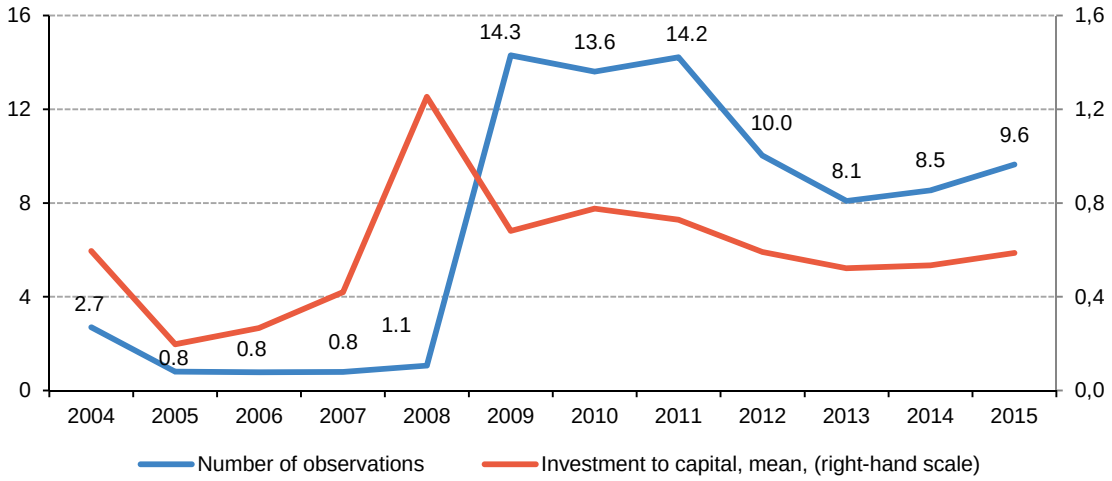
Figure 3: Number of Firms in the Original Dataset by Year, in Thousands



Note: In this figure, we count firms for which at least one observation of at least one variable is recorded in the dataset.

Source: CNB database for CompNet.

Figure 4: Number of Observations and Investment-to-capital Ratio by Year

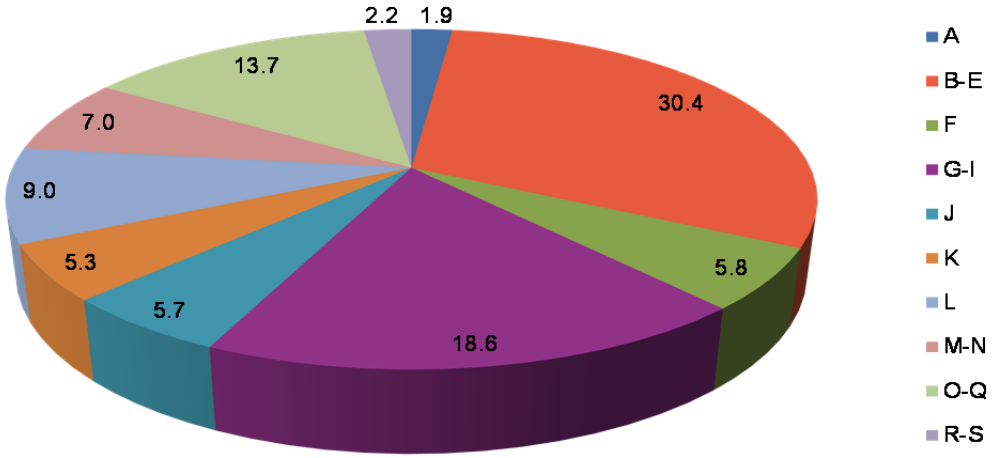


Note: The numbers in the figure denote the number of observations (in thousands) available in the original database.

Source: CNB database for CompNet, authors' computation.

We perform the analysis in such a way that we are able to distinguish firms by size (with respect to the number of employees and sales) and by economic activity. We consider 18 economic sectors from categories B–S of the standard NACE classification. This corresponds to categories 5–96 in the two-digit codification. There is no data on agriculture (category A, or 01–04) and on services in categories T–U (97–98). A detailed definition of firm size and a list of industries are given in the appendix. The Czech economic structure is dominated by industry – mainly manufacturing – accounting for about 30% of total activity (Figure 5). Wholesale and retail trade is another important segment of the economy, currently representing more than 18%. As Figure 6 shows, the structure of the firm database broken down by employment and turnover broadly corresponds to the structure of economic activity at the macro level.

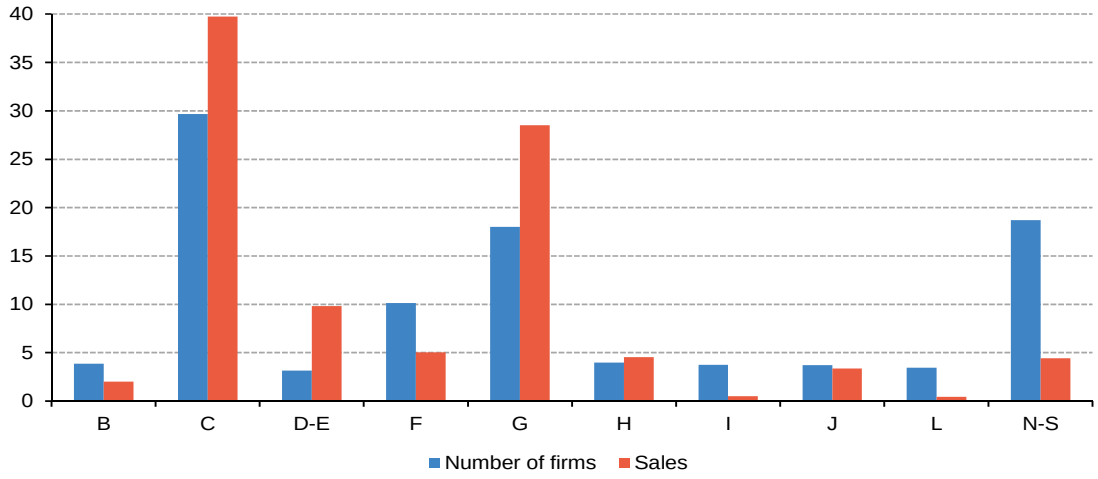
Figure 5: Value Added by Economic Activity in 2016, in % of Total



Note: A (agriculture, forestry and fishing), B-E (industry), F (construction), G-I (trade, transporting and accommodation and food service activities), J (information and communication), K (financial and insurance activities), L (real estate activities), M-N (professional, scientific, technical activities, administrative and support service activities), O-Q (publ. administration, education, human health, R-S (arts, entertainment, recreation and other services activities), see also Table A1 in the appendix for a description of the NACE codes.

Source: Eurostat, authors' computation.

Figure 6: Number of Firms and Amount of Sales per Industry, in % of Total Economy



Note: See Table A1 in the appendix for a description of the NACE codes.
Source: CNB database for CompNet, authors' computation.

6. Results

6.1 Results for all Firms

The economic and financial crisis induced a significant change in the time series. In addition, the number of firms in our database increases dramatically after 2009. Due to the low number of observations in the pre-crisis period, the results before and after 2008–2009 are not fully comparable, i.e. we do not observe the same firms in both periods. For this reason, we present all the estimations for the period 2010–2015 and the results for all firms for the whole period (Table 3).[8]

Financial constraints have the expected sign (an increase in indebtedness reduces investment and more liquidity supports investment) and are almost always significant (Table 3). Expectations about domestic GDP growth one year ahead and improvements in business sentiment are positively related to investment. Finally, monetary policy, approximated by the real 3M PRIBOR, is found to be significant in all periods, although the elasticity of the corresponding regression coefficient is lower due to distortion of the transmission mechanism in the crisis years. In addition, the last available years are those when the interest rate approached the zero lower bound, which are also the years of the exchange rate commitment introduced by the CNB in November 2013 and removed in April 2017. During this period, the exchange rate was used as an additional monetary policy instrument.

[8] Results for 2005–2007 and 2005–2015 are available from the authors upon request.

Table 3: Results for all Firms

	2010–2015			2005–2015		
Invest-to-capital	0.355	(0.013)	***	0.363	(0.013)	***
Invest-to-capital sq.	-0.054	(0.003)	***	-0.056	(0.003)	***
Sales-to-capital	0.002	(0.000)	***	0.002	(0.000)	***
Cash flow-to-capital	0.000	(0.000)	***	0.000	(0.000)	**
Total debt	-0.175	(0.017)	***	-0.168	(0.016)	***
Liquidity	0.805	(0.097)	***	0.793	(0.096)	***
3M PRIBOR	-0.035	(0.003)	***	-0.034	(0.003)	***
Confidence	0.001	(0.000)	***	0.002	(0.000)	***
Expectations	0.062	(0.002)	***	0.062	(0.002)	***
N. obs.	45,516			48,251		
R-sq.	0.29			0.30		

Note: The dependent variable is the investment ratio. All the explanatory variables enter the regression with one lag. Standard errors are given in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% level respectively. Results for dummies are not displayed here.

We experimented with other measures of monetary policy. In addition to the real 3M PRIBOR deflated by consumer price inflation, we constructed a real short-term interest rate using the deflator of value added for the total economy and value added deflators for individual sectors. We also tried to use the real monetary conditions index (RMCI) estimated by the CNB. The significance of the estimated coefficients decreases when alternative measures of monetary policy are used in the specification. For this reason, we use the 3M PRIBOR deflated by CPI as our monetary policy measure.

We also tried to include alternative measures of uncertainty and expectations in our specification. For instance, we used the European Commission's confidence indicator, which is available for four sectors, and the EU and German News-based Economic Policy Uncertainty indicators (Baker et al., 2013). We also approximated expectations with vintage data from Consensus Forecasts on the GDP forecast one year ahead. The results are broadly similar to those presented in this paper. We also wanted to use effective EU GDP growth or German GDP growth as a proxy for the dynamics of external demand, but we were unable to put these variables into the regression, possibly due to the absence of variation within the cross-section.

6.2 Results for Financial Constraints

Before replicating the estimation on sub-samples clustered by size and type of economic activity, we check whether the coefficients on debt leverage and liquidity are stable over time. Furthermore, the economic literature argues that a positive correlation between liquidity and investment does not necessary indicate a financially unconstrained situation. Fazzari et al. (2000) assume that large liquidity holdings could mean that firms are financially constrained. A positive relation between investment and liquidity could thus be a sign of financial constraints. Firms do not use liquidity and are unable to substitute internal finance with external finance. And for financially unconstrained firms, the coefficient is simply different from zero, as such firms are able to switch between external and internal financing. By contrast, Kaplan and Zingales (1997) believe that higher liquidity levels are associated with a lack of financial constraints, i.e. the relation between investment and liquidity is expected to be positive for financially unconstrained

firms. Finally Hobdari et al. (2009) argue that the relation between investment and liquidity changes above a certain threshold.

We do not aim to estimate a threshold model. If we assume the presence of a threshold for one variable, other variables may require the introduction of a threshold as well. However, it would be hard or even impossible to estimate a model containing several thresholds on our data. In order to check how the elasticity of financial constraints changes over time, we re-estimate the baseline specification for each year separately (and without macro-variables which have low or no variation within the cross-section). We compare the dynamics of the estimated coefficients with selected balance sheet items.

The results in Table 4 show that the coefficients on debt and liquidity changed in 2010–2015. At the same time, profitability was relatively stable and the ratio of profit to debt decreased. This might indicate a relatively limited effect of financial constraints after the crisis. The moderately higher indebtedness coupled with firms' lower profitability in this period could indicate that firms had difficulty obtaining additional credit due to risk perceptions. At the same time, firms tended to accumulate more liquidity due to uncertainty about the economic conditions. To some extent, this result coincides with the conclusion of Babecký et al. (2015) on the limited importance of credit availability.

Table 4: Financial Constraints

		2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Selected balance sheet items, BACH									
Net profit or loss for the period, % of net turnover	It3	3.8	3.9	4.5	3.8	4.8	4.1	4.2	*N/A*
Gross operating profit to total net debt, %	R27	29.4	28	26.9	24.5	23.3	23.4	25.7	*N/A*
Regression results									
Total debt	coeff.	*N/A*	*N/A*	-0.25	-0.16	-0.14	-0.10	-0.15	-0.24
Liquidity	coeff.	*N/A*	*N/A*	1.06	0.67	0.74	1.09	0.87	0.87
Number of observations		*N/A*	*N/A*	9,445	10,019	7,555	6,369	6,411	6,721
R-sq.		*N/A*	*N/A*	0.07	0.08	0.08	0.08	0.09	0.09

Note: The dependent variable is the investment ratio. All the explanatory variables enter the regression with one lag. Grey font denotes unavailable data or insignificant coefficients. The balance sheet data come from the EC BACH database; data for 2015 are not yet available. The coefficients on the financial constraints in the cross-section regressions are insignificant for the years 2005–2009 and are not reported here.

6.3 Results for Firms by Size and Economic Activity

Looking at the results estimated on sub-samples of firms of different size and across various economic sectors, both debt leverage and liquidity are significant in 2010–2015. The relation is always negative in the case of debt and positive in the case of liquidity when the number of observations is large enough (Table 5). It seems that medium-sized firms (as measured by

turnover) and firms with more than 250 employees are less sensitive to financial constraints. Comparing the results across economic sectors, industry and services (mainly transportation) have the highest elasticity to debt, while industry and retail and wholesale trade are the most sensitive to liquidity (see Tables A3 and A4 in the appendix for detailed results by sector).

Monetary policy tightening increases the costs of investment, which most strongly affects small firms and the service sector. However, all firms regardless of size (as measured by the number of employees) and economic sector are negatively affected by an increase in the interest rate. The only exception here is construction.

Table 5: Results by Firm Size and Sector

	Total debt			**Liquidity**			**3M PRIBOR**			N.obs.	R-sq.
By number of employees											
Small	-0.219	(0.029)	***	0.819	(0.121)	***	-0.042	(0.006)	***	19.055	0.28
Medium	-0.139	(0.022)	***	0.602	(0.174)	***	-0.034	(0.003)	***	19.847	0.32
Large	-0.112	(0.028)	***	0.373	(0.257)		-0.032	(0.004)	***	6.614	0.35
By turnover											
Small	-0.201	(0.033)	***	0.537	(0.134)	***	-0.032	(0.005)	***	9.772	0.29
Medium	-0.100	(0.032)	***	0.706	(0.340)	**	-0.040	(0.005)	***	5.165	0.34
Large	-0.173	(0.021)	***	0.889	(0.124)	***	-0.035	(0.004)	***	30.579	0.30
By sector											
Industry	-0.154	(0.021)	***	0.868	(0.152)	***	-0.029	(0.004)	***	20.445	0.30
Construction	-0.079	(0.168)		0.223	(0.286)		-0.016	(0.027)		3.046	0.32
Trade	-0.137	(0.031)	***	1.017	(0.216)	***	-0.035	(0.010)	***	10.951	0.30
Services	-0.194	(0.034)	***	0.701	(0.140)	***	-0.042	(0.015)	***	11.063	0.30

Note: The dependent variable is the investment ratio. All the explanatory variables enter the regression with one lag. Standard errors are given in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% level respectively. For economy of space, the coefficients on the investment-to-capital ratio, cash flow, uncertainty and expectations are moved to the appendix. Results for dummies are not displayed here.

7. Conclusion

This paper analysed the sensitivity of firm investment to financial variables and the effect of monetary policy. We used harmonised firm-level balance sheet data from the ECB Competitiveness Network database covering the period 2003–2015.

First, we found that indebtedness and the availability of liquidity have significant effects on investment. Slightly higher indebtedness might have caused firms to obtain less additional credit due to greater riskiness in the post-crisis period. At the same time, firms have tended to accumulate more liquidity due to uncertainty about the economic conditions and future profitability. Second, expectations about domestic GDP growth one year ahead and business sentiment are positively related to investment. The results are also robust to alternative measures of expectations and uncertainty. Third, our results show that the coefficient on the real interest rate is mostly negative and significant, indicating that monetary policy tightening increases the

costs of financing and reduces investment. Monetary policy tightening most strongly affects small firms. Finally, the highest elasticity to debt was found in industry and services, while industry and retail and wholesale trade are the most sensitive to liquidity. Firms of various sizes and areas of economic activity (with the exception of construction) are significantly and negatively affected by a change in the real interest rate.

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Appendix

Table A1: List of NACE Codes

A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam and air conditioning supply
E	Water supply; sewerage; waste management and remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	Transporting and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support service activities
O	Public administration and defence; compulsory social security
P	Education
Q	Human health and social work activities
R	Arts, entertainment and recreation
S	Other services activities

Table A2: Breakdown of Firms by Size

	By number of employees	By turnover, in CZK
Small	less than 50	less than 250,000
Medium-sized	between 50 and 250	between 250,000 and 1,250,000
Large	more than 250	more than 1,250,000

Table A3: Results for Individual Sectors

NACE code	**Total debt**			**Liquidity**			**3M PRIBOR**			N.obs.	R-sq.
B	0.899	(0.351)	**	-4.464	(2.40)	*	-0.021	(0.034)		35	0.78
C	-0.150	(0.024)	***	0.811	(0.156)	***	-0.028	(0.005)	***	17.866	0.30
D	-0.178	(0.044)	***	2.870	(1.056)	***	-0.028	(0.015)	*	1.125	0.29
E	-0.185	(0.072)	***	1.138	(0.595)	*	-0.025	(0.012)	**	1.42	0.34
F	-0.079	(0.168)		0.223	(0.286)		-0.016	(0.027)		3.046	0.32
G	-0.027	(0.043)		1.274	(0.340)	***	-0.023	(0.013)	*	7.585	0.32
H	-0.240	(0.080)	***	0.373	(0.359)		-0.038	(0.015)	***	2.055	0.32
I	-0.143	(0.053)	***	0.996	(0.325)	***	-0.047	(0.020)	**	1.311	0.29
J	-0.029	(0.171)		1.683	(0.780)	**	-0.020	(0.037)		1.592	0.39
K	-0.080	(0.042)	*	0.330	(0.242)		0.549	(0.206)	***	543	0.32
L	-0.092	(0.028)	***	2.416	(1.320)	*	-0.043	(0.024)	*	1.432	0.24
M	-0.290	(0.165)	*	0.961	(0.599)	*	-0.037	(0.026)		2.268	0.31
N	-0.203	(0.079)	***	0.715	(0.262)	***	-0.068	(0.031)	**	2.35	0.35
O	0.000	(omitted)		0.000	(omitted)		0.052	(omitted)		7	1.00
P	-0.406	(0.183)	**	0.358	(0.599)		-0.129	(0.087)		376	0.35
Q	-0.209	(0.093)	**	2.009	(0.683)	***	-0.013	(0.025)		1.39	0.27
R	-0.257	(0.105)	**	0.104	(0.190)		0.045	(0.025)	*	748	0.23
S	-0.158	(0.127)		1.147	(0.928)		0.037	(0.053)		357	0.39

Table A4: Remaining Explanatory Variables from Tables 5 and A3

Specification	**Invest-to-capital**			**Invest-to-capital sq.**			**Cash flow-to-capital**		
Small, employees	0.325	(0.02)	***	-0.047	(0.005)	***	0.000	(0.00)	***
Medium, employees	0.378	(0.02)	***	-0.062	(0.006)	***	0.001	(0.00)	*
Large, employees	0.394	(0.03)	***	-0.079	(0.008)	***	0.001	(0.00)	
Small, turnover	0.342	(0.03)	***	-0.052	(0.007)	***	0.000	(0.00)	
Medium, turnover	0.403	(0.03)	***	-0.071	(0.008)	***	0.003	(0.00)	
Large, turnover	0.351	(0.02)	***	-0.053	(0.004)	***	0.000	(0.00)	***
Industry	0.364	(0.02)	***	-0.055	(0.006)	***	0.005	(0.00)	**
Construction	0.266	(0.04)	***	-0.038	(0.011)	***	0.019	(0.02)	
Trade	0.312	(0.02)	***	-0.045	(0.006)	***	0.007	(0.00)	**
Services	0.359	(0.02)	***	-0.056	(0.006)	***	0.000	(0.00)	***
B	0.185	(0.31)		-0.220	(0.268)		0.178	(0.05)	***
C	0.358	(0.02)	***	-0.053	(0.007)	***	0.009	(0.01)	
D	0.387	(0.08)	***	-0.069	(0.018)	***	0.003	(0.00)	
E	0.385	(0.07)	***	-0.068	(0.015)	***	0.021	(0.02)	
F	0.266	(0.04)	***	-0.038	(0.011)	***	0.019	(0.02)	
G	0.291	(0.03)	***	-0.044	(0.008)	***	0.004	(0.00)	
H	0.324	(0.05)	***	-0.040	(0.014)	***	0.013	(0.01)	*
I	0.315	(0.08)	***	-0.062	(0.022)	***	0.002	(0.00)	
J	0.295	(0.06)	***	-0.049	(0.014)	***	0.004	(0.00)	**
K	0.548	(0.12)	***	-0.107	(0.029)	***	0.000	(0.00)	
L	0.340	(0.08)	***	-0.059	(0.015)	***	0.023	(0.01)	
M	0.336	(0.07)	***	-0.049	(0.018)	***	0.000	(0.00)	*
N	0.247	(0.05)	***	-0.033	(0.011)	***	0.000	(0.00)	
O	0.000	(omitted)		-0.010	(omitted)		0.000	(omitted)	
P	0.210	(0.10)	**	-0.030	(0.020)		-0.015	(0.02)	
Q	0.310	(0.07)	***	-0.053	(0.021)	**	0.005	(0.03)	
R	0.461	(0.10)	***	-0.095	(0.025)	***	0.002	(0.00)	
S	-0.014	(0.08)		0.002	(0.017)		0.095	(0.04)	**

Table A4 (continued): Remaining Explanatory Variables

Specification	**Sales-to-capital**			**Confidence**			**Expectations**		
Small, employees	0.003	(0.00)	***	0.001	(0.00)	***	0.070	(0.00)	***
Medium, employees	0.002	(0.00)	***	0.001	(0.00)	***	0.058	(0.00)	***
Large, employees	0.001	(0.00)		0.002	(0.00)	***	0.044	(0.00)	***
Small, turnover	0.004	(0.00)	***	0.001	(0.00)	***	0.063	(0.00)	***
Medium, turnover	0.001	(0.00)		0.001	(0.00)	***	0.048	(0.00)	***
Large, turnover	0.002	(0.00)	***	0.002	(0.00)	***	0.063	(0.00)	***
Industry	0.003	(0.00)	***	0.005	(0.00)	**	0.070	(0.01)	***
Construction	0.002	(0.00)	**	0.000	(0.00)		0.055	(0.02)	***
Trade	0.002	(0.00)	**	0.002	(0.00)		0.059	(0.01)	***
Services	0.001	(0.00)	***	0.000	(0.00)		0.076	(0.01)	***
B	-0.017	(0.01)	***	-0.002	(0.00)		0.018	(0.04)	
C	0.003	(0.00)	**	0.007	(0.00)	**	0.078	(0.01)	***
D	0.004	(0.00)	**	-0.004	(0.01)		0.025	(0.02)	
E	0.009	(0.01)	*	0.000	(0.00)		0.047	(0.01)	***
F	0.002	(0.00)	**	0.000	(0.00)		0.055	(0.02)	***
G	0.005	(0.00)	***	0.003	(0.00)		0.046	(0.01)	***
H	0.000	(0.00)		0.005	(0.00)	**	0.070	(0.01)	***
I	0.008	(0.00)	**	-0.003	(0.00)		0.055	(0.01)	***
J	0.003	(0.00)	***	0.002	(0.00)		0.091	(0.02)	***
K	0.002	(0.00)		0.081	(0.03)	***	-0.290	(0.11)	***
L	0.005	(0.00)	***	-0.002	(0.00)		0.036	(0.01)	***
M	0.001	(0.00)	**	0.001	(0.00)		0.088	(0.02)	***
N	0.001	(0.00)		0.000	(0.00)		0.102	(0.02)	***
O	0.000	(omitted)		0.003	(omitted)		0.033	(omitted)	
P	0.014	(0.00)	***	-0.003	(0.01)		0.082	(0.05)	*
Q	0.002	(0.00)		0.003	(0.00)		0.065	(0.01)	***
R	0.002	(0.00)	*	0.008	(0.00)	***	0.012	(0.01)	
S	0.018	(0.01)	***	0.010	(0.01)	**	0.002	(0.03)	

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Czech National Bank
Economic Research Division
Na Příkopě 28, 115 03 Praha 1
Czech Republic
phone: +420 2 244 12 321
fax: +420 2 244 12 329
http://www.cnb.cz
e-mail: research@cnb.cz
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