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What Influences Private Investment? The Case of the Czech Republic

Martin Gürtler *

Abstract

What influences private investment in the Czech Republic? This paper arrives at a conclusion based on a survey of fixed-asset purchases in 30,000 non-financial corporations over the period 2008–2015. BVAR models are estimated on aggregates for 19 industries and the whole non-financial economy. As our results show, foreign demand is the most important factor for Czech business investment, especially in manufacturing and tourism. We also find an increased importance of expectations and uncertainty during the period under review. According to our findings, business investment is fostered by a devalued currency and is crowded out by public investment. The most profound crowding-out was seen in manufacturing and agriculture, whereas services, trade, and construction exhibit crowding-in. Finally, EU funds are found to be successful in providing occasional support to private investment.

Abstrakt

Co ovlivňuje vývoj soukromých investic v České republice? Tento článek nabízí odpověď založenou na analýze dat o pořízení dlouhodobého hmotného a nehmotného majetku, které vyplývají z dotazníkového šetření mezi 30 tisíci nefinančních podniků v průběhu let 2008-2015. Výsledky vychází z odhadu BVAR modelů, a to jak pro celý nefinanční sektor, tak také pro 19 vybraných odvětví. Tyto výsledky ukazují, že nejvýznamnější proměnnou pro vývoj soukromých investic v České republice je zahraniční poptávka. To platí především ve zpracovatelském průmyslu a v odvětví cestovního ruchu. Ve zkoumaném období lze zároveň pozorovat narůstající vliv ekonomických očekávání v důsledku zvýšené míry nejistoty. Z výsledků výzkumu také plyne, že zatímco oslabení české koruny podporuje tvorbu nových soukromých investic, vyšší vládní investice mohou naopak soukromé investice vytěsňovat. Nejsilnější vytěsňovací efekt byl zaznamenán ve zpracovatelském průmyslu a v zemědělství. V odvětví služeb, obchodu a ve stavebnictví však vládní investice působí pozitivně. Jako poslední lze pak zmínit zjištění, že čerpání fondů EU může mít významný vliv nejen na vládní, ale i na soukromé investice.

JEL Codes: C55, D22, E22, H32, M21.
Keywords: Bayesian VAR, crowding-out, Czech Republic, EU funds, exchange rate, interest rate, investment, monetary and fiscal policy, survey data, uncertainty.

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Nontechnical Summary

Business investment constitutes a crucial source of economic growth. The factors behind its development are therefore often discussed, but to our knowledge there has been no research on this topic for the Czech Republic. As a consequence, we propose an investigation based on a Czech Statistical Office survey among 30,000 Czech non-financial corporations over the period 2008–2015. We explore all potential factors and aim to classify them according to their relative importance and the direction of their effect on business investment. The factors include macroeconomic variables, namely, foreign demand, the real interest rate, and the real exchange rate, and also economic expectations. Moreover, we are interested in the influence of fiscal policy and so study the impact of government investment and the drawdown of EU funds. Results are provided not only for the aggregate economy, but also for 19 industries.

According to the results, foreign demand has the strongest effect on Czech business investment. This holds both for the aggregate economy and for the majority of industries. That investment is closely related to foreign demand is due to the high openness of the Czech economy. A rise in foreign demand thus mainly supports investment in sectors with a large share of exports in production. This especially concerns the manufacturing and tourism, which exhibit the strongest response. In the manufacturing sector, the automotive and electrical engineering industries have the most pronounced reaction. As in many other countries, the results are in line with the predictions of the accelerator theory, so the variation in total output explains a large part of the variation in Czech business investment. Along with currently observed demand, demand expected in the future has some effect. Its influence has become more significant in the recent period, when a general upsurge of uncertainty can be observed.

Monetary policy has effective leverage over business investment in the form of the interest rate and the exchange rate, as our research confirms that the level of investment is negatively affected by an increase in the interest rate and positively affected by currency devaluation. The negative effect of a higher real interest rate is stronger in sectors containing smaller enterprises, as these are dependent to a great extent on external sources of finance. Examples include agriculture and tourism. The positive effect of real exchange rate devaluation is observed mainly in export-oriented industries such as manufacturing. Furthermore, we do not uncover any evidence of laziness in investment induced by a long-lasting currency devaluation. The laziness argument was used in the policy debate against the CNB's devaluation of the Czech koruna starting in November 2013.

In comparison with other variables, fiscal policy has a smaller effect on business investment. Although the aforesaid applies in the long run, there are some periods when the impact of fiscal policy becomes more significant. This concerns large fiscal impulses and the repercussions of the EU funding cycle. Based on the results, government investment can crowd out private investment. The most striking crowding-out was witnessed in agriculture and manufacturing. We see the explanation of this crowding-out effect as lying in the interaction of monetary policy with frequently procyclical Czech fiscal policy. Yet there are also sectors where government investment has a positive influence, namely, services, trade, and construction. Regarding the EU funding cycle, our results confirm that it affects not only government investment, but also business investment. This effect goes through funds directed at improving investment activity in the business sector.

1. Introduction

Investment is probably the most volatile component of aggregate demand. While theoretical studies mostly consider the interest rate to be the main determinant of private investment, the empirical literature finds a large set of variables to be important. They include easily definable macroeconomic variables and also expectations about economic activity, which are hard to measure. Therefore, most studies do not take expectations into account. The problem is, though, that the importance of expectations has increased due to a recent upsurge in uncertainty due to political events, terrorist attacks, financial crises, and increased volatility on commodity markets. Naturally, many other causes of uncertainty can be listed as well. For a general exposition of uncertainty, see Bloom (2014).

This study contributes to the literature by exploring all the potentially important factors behind private investment for the case of the Czech Republic. In order to answer the question in the title, the paper sets out to determine which covariates are more important than others, to evaluate their effect, and to derive implicit elasticities. The standard factors identified in the literature are the interest rate, output, the exchange rate, and sometimes also public investment. On top of that, we use expectations and the drawdown of EU funds by private firms. This drawdown became particularly significant during the last EU funding cycle and so presumably had sufficient power to affect private investment. This was the case not only in the Czech Republic, but also in many other EU economies. The novelty of the paper lies in its wide scope, that is, in the large number of factors investigated. There are few similar studies in the literature in general, and none at all for the Czech Republic.[1]

The results presented herein are based on the estimation of Bayesian VAR (BVAR) models using survey data on Czech firms. The survey is conducted each quarter by the Czech Statistical Office (CZSO) and predominantly covers large non-financial corporations situated in the Czech Republic under both domestic and foreign control. For each quarter, the sample includes around 30,000 companies and covers the period 2008–2015. Because the data are confidential, they are not publicly available.

Exploring this unique data set, we arrive at the conclusion that the most important factor for Czech private investment is foreign demand. This reflects the openness of the Czech economy and is also in line with the accelerator theory. According to our results, investment depends not only on actually observed demand, but also on expected demand. This confirms the importance of expectations, which we highlight throughout the text. We also find that private investment depends on monetary variables, namely, the real interest rate and the real effective exchange rate. An increase in the interest rate dampens private investment, whereas a devaluation of the exchange rate supports it. The effect of public investment and EU funds was less pronounced. However, the influence of these fiscal variables proved to be much more significant in periods of strong fiscal stimulus, as was the case in 2015. Besides the behavior of private investment on the aggregate level, we investigate investment in 19 sectors of the Czech economy.

The rest of the paper is structured as follows. Section 2 provides the rationale for the choice of private investment covariates included in the research, Section 3 discusses stylized facts of Czech investment, Section 4 discusses the data, Section 5 deals with the methodology, Section 6

[1] Most papers concentrate on a particular area of interest, such as the influence of firm-specific factors or financial conditions, rather than taking the issue globally.

presents the results, and Section 7 concludes.

2. Beyond the Interest Rate

In this section, we discuss the factors we use to explain movements in private investment. We look beyond the influence of the real interest rate, which we consider to be the most basic factor and the one best explained in most economics textbooks. It makes sense that when the interest rate rises and the cost of capital goes up, some investment projects become unprofitable and so are not undertaken. There are, of course, empirical research studies, such as Sharpe and Suarez (2014), that find an insignificant link between business investment and the interest rate. Yet, as Shapiro (1986) explained, it is still reasonable to assume a negative relation between investment and the interest rate even though the data are non-supportive. In his article, he discusses the nature and causes of these instances and subsequently gives an even stronger theoretical basis for this relationship.

The first variable beyond the interest rate which may be able to affect Czech business investment is foreign demand. This is due to the high openness of the Czech economy. The theoretical foundation for the dependence of private investment on changes in output is the accelerator principle (Clark, 1917; Chenery, 1952; Koyck, 1954). According to this theory, the capital stock varies in order to sustain or reach the required capital-output ratio. That the proposition based on the accelerator principle is still relevant today is documented by a vast amount of studies. One of the most recent is European Central Bank (2017), which argues that output growth is a main driver of business investment in the EU and US economies. Obviously, there are exceptions – such as Italy and Portugal with their high shares of non-performing loans and over-leveraged private sectors – defending a place for other explanatory variables. Similar results also follow from Barkbu et al. (2015).

The strong correlation between output growth and investment is puzzling for Serven and Solimano (1992), who emphasize that a substantial part of the fluctuations in production appears to be transitory and therefore should not affect investment. They see the reason in investors' myopic expectations or short planning horizons. Regarding this issue, one must take into account the difference between business-cycle investment and structural investment. Structural investment relates to long-run trends in the economy such as demographics and technical innovations, so it has a long planning horizon, whereas the horizon of business-cycle investment is considerably shorter. An expansionary phase of the business cycle therefore boosts investment simply because of a larger amount of orders in production.[2]

The problem is that investment created during a boom is hard to reverse during a recession. That disinvestment is costly or unfeasible is a central tenet of the theory of irreversible investment (Arrow, 1968). Under certainty, irreversible investment puts a wedge between marginal revenue and the cost of capital. The wedge has a tendency to increase during booms and decrease during recessions. As booms last longer than recessions, the discounted sum of the wedges over the entire business cycle should be positive. This lends further support to output-investment correlation.

Irreversible investment is negatively affected by uncertainty (Bernanke, 1983; McDonald and Siegel, 1986; Pindyck, 1988 and 1991; Bertola and Caballero, 1994; Abel and Eberly, 1994 and

[2] Assuming that there is a constant capital-labor ratio in production in the short run.

1996; Bachmann and Bayer, 2013; Binding and Dibiasi, 2017). If the future is largely uncertain, the option of waiting for a while rather than investing immediately has a larger utility value for the firm. Waiting for assurance that an investment will be profitable and the firm will not suffer from excess capital causes business investment to lag behind economic output. This delay is actually observed in most advanced economies and is a reason for using dynamic models in the research of investment.

Current and future profitability, and hence investment by firms, can also be affected by the real exchange rate. Campa and Goldberg (1999) provide evidence for manufacturing industries in the United States, Japan, the United Kingdom, and Canada. According to their results, the direction of the effect of the exchange rate on investment varies with the changing export and imported-input orientation of producers. The positive effects of a home currency depreciation on investment are increasing in an industry's export share and decreasing in its imported-input share. Demand elasticities on the domestic and foreign markets for both final production and production factors also play a role. In this connection, the exchange rate tends to have weak or relatively insignificant effects on the investment rate in high-markup sectors, where direct transmission of exchange rate movements to the prices of final production is likely. The opposite holds for low-markup sectors.

In addition to the influence of macroeconomic factors, researchers have examined the role of firm-specific variables such as cash flow, liquidity, equity prices, and leverage. The link between business investment and financial factors on a panel of manufacturing firms for Belgium, France, Germany, and the United Kingdom was researched by Bond et al. (2003). They realized that cash flow and profits appear to be both statistically and quantitatively more significant in the United Kingdom than in the three continental European countries, presumably as a result of more severe financial constraints on investment in the more market-oriented British financial system. Those financial constraints are in many cases related to asymmetric information (see, for example, Stiglitz and Weiss, 1981).[3] The presence of asymmetric information on the financial market imposes a risk premium over the cost of external finance (bond, equity, or bank credit) and thus favors internal funds (retained profits). Consequently, investment by constrained firms depends more on cash flow (Fazzari et al., 1988a,b; Calomiris and Hubbard, 1989; Hubbard, 1998). On the other hand, Kaplan and Zingales (1997, 2000) and Hovakimian (2009) point out that excess sensitivity of investment to cash flow need not be an indication of financial frictions.

The most complex measure involving the expected flow of current and future profits and the fundamentals of a firm is Tobin's Q (Tobin, 1969; Brainard and Tobin, 1968). Tobin's marginal Q expresses the increase in the intrinsic value of the firm due to new investment and relates it to the firm's replacement cost. A Tobin's Q exceeding one encourages the firm to invest. As the marginal Q is an unobservable quantity, it is frequently replaced by the average Q as measured by the market to book value ratio (Hayashi, 1982). The high correlation between the expected flow of current and future profits and Tobin's Q may explain why most authors find one of them to be statistically insignificant when tested in a one-equation model[4] (Abel and Eberly, 2012; Cummins et al., 2006). Moreover, the strong correlation of firm-specific variables with overall economic activity (aggregate demand) is an obstacle to the use of these indicators in macroeconomic investigations. It is also the reason why we do not consider them.

[3] The more concentrated the financial market is, the less severe the information asymmetries usually are.
[4] This is a well-known consequence of multicollinearity in econometric models.

However, a concurrent study by Babecká Kucharčuková and Pašaličová (2017) explores the role of firm-specific variables for a sample of Czech companies.

An issue often discussed among economists is the crowding-out effect of public investment. According to the crowding-out theory, greater investment activity by the government spills over into an increase in the interest rate and, in the final instance, into a decrease in interest-sensitive private investment. The increase in the interest rate is due to higher demand for loanable funds. More theoretically, such financial crowding-out would be strengthened further in a world of Ricardian agents, where increased public debt is regarded as a future tax burden.[5] But there is yet another reason for the increase in the interest rate, namely, the interaction of monetary and fiscal policy. While higher government investment represents fiscal expansion, it is usually accompanied by a reaction of the policy rate under inflation targeting.

In the literature, crowding-out is also justified by the productivity of government investment.[6] Given the productivity of government investment, private investment is postponed until government investment is put into service so that firms can exploit the synergy. Waiting for the synergy effect implies crowding-out in the short run, whereas crowding-in is observed in the long run (Erenburg and Wohar, 1995). Nevertheless, this will hold for less developed economies with insufficient infrastructure rather than for more advanced economies. Therefore, it is more reasonable to assume that the short-run negative effect is tied to financial crowding-out and that the productivity of government investment promotes crowding-in in the long run. Similar results are obtained by Blanchard and Perotti (2002) and Aschauer (1989) for the United States and by Mitra (2006) for India.

Xu and Yan (2014) highlight the allocation aspect of government investment, finding crowding-out in investment in private goods (through state-owned companies) but crowding-in for investment in public goods (infrastructure, education, health, etc.).[7] In advanced market economies, governments mostly invest in infrastructure projects (such as highways) and contract private firms to implement them. This applies in particular to the construction industry. To satisfy higher demand, the construction industry expands its production capacity and therefore invests. To give a preview of our results, we actually observed a positive correlation between investment in construction and public investment.

In the Czech Republic, there is one sector of the economy where the consequences of public investment have been studied for a long time, namely, agriculture. Agriculture is specific in having a high share of capital subsidies. Some are co-financed by the European Union (EU) and others use just national funds. From the national accounts perspective, these subsidies are a part of government investment. An increase in capital subsidies leads naturally to a loss in the motivation of agricultural enterprises to invest their own funds. Svoboda et al. (2016) found an almost 50 % correlation between investment in agriculture and capital subsidies in the Czech Republic. While the majority of papers in this field evaluate the efficiency of capital subsidies, they consider the influences of public investment on enterprises' performance indicators (such as profitability, labor productivity, and indebtedness), rather than dealing with the direct effect on firms' investment. Their results offer rare evidence in favor of capital subsidies (for the case of the Czech Republic, see Špička et al., 2017, and Náglová and Gürtler, 2016). On

[5] The crowding-out effect assumes debt financing of public investment.

[6] In the sense that government investment leads to an increase in total factor productivity.

[7] The research was conducted for the specific Chinese economy, where many enterprises are state-owned and the government controls the lending rate and credit rationing.

the other hand, we investigate the direct relationship between investment in agriculture and public investment and we will show that agriculture is among the sectors exhibiting the strongest crowding-out effect of government investment in the Czech Republic.

That the drawdown of EU funds influences the volume of government investment and economic growth as a whole is widely known. This effect is especially pronounced in Central European countries (the Czech Republic, Slovakia, Poland, and Hungary). It is referred to as the EU funding cycle, because national governments usually have trouble absorbing funds at the beginning of each new European financial perspective and thus have to step up their efforts at the end. What was not known until recently, however, is that the drawdown of EU funds has a similar effect on business investment (see CNB's Inflation Report IV/2016). This is particularly the case with funds targeted at improving innovation activity, a large amount of which are drawn by manufacturing industries.

3. Stylized Facts and Recent Developments

This section aims to give some intuitive visible facts about investment behavior in the Czech Republic over the last decade.[8] It is based on the evolution of the annual growth rates of selected variables; the analysis is thus superficial and the results must be taken as preliminary. The comparison of the annual dynamics of Czech GDP and the gross fixed capital formation of non-financial corporations provides an insight into the usefulness of the accelerator theory for the Czech Republic.[9] As shown in the top-left part of Figure 1, both dynamics have the same long-run trend, in line with the accelerator principle.

However, there are large deviations from this trend in the gross fixed capital formation of non-financial corporations. These deviations are more pronounced than in the case of total gross fixed capital formation. This is because an acceleration in private investment is often scaled down by a deceleration in public investment (see the top-right part of Figure 1). The unusually strong growth in government investment in 2015 was fostered by the Czech government's efforts to draw the remainder of its allocated funds from the European financial perspective for 2007–2013.[10] In fact, similar efforts were observed in private firms. The bottom-left part of Figure 1 shows that the share of EU funds in financing private investment suddenly increased in 2015.[11]

Looking at the bottom-right part of Figure 1, there was a slowdown in the growth of the capital to labor ratio. Until 2012 the capital stock grew faster than employment, but thereafter its relative growth slowed.[12] It was despite easy monetary policy, with the policy rate stuck at the zero lower bound and the CZK/EUR exchange rate weakened above its equilibrium level. One possible explanation of the shrinkage in growth of the capital stock to labor ratio is an increase

[8] The date range used in this section, 2005 through 2015, is somewhat longer than in the following in-depth analysis based on the survey data. The survey data available at the beginning of the research project covered the period from 2008 to 2015.

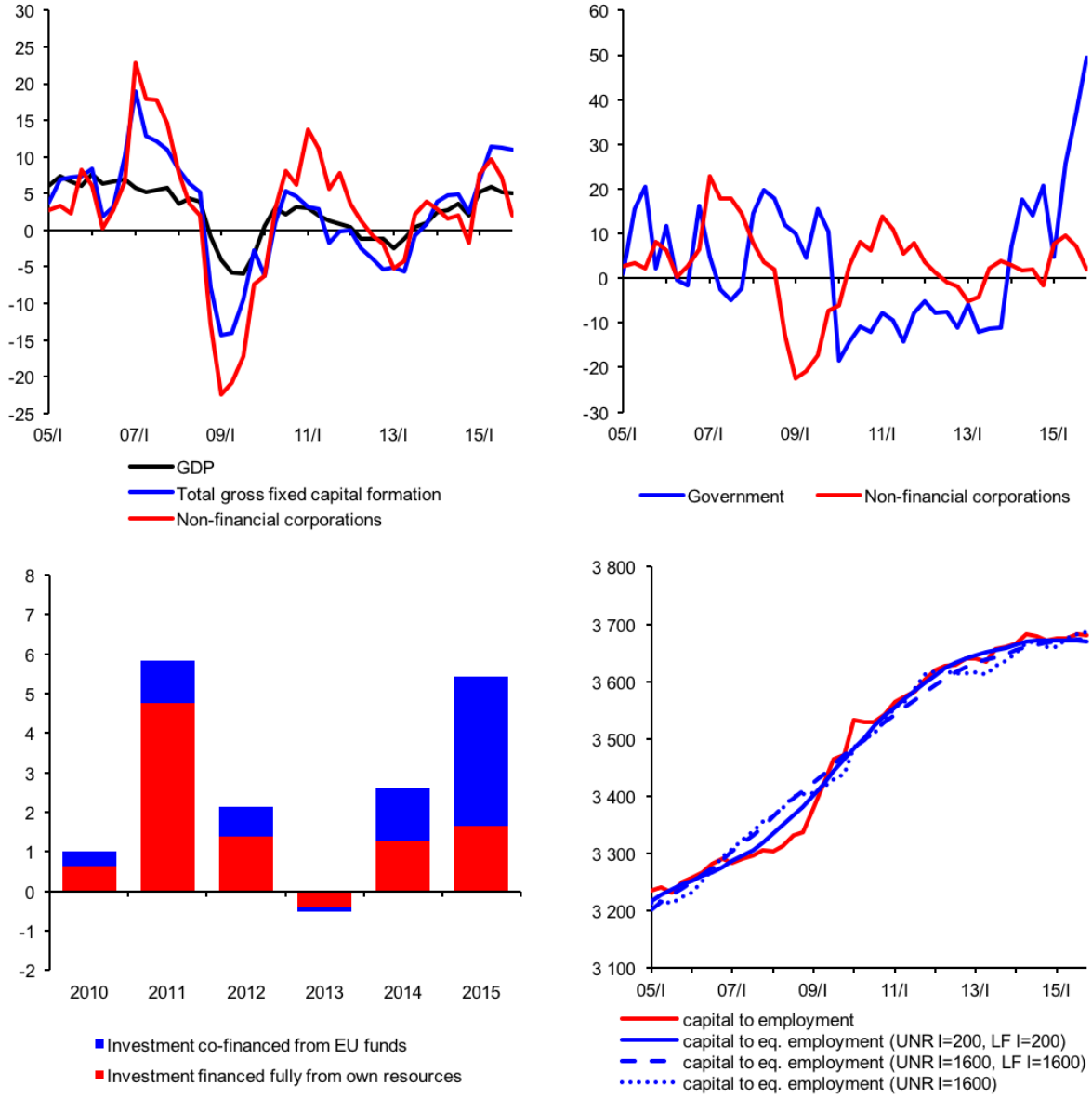
[9] By gross fixed capital formation of non-financial corporations we mean the indicator taken from the Czech national accounts. It will be evident in the next section why we emphasize this.

[10] Funds could be drawn up to two years after the end of the financial perspective.

[11] I am indebted to Mário Vozár for his computations of this shares. This figure also appeared in the CNB's Inflation Report IV/2016.

[12] The slowdown in the growth of the capital to labor ratio was due mainly to a rapid increase in employment rather than to slower growth in the capital stock.

Figure 1: Stylized Facts of Czech Investment



Note: The top-left and top-right figures contain annual growth rates of stable-price quantities – all from the Czech national accounts. The lines labeled non-financial corporations and government depict the gross fixed capital formation of, respectively, non-financial corporations and government. The bottom-left figure sums up the contributions of the different sources of finance (in percentage points) to the annual growth in investment by non-financial corporations. In the bottom-right figure we relate the capital stock to employment and various measures of equilibrium employment.

Source: Czech Statistical Office and Czech National Bank.

in uncertainty, favoring the use of easily removable labor, in contrast to irreversible capital, to expand production capacity.

4. Sample of Firms and Data

In our research, we use individual or micro-level data on non-financial corporations (NFCs) situated in the Czech Republic under both domestic and foreign control. The data come from a quarterly survey conducted by the Czech Statistical Office and thus have quarterly frequency. Due to their confidentiality, the data are not publicly available. The survey is biased slightly towards larger companies, as the average number of employees per firm is around 50 or more (see Table 1, showing the average number of employees by selected industries). More information about the distribution of the firms in the sample with respect to number of employees is provided in Appendix H and Appendix I. Experience has shown that larger companies provide more reliable data in the questionnaire (compared to smaller ones), as they have more time and more educated people to deal with it. The sample spans the period from 2008 to 2015. The total number of firms surveyed in each quarter is around 30,000 on average. In fact, only half of the firms are in the sample for the entire period. The rest are chosen in order to ensure that the sample is representative. The data thus form an unbalanced panel. Based on their origin, scope, and granularity, the data represent a unique sample for the research of investment behavior.

Table 1: Investment and Number of Employees by Average Firm

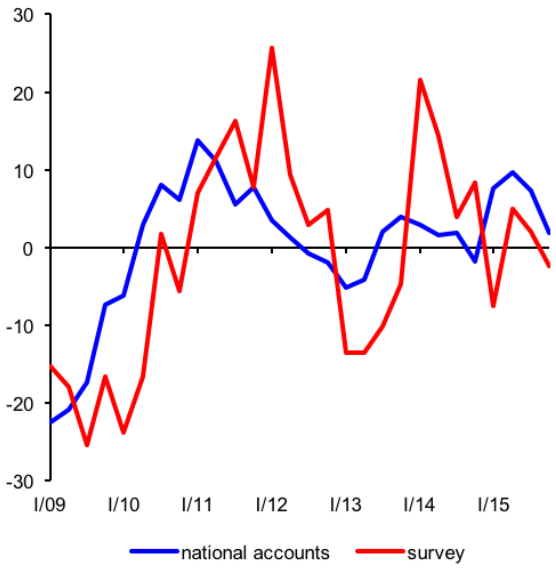
Industry	Investment mil. CZK	Number of employees	Number of firms in the sample
Automotive	26.0	373	386
Chemicals	5.2	118	1510
Transportation	6.3	136	1462
Other means of transport	7.8	209	91
Electrical engineering	5.2	164	711
Energy	22.1	103	679
Metallurgy and heavy engineering	3.0	102	2665
Retail	2.2	117	1539
Motor vehicle trade	2.9	49	692
Other services (n.s.e.)	2.1	72	5611
Other manufacturing (n.s.e.)	1.5	74	1597
Tourism	0.5	47	1136
Food and beverages	2.9	91	1060
Construction	1.0	53	2927
Telecommunication	45.9	226	77
Clothing	1.3	74	577
Mining	25.1	355	95
Wholesale	1.2	44	2949
Agriculture	3.0	55	1491

Note: Investment was computed as the ratio of average quarterly investment in the sector to the number of firms in the sector and employment as the ratio of the average number of employees in the sector to the number of firms in the sector. n.s.e. – not specified elsewhere.

Source: Author's computations.

This paper focuses on purchases of tangible and intangible fixed assets as reported by the firms in the questionnaire. These purchases were recorded in thousands of Czech koruna, but for modeling purposes they were deflated, seasonally adjusted, and converted into natural logarithms.[13] Because the purchases represent increases in the stock of fixed assets during the quarter (a flow variable), they can be considered gross investment. If we aggregate these fixed asset purchases over all firms in the sample, we obtain an alternative indicator of the investment activity of NFCs, which can be compared with the usual measure from the national accounts, namely, gross fixed capital formation for the NFC sector as a whole (this measure is publicly available from the CZSO website and covers all non-financial corporations, including smaller ones). As Figure 2 illustrates, these two measures are strongly correlated. However, there are still discrepancies in the annual growth rates. These discrepancies are obviously driven by the companies not included in the sample and potentially also relate to noise in the survey data.[14] Though limited to some extent, the survey data have the great advantage of being amenable to disaggregation and can thus provide a much more detailed picture of investment behavior.

Figure 2: Annual Dynamics of Alternative Measures for Private Investment



Note: Year-on-year growth in the gross fixed capital formation of non-financial corporations (national accounts) and purchases of fixed assets (survey), both at constant prices.

Source: Czech Statistical Office; author's computations.

Purchases of fixed assets by one specific firm are accompanied by identifiers such as the number of employees and the sector of the economy. The latter is determined with the aid of the NACE classification[15] (see Appendix G for the definition of the industries used for the investigation). The distribution of the firms in the sample over the different sectors of the Czech economy is described in the last column of Table 1.

[13] The gross fixed capital formation deflator from the national accounts was used to remove the effect of price changes.

[14] Issues regarding statistical noise are discussed in the next section. Here, we merely note that aggregation can reduce the noise but cannot remove it altogether.

[15] NACE is the French acronym for the classification of economic activities in the European Union.

Table 2: Macroeconomic Covariates

Variable	Source	Transformations
Real GDP in EA14	CNB	In logs and seasonally adjusted.
Real effective exchange rate	CNB	In logs and seasonally adjusted.
Real interest rate	CNB	Without data transformation.
Real government investment	CSO	In logs and seasonally adjusted.
Real volume of EU funds	Ministry of RD	In logs and seasonally adjusted.
Confidence indicator for EU	Eurostat	In logs and seasonally adjusted.

Variable	Mean	Median	Std. Dev.	Skewness	Kurtosis
Real GDP in EA14	4.80	4.80	0.03	-0.59	-0.07
Real effective exchange rate	4.59	4.60	0.04	-0.07	-0.56
Real interest rate	-0.10	-0.04	1.23	0.15	0.10
Real government investment	10.73	10.70	0.15	0.58	-0.36
Real volume of EU funds	14.58	15.07	1.64	-1.96	3.60
Confidence indicator for EU	4.56	4.60	0.12	-1.41	1.79

Note: Logs mean natural logarithms. Seasonal adjustment was done by the TRAMO/SEATS method in all cases.
Source: Author's computations.

Table 1 also presents the average quarterly investment of the average firm in a selected sector. Averaging is therefore done across both the time-series and the cross-sectional dimension. Accordingly, although other services (n.s.e.[16]) contain a large number of firms, the investment per average firm is relatively low. Other services (n.s.e.) consist mainly of computer and data processing services, real estate activities, professional, scientific, technical and administrative activities, and education and health services. The lowest level of investment per average firm was recorded in tourism. Trade and construction also exhibit low levels of investment per average firm. On the other hand, a high level of investment per average firm was observed in telecommunications, mining, energy, and manufacturing (especially the automotive industry), i.e., mainly in industrial firms.

Regarding the number of employees, the firms investigated tend to be large ones. As Table 1 shows, the average number of employees ranges between 50 and more than 300. Firms with a high number of employees are concentrated mainly in manufacturing, mining, and telecommunications. Firms with a lower number of employees are found in services, trade, construction, and agriculture.

Because the aim of this paper is to describe the behavior of private investment, we link it with a diverse set of macroeconomic variables. See Table 2 for the list of these variables, the data sources, the transformations, and the descriptive statistics. The justification for the choice of specific covariates was discussed in the previous sections. All the variables entering the model are real quantities. The real GDP of the effective Eurozone – the dominant foreign trade partner of the Czech Republic – was chosen as a proxy for external or foreign demand. This effective index weights the real gross domestic products of the 14 Eurozone countries (denoted as EA14 in Table 2) based on their shares in Czech exports. The weights for the computation of the real effective exchange rate also correspond to the foreign-trade flows of the Czech Republic,

[16] Not specified elsewhere.

and producer prices indices (PPIs) were used as the price indices. The real interest rate is computed as the ex-post rate (using observed inflation instead of expected inflation), with the one-year maturity PRIBOR serving as the base. Because of its negative values, the real interest rate – unlike all the other variables – was not converted into logarithmic form. Gross fixed capital formation in the government sector deflated by the fixed capital deflator is considered as real government investment. The amount of EU funds drawn by private firms to finance their investment plans was obtained from the database of the Ministry of Regional Development. Specifically, funds from the European Regional Development Fund (ERDF) form a large part of this amount.[17] In this case, too, the fixed capital deflator was used to obtain the real amount. Finally, the economic confidence indicator in the EU was employed to incorporate the factor of expectations.

5. Methodology

From the methodological point of view, Bayesian VAR (BVAR) models adapted for level variables are used. The particular approach will be sketched out in this section. The final choice of BVAR models is a result of an iterative process in which a large number of methodologies were entertained. We first wanted to use a full information set, or full data structure, and employ panel data models – we estimated both static and dynamic panel data models. However, the estimated parameters were mostly statistically insignificant and often also had the wrong sign. It was therefore very hard to interpret them. This may have been due to data noise, as the use of survey data usually faces this problem. We then decided to conduct the estimation on aggregated data and to use vector autoregressions. As a result, there are 19 models for industries (see Table 1 and Appendix G for the list of industries) and one more model for the non-financial economy as a whole. The list of macroeconomic covariates (see Table 2) remains the same in all the regressions. Initially, we estimated VAR models on growth rates, but the impulse responses again lacked economic sense. Moreover, it was hard to interpret some of the covariates in growth rates (for example, the interest rate and economic sentiment). So, we chose to use levels and to establish convergence of the models with Bayesian priors. To do so, we assumed that it is possible to approximate the dynamics of a unit root process with the dynamics of a process with a high rate of persistence. The prior distribution of the autoregressive parameters was set according to this assumption (see below). To be sure that there is a long-run relation between the observed variables, the existence of cointegration was tested[18] and confirmed for all 20 models. See Appendix A for the results of the cointegration testing on the aggregate level.[19]

As macroeconomic variables usually depend on each other, they should be considered as one multi-dimensional variable or random vector $\mathbf{x}_t$. Assume that the evolution of $\mathbf{x}_t$ can be described with the use of a Gaussian VAR(p) model

$$\mathbf{x}_t = \Phi_1 \mathbf{x}_{t-1} + \Phi_2 \mathbf{x}_{t-2} + \Phi_3 \mathbf{x}_{t-3} + \cdots + \Phi_p \mathbf{x}_{t-p} + \varepsilon_t, \tag{1}$$

with $\varepsilon_t \sim i.i.d.\,\mathrm{N}(\mathbf{0}, \Omega_\varepsilon)$, where Ω_ε is positive definite covariance matrix, and $\mathbb{E}(\mathbf{x}_t) = \mathbf{0}$. Ac-

[17] On the other hand, the amount entirely excludes funds from the Common Agricultural Policy.
[18] By means of the Johansen cointegration test.
[19] The results of the tests for individual industries are available on request.

cordingly, the likelihood function of $\mathbf{x}_t$ has the following form

$$l(\phi|\mathbf{x}) = \left(\frac{1}{2\pi}\right)^{nT/2} |\mathbf{I}_{T\times T} \otimes \Omega_\varepsilon|^{-1/2} \times \\ \times \exp\left\{-\frac{1}{2}\left[\mathbf{x} - \left(\mathbf{Z}^T \otimes \mathbf{I}_{n\times n}\right)\phi\right]^T \left(\mathbf{I}_{T\times T} \otimes \Omega_\varepsilon^{-1}\right)\left[\mathbf{x} - \left(\mathbf{Z}^T \otimes \mathbf{I}_{n\times n}\right)\phi\right]\right\}, \quad (2)$$

where $\phi = \text{vec}(\Phi_1, \ldots, \Phi_p)$, $\mathbf{x} = \text{vec}(\mathbf{x}_1, \ldots, \mathbf{x}_T)$, $\mathbf{Z} = [\mathbf{Z}_0, \ldots, \mathbf{Z}_{T-1}]$ and $\mathbf{Z}_t^T = [\mathbf{x}_t, \ldots, \mathbf{x}_{t-p+1}]$.

The initial guess of the model parameters ϕ will be incorporated through the prior probability density function, which has a multivariate normal distribution

$$g(\phi) = \left(\frac{1}{2\pi}\right)^{n^2 p/2} \left|\mathbf{V}_\phi\right|^{-1/2} \times \exp\left[-\frac{1}{2}(\phi - \phi^*)^T \mathbf{V}_\phi^{-1}(\phi - \phi^*)\right], \quad (3)$$

where ϕ^* is the prior mean, $\mathbf{V}_\phi$ is the corresponding prior covariance matrix, n denotes the number of variables in the VAR, and p stands for the lag length order. Because we assume that the variables exhibit high persistence, we chose the value of 0.8 as the prior mean for all the AR(1) coefficients. Therefore, disturbances influence the economic variables for a long time, but not forever. With the distribution around this mean set properly (this will be discussed below), this choice ensures convergence of the estimated IR functions and the system as a whole. As the data encourage us to choose VAR(1) as the optimum lag length, the AR(1) coefficients completely describe the autoregressive structure.[20] To support our choice of VAR(1), Appendix B provides the residuals from all seven equations of the aggregate model.[21] To be more confident about VAR(1), we also estimated models with a higher lag length, but the implied economic results were roughly the same. It should be noted that additional lags led to exponential growth in the model parameters and to a substantial decrease in the degrees of freedom, with a real threat of overparametrization. Consequently, VAR(1) is the ideal compromise between data fit and a reasonable number of estimated parameters.

Following Litterman (1986) and Doan, Litterman, and Sims (1984), the prior mean of the cross-variable coefficients was set to zero and the prior covariance matrix $\mathbf{V}_\phi$ takes the form

$$v_{ij,l} = \begin{cases} (\lambda/l)^2 & \text{for} \quad i = j, \\ (\lambda\theta\sigma_i/l\sigma_j)^2 & \text{for} \quad i \neq j, \end{cases} \quad (4)$$

where λ is the prior standard deviation for AR(1) coefficients. We chose a value of 0.05 for λ, so the prior value of the AR(1) coefficients ranges between 0.7 and 0.9 with 0.95 probability. The parameter l denotes the lag. In the case of VAR(1), it easily takes the fixed value of one. The decay parameter θ was set to 1. The prior variance of the cross-variable coefficients (the case where $i \neq j$) is therefore driven by the ratio σ_i^2/σ_j^2 (the ratio of the residual variances[22]). Note that due to the log-linear form of the model, the residual variances are smaller than one. Therefore, if the residual variance of the forcing variable is small enough, much of the cross-variable dependence probably acts within the systematic part of the model. Accordingly, the

[20] Although we use VAR(1) for the empirical analysis, we will continue to be general in the description of the methodology.

[21] By aggregate model, we mean the model estimated on the data for the whole non-financial economy. The residuals are also mostly insignificant in the sectoral models.

[22] The diagonal entries of the matrix Ω_ε.

prior variance of the cross-variable coefficient will be large enough to provide huge space for the data in the estimation process. Conversely, if the residual variance of the forcing variable is large enough, much of the cross-variable dependence is probably fostered by the effect of the external shock. The cross-variable coefficient in the systematic part of the model should now be near zero, and this fact is also reflected in the prior variance.

The posterior distribution of ϕ takes the form[23]

$$g(\phi|\mathbf{x}) \propto g(\phi)l(\phi|\mathbf{x}) = \exp\left\{-\frac{1}{2}\left[\left(\mathbf{V}_\phi^{-1/2}(\phi-\phi^*)\right)^T\left(\mathbf{V}_\phi^{-1/2}(\phi-\phi^*)\right)+\right.\right.$$
$$+\left\{\left(\mathbf{I}_{T\times T}\otimes\Omega_\varepsilon^{-1/2}\right)\mathbf{x}-\left(\mathbf{Z}^T\otimes\Omega_\varepsilon^{-1/2}\right)\mathbf{x}\right\}^T\times \tag{5}$$
$$\left.\left.\times\left\{\left(\mathbf{I}_{T\times T}\otimes\Omega_\varepsilon^{-1/2}\right)\mathbf{x}-\left(\mathbf{Z}^T\otimes\Omega_\varepsilon^{-1/2}\right)\mathbf{x}\right\}\right]\right\},$$

where the matrix Ω_ε is known in advance and contains the actually observed covariances of the model disturbances (in other words, it contains the ML estimates of the residual variances). Additionally, we applied zero restrictions on the non-diagonal entries of the matrix Ω_ε. This in fact identifies the structural version of the VAR.[24] The density (5) is the likelihood function of the Bayesian VAR. The posterior mean of $g(\phi|\mathbf{x})$ corresponds to

$$\bar{\phi} = \left[\mathbf{V}_\phi^{-1}+\left(\mathbf{Z}\mathbf{Z}^T\otimes\Omega_\varepsilon^{-1}\right)\right]^{-1}\left[\mathbf{V}_\phi^{-1}\phi^*+\left(\mathbf{Z}\otimes\Omega_\varepsilon^{-1}\right)\mathbf{x}\right], \tag{6}$$

and the posterior covariance matrix to

$$\bar{\Sigma}_\phi = \left[\mathbf{V}_\phi^{-1}+\left(\mathbf{Z}\mathbf{Z}^T\otimes\Omega_\varepsilon^{-1}\right)\right]^{-1}. \tag{7}$$

The posterior distribution of the AR(1) coefficients in the private investment equations (representing the time-to-build constraint) can be found in Appendix F. See Koop (2003) and Lütkepohl (2005) for more informative treatises about Bayesian statistics and BVAR.

Based on the stylized facts of the Czech economy, a question could be raised about the application of block restrictions to some parameters of the models. Specifically, the question is whether the cross-variable coefficients in the equations of foreign demand and economic sentiment in the EU (exogenous variables for the Czech economy) should be set to zero in advance. In fact, we do not follow this approach and consider all the cross-variable coefficients symmetrically. Moreover, the application of block restrictions would increase the computational difficulty. So, we instead checked the posterior distribution of the cross-variable coefficients in the equations for foreign demand and economic sentiment in the EU. All of these coefficients had a zero mean with a narrow confidence interval.

6. Results

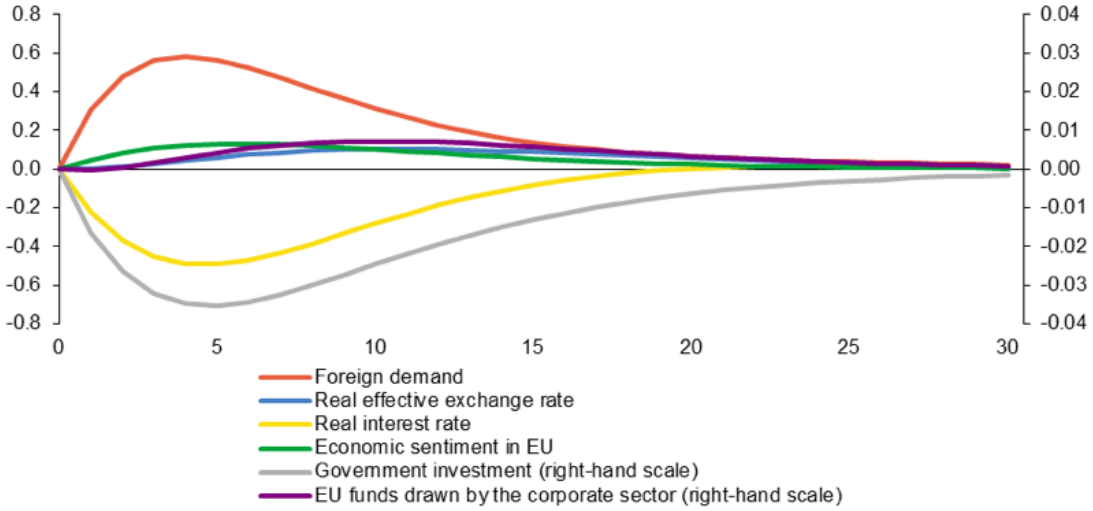
Based on Figure 3, foreign demand is the main force driving the decision about new investment. The elasticity of private investment with respect to foreign demand tends to peak in the year after the shock at 0.6. This holds for the aggregate economy. Furthermore, positive effects

[23] In fact, this is the kernel of the posterior probability density function.

[24] We also worked with various non-diagonal versions of the covariance matrix Ω_ε and hence with various structural versions of the VAR, but the results did not differ significantly.

of increased foreign demand on private investment are observed in most sectors of the Czech economy (see Figure 4a and Appendix C). The impulse responses are especially pronounced in manufacturing and tourism, where the elasticity sometimes greatly exceeds one. Within manufacturing, it is mainly the automotive and electrical engineering industries which exhibit a highly elastic reaction; the elasticity reaches 2 in both cases. It is no accident that these two industries also constitute a crucial part of Czech foreign trade. In addition, there is a significant increase in investment following an increase in foreign demand in the sectors of trade and services and in construction. In line with the aggregate economy, most sectors show a hump-shaped response peaking in the fourth quarter. As in many other countries, the results therefore support the predictions of the accelerator theory, and the evolution of total output explains a large part of the fluctuations in Czech private investment.

Figure 3: Impulse Responses of Private Investment to Different Shocks



Note: Responses in % to a shock of 1 %, or 1 pp in the case of the real interest rate. Horizontal axis – number of quarters.

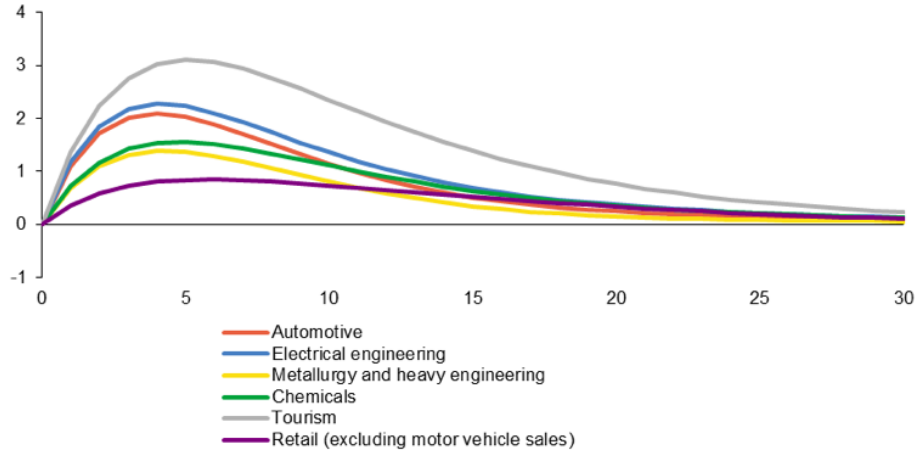
Source: Author's computations.

Of course, there are exceptions, such as investment in agriculture and the food industry, which are roughly immune to foreign demand, and investment in energy, mining, and telecommunications, which even shows a negative response to foreign demand. As stated previously, agricultural investment is heavily subsidized by the government and so is not driven by its expected profitability (the same, in fact, applies to the food industry). Investment in energy, mining, and telecommunications is also specific in nature, as firms in these sectors frequently possess monopoly power and invest in some form of cycle without any link to economy-wide fundamentals. According to this analysis, investment in energy, mining, and telecommunications can ultimately go against the business cycle.

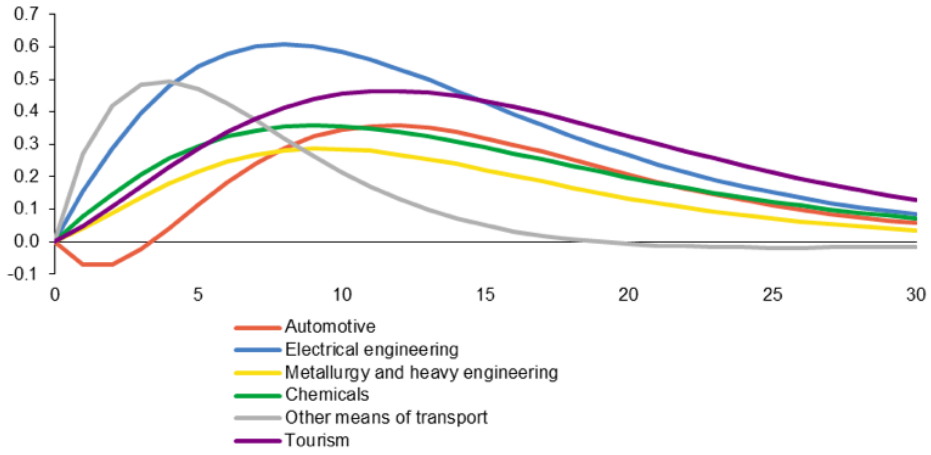
Not only currently observed demand, but also demand expected in the future plays an important role, although to a smaller extent (see Figure 3). Optimistic expectations positively affect investment in almost every sector of the Czech economy (see Appendix C). Compared with currently observed demand, the largest response (an elasticity of 0.1) comes with a delay, being observed in the seventh or eighth quarter after the shock occurs. This cautious reaction probably relates to the uncertainty surrounding expectations, in line with the wait-and-see theory of irreversible investment.

Figure 4: Impulse Responses in Selected Industries – Real Economy Disturbances

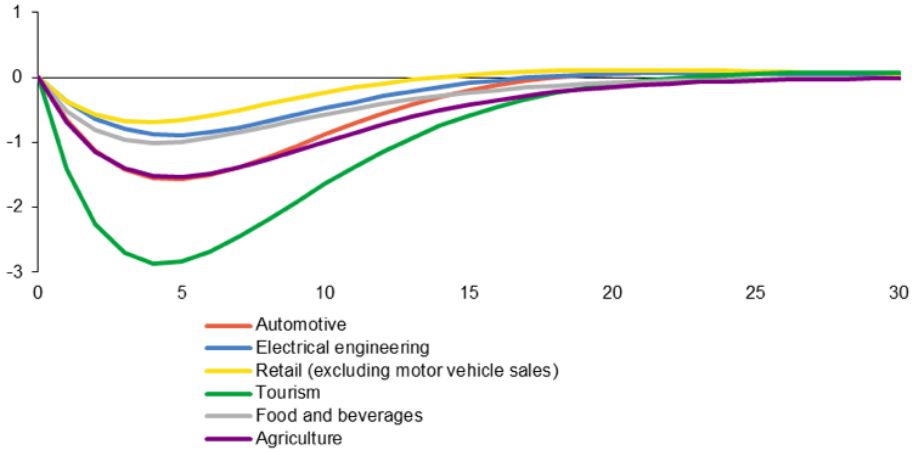
(a) Impulse Responses to an Increase in Foreign Demand



(b) Impulse Responses to a Weakening of the Real Exchange Rate



(c) Impulse Responses to an Increase in the Real Interest Rate

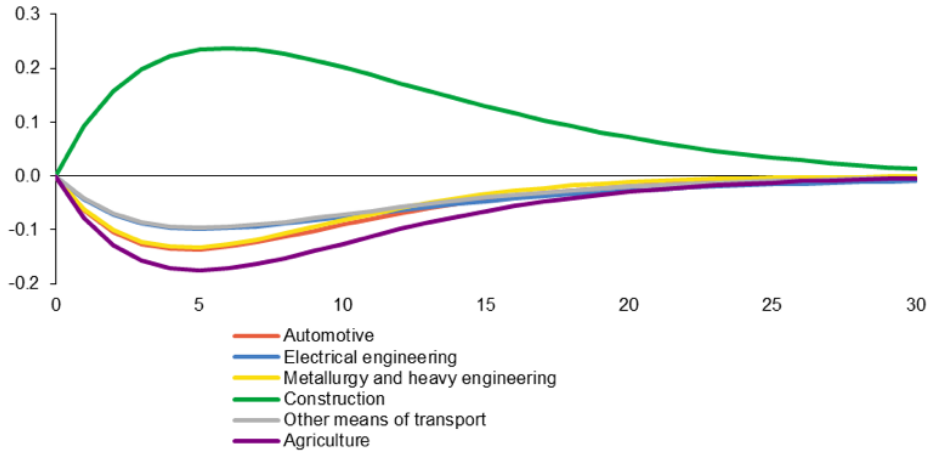


Note: Responses of private investment in % to a shock of 1 %, or 1 pp in the case of the real interest rate. Horizontal axis – number of quarters.

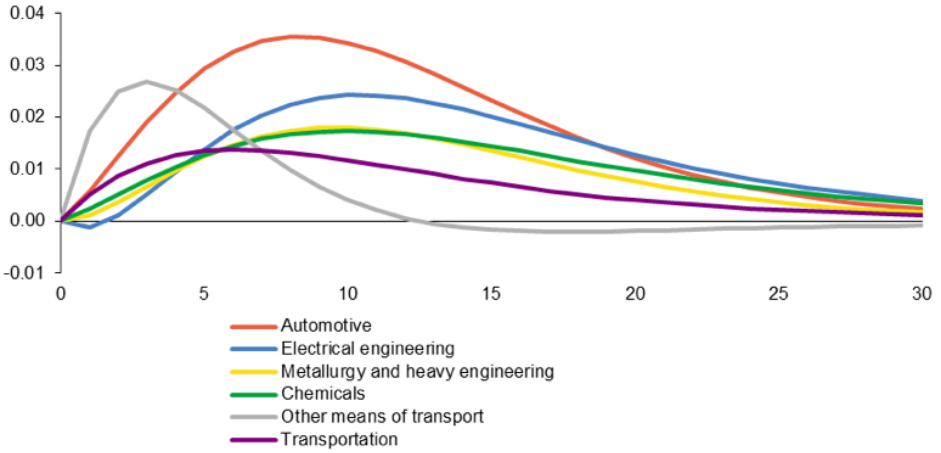
Source: Author's computations.

Figure 4: Impulse Responses in Selected Industries – Fiscal Disturbances

(d) Impulse Responses to an Increase in Government Investment

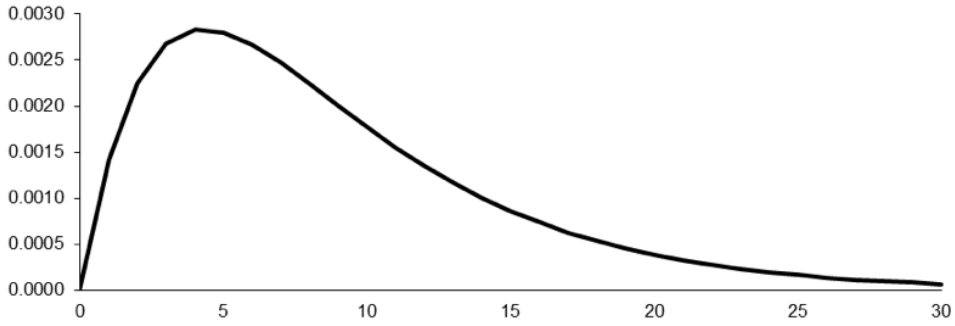


(e) Impulse Responses to an Increase in Drawdown of EU Funds



Note: Responses of private investment in % to a shock of 1 %; horizontal axis – number of quarters.
Source: Author's computations.

Figure 5: Response of the Interest Rate to an Increase in Government Investment



Note: Response in percentage points to a shock of 1 %; horizontal axis – number of quarters.
Source: Author's computations.

A change in the real effective exchange rate takes effect with an even greater delay. The impulse response has a tendency to peak (at an elasticity of 0.1) two years after the shock (see Figure 3). The delayed response is probably connected with staggered contracts in international trade. As the impulse response also shows, depreciation of the real effective exchange rate leads to an increase in private investment. Moreover, no negative effect in the form of reduced investment activity is observed at all. Clearly, the increased price competitiveness of Czech goods and services on foreign markets outweighs the increase in the price of imported investment goods at the aggregate level. As expected, a similar response was recorded in export-oriented industries, particularly in manufacturing and also in tourism (see Figure 4b). In these industries, the elasticity exceeds the aggregate value of 0.1 and ranges between 0.3 and 0.6. A few industries, namely, agriculture, energy, and mining, exhibit a clear one-sided negative response to exchange rate depreciation (see Appendix C). All these industries are less export intensive and more investment-import intensive.

Private investment behaves in the expected manner with respect to the real interest rate. An increase in the real interest rate is accompanied by a slowdown in investment (see Figure 3). The impulse responses have a tendency to bottom out around a year after the shock and are very similar across different sectors of the Czech economy (see Figure 4c and Appendix C). Tourism and agriculture display the biggest response, which corresponds nicely with the high proportion of debt in their investment financing. The automotive, electrical engineering, clothing, and food and beverages industries also show above-average responses. Generally, it can be said that investment in industries with smaller firms is more vulnerable to interest rate movements. Note that in the case of the real interest rate, it is not possible to compare its impulse responses with those of the other variables, because the shock is 1 pp rather than 1 %.

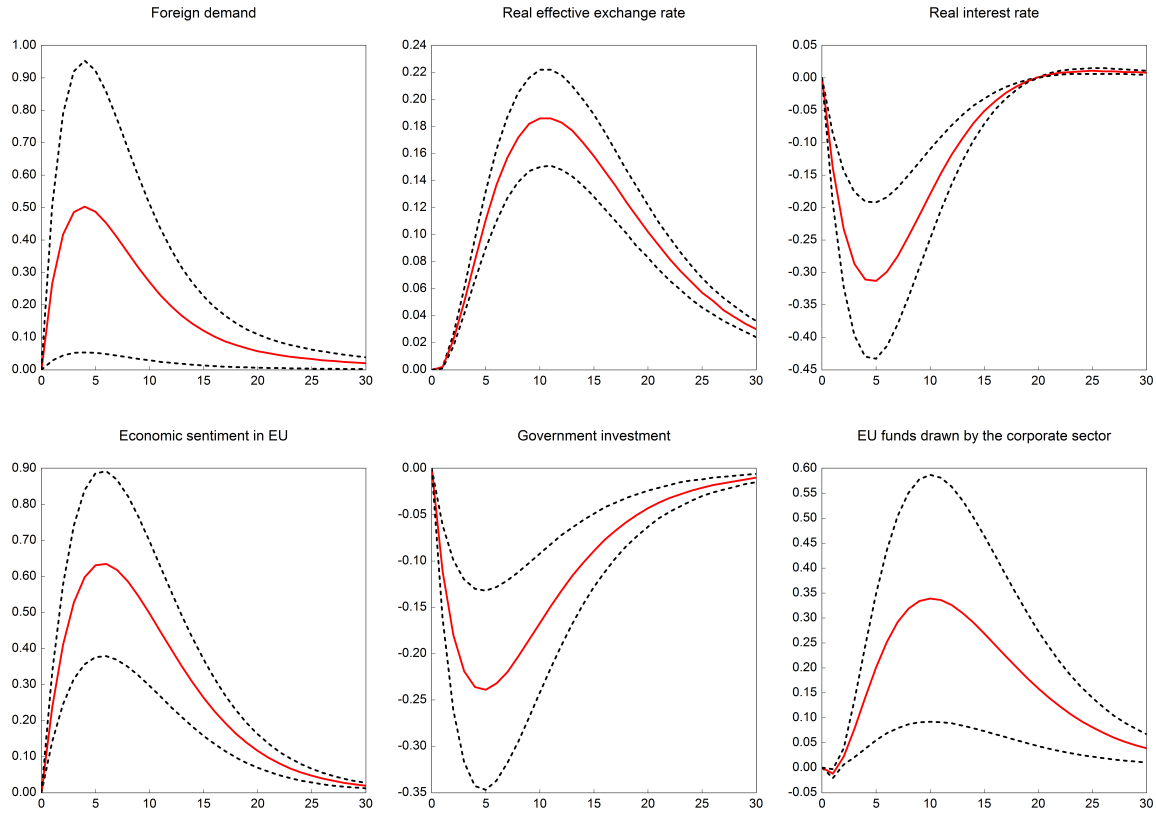
Government investment and EU funds have a smaller impact on the behavior of private investment. The elasticity attains the value of 0.04 for the former and 0.01 for the latter (see Figure 3). Taking into account the direction of the effect on the aggregate level, government investment affects private investment negatively, in accordance with the crowding-out hypothesis. The most striking crowding-out was witnessed in agriculture and manufacturing (see Figure 4d). Conversely, as a consequence of increased government investment, firms in the construction industry invest more. Note that the majority of government investment is realized in construction, so building firms strive to expand their production capacity. Crowding-in was also observed in services (including tourism) and trade (see Appendix C). These industries probably welcome improved infrastructure, education, and health (or any other product of public investment) for their future business opportunities and are accordingly willing to invest. We did not find any signs of waiting for synergy. In other words, the impulse responses do not vary in sign.

We consider the interaction of monetary and fiscal policy to be the most probable explanation of the crowding-out effect. Figure 5 traces the interest rate response to an increase in government investment. In fact, the response speaks for that explanation, but is also consistent with financial crowding-out. However, financial crowding-out rather contradicts the observed excess of liquidity on the Czech capital market in recent years. Based on the aforementioned, the crowding-out is likely to be a business cycle phenomenon. This reasoning is supported by the procyclicality of Czech fiscal policy over the sample. It is no surprise, then, that manufacturing exhibits the strongest response, as it is the main driving force of the Czech business cycle. The crowding-out in agriculture is connected with the loss-of-motivation aspect of government subsidies (see Section 2 of this paper).

Drawdown of EU funds by private firms, and not only by national governments, is a new way of financing private investment. Such drawdown has recently increased by a large amount (see Section 3 containing the stylized facts). This is partly why we included the drawdown of EU funds by private firms in our analysis. As Figure 3 shows, EU funds really do encourage private firms to invest more. This holds especially in manufacturing and transportation (see Figure 4e).

So far, we have commented on the long-run systematic linkages between the observed variables without paying special attention to the distribution of the shocks.[25] Because the period under review (2008 through 2015) was unusual in many respects, it should be worthwhile also to consider the responses of private investment to one standard deviation shocks[26] (see Figure 6 and Appendix C). Actually, the pattern of these impulse responses is similar to the case of a one-unit shock, as the transmission mechanism remains the same. What differs is the magnitude of the shocks (see Appendix D).

Figure 6: Impulse Responses to a One Standard Deviation Shock



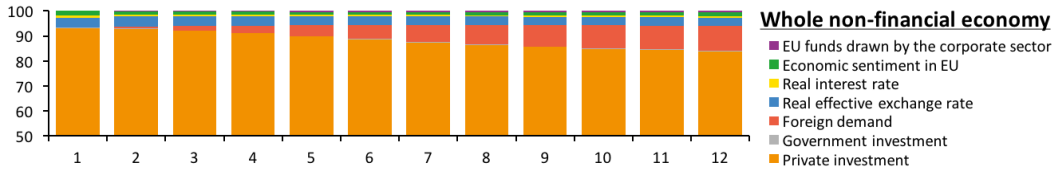
Note: Responses of private investment in % to a one standard deviation shock to selected macroeconomic covariates; horizontal axis – number of quarters. The confidence intervals correspond to the 5th and 95th percentiles.

Source: Author's computations.

[25] In order to analyze the systematic part of the model, we considered all the shocks to have the same relative importance (except for the real interest rate, all the variables were shocked by 1 percent).

[26] A one standard deviation shock is a typical disturbance for the period under review.

Figure 7: Variance Decomposition on the Aggregate Level



Note: Forecast error variance decomposition of private investment. Vertical axis – %; horizontal axis – time periods.

Source: Author's computations.

Figure 6 highlights the increased importance of expectations in the period 2008–2015 (recall the increase in uncertainty mentioned in the introduction, which influenced modern economies after the Great Recession). Figure 6 also shows the unprecedented drawdown of EU funds by private firms, especially at the end of the sample. Note that the massive drawdown of EU funds by private firms was merely a consequence of the transition from one EU financial perspective to the next. Therefore, it does not represent a structural change in how Czech private investment is financed or how it behaves, at least for the moment. Yet it may be a significant factor in some periods. The same applies to government investment as well. From the long-run perspective, its crowding-out of private investment seems to be weak, but it is amplified when government investment gets large. Intense external shocks affected the real interest rate. This was a result of accommodative monetary policy during a period of depressed demand. On the other hand, the introduction of a one-sided exchange rate peg by the Czech National Bank in November 2013 protected the real effective exchange rate from external shocks. As a consequence, the conditions of low interest rates and a weaker and stable exchange rate supported the creation of new investment in the period studied.

As regards the observed magnitude of the shocks, we also conducted a sensitivity analysis and generated confidence intervals for the estimated impulse responses (see Figure 6). These bands come from a bootstrap resampling algorithm, which took draws from the sample of observed shocks. As a matter of fact, the bands take into account the uncertainty with respect to the shock magnitude, but not with respect to the model parameters.[27] Consequently, it is the disturbance in foreign demand that could take a value from the most diverse set. Note that the period studied includes both the financial and euro area debt crisis and the period of rebounding European demand, so it is fruitful for sudden shifts in external demand.[28] The shock to the volume of EU funds also has wide bands. This is due to the discontinuous nature of their drawdown in the Czech Republic, which constitutes the previously mentioned EU funding cycle.

We present the results of the forecast error variance decomposition (FEVD) in Figure 7 for the whole non-financial economy and in Appendix E for the individual industries. The aggregate picture sends out a clear message that there is little space for fundamental factors in explaining the deviations from the expected value of private investment. These deviations are thus probably driven by expectational factors or uncertainty. This is just a manifestation of what Keynes called animal spirit. Nevertheless, there are industries in which fundamental factors play a greater role. Unexpected fluctuations in foreign demand explain up to 30 % of the deviations from the expected value of investment in manufacturing, especially in the automotive industry.

[27] In the simulation, we take the estimated data-generating process as a true process.
[28] With respect to this, compare the theoretical and empirical distribution of the shocks in Appendix D.

Fluctuations in the real exchange rate influence investment in retail, tourism, and energy. Disturbances in the real interest rate affect investment in agriculture, food and beverages, electrical engineering, and construction.

7. Conclusion

The factors influencing decisions about new business investment are frequently discussed, but until this study there was no empirical evidence to clarify these discussions – at least for the Czech Republic. Consequently, we proposed results based on a survey of fixed-assets purchases in 30,000 Czech non-financial corporations over the period 2008–2015. Through the estimation of BVAR models, we observe an influence of foreign demand, economic expectations, the interest rate, the exchange rate, public investment, and EU funds on private investment. The investigation is done for 19 industries and for the whole non-financial economy as well.

We found that foreign demand is most important for the performance of Czech private investment. According to our results, an increase in foreign demand promotes investment in most sectors of the economy, especially manufacturing and tourism. We also revealed a strengthened role of expectations and uncertainty in the demand for investment. The findings show that investment activity is negatively affected by a rise in the price of credit. On the other hand, devaluation of the exchange rate leads to higher investment through improved price competitiveness on foreign markets. This holds for the export-oriented manufacturing sector in particular. What should also be noted is that that we did not see any indication of laziness in investment as a consequence of long-lasting depreciation of the real exchange rate. The laziness argument was used in the policy debate against the CNB's devaluation of the Czech koruna.

As our results show, public investment crowds out private investment. While private investment in manufacturing and agriculture is crowded out by public investment, crowding-in was observed in construction, services, and trade. The interaction of monetary policy with procyclical fiscal policy seems to be the most probable explanation of the crowding-out effect. Finally, our research confirmed that EU funds can encourage private investment. Although the impact of EU funds on private investment is small from the long-run perspective, it can be intense in specific periods, as was the case in 2015. In fact, the same holds for government investment.

References

ABEL, A.B. AND J.C. EBERLY (1994): "A Unified Model of Investment Under Uncertainty." *The American Economic Review*, vol. 84, no. 5, pp. 1369-1384.

ABEL, A.B. AND J.C. EBERLY (1996): "Optimal Investment with Costly Reversibility." *The Review of Economic Studies*, vol. 63, no. 4, pp. 581-593.

ABEL, A.B. AND J.C. EBERLY (2012): "Investment, Valuation, and Growth Options." *Quarterly Journal of Finance*, vol. 2, no. 1.

ARROW, K.J. (1968): "Optimal Capital Policy with Irreversible Investment" in J.N. Wolfe, ed., *Value, Capital, and Growth*. Chicago: Aldine, pp. 1-20.

ASCHAUER, D.A. (1989): "Does Public Capital Crowd Out Private Capital?" *Journal of Monetary Economics*, vol. 24, no. 2, pp. 171-188.

BABECKÁ KUCHARČUKOVÁ, O. AND R. PAŠALIČOVÁ (2017): "Firm Investment, Financial Constraints and Monetary Transmission: An Investigation with Czech Firm-Level Data." *CNB Working Paper Series*, 16/2017.

BACHMANN, R. AND C. BAYER (2013): "Wait-and-See Business Cycles?" *Journal of Monetary Economics*, vol. 60, no. 6, pp. 704-719.

BARKBU, B., S.P. BERKMEN, P. LUKYANTSAU, S. SAKSONOVS, AND H. SHOELERMANN (2015): "Investment in the Euro Area: Why Has It Been Weak?" *IMF Working Paper*, no. 15/32.

BERNANKE, B.S. (1983): "Irreversibility, Uncertainty, and Cyclical Investment." *The Quarterly Journal of Economics*, vol. 98, no. 1, pp. 85-106.

BERTOLA, G. AND R.J. CABALLERO (1994): "Irreversibility and Aggregate Investment." *The Review of Economic Studies*, vol. 61, no. 2., pp. 223-246.

BINDING, G. AND A. DIBIASI (2017): "Exchange Rate Uncertainty and Firm Investment Plans Evidence from Swiss Survey Data." *Journal of Macroeconomics*, vol. 51, March 2017, pp. 1-27.

BLANCHARD, O. AND R. PEROTTI (2002): "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output." *The Quarterly Journal of Economics*, vol. 117, no. 4, pp. 1329-1368.

BLOOM, N. (2014): "Fluctuations in Uncertainty." *Journal of Economic Perspectives*, vol. 28, no. 2, pp. 153-176.

BOND, S., J.A. ELSTON, J. MAIRESSE, AND B. MULKAY (2003): "Financial Factors and Investment in Belgium, France, Germany, and the United Kingdom: A Comparison Using Company Panel Data." *The Review of Economics and Statistics*, vol. 85, no. 1, pp. 153-165.

BRAINARD, W.C. AND J. TOBIN (1968): "Pitfalls in Financial Model Building." *The American Economic Review*, vol. 58, no. 2, pp. 99-122.

CALOMIRIS, C.W. AND R.G. HUBBARD (1989): "Price Flexibility, Credit Availability, and Economic Fluctuations: Evidence from the United States, 1894-1909." *The Quarterly Journal of Economics*, vol. 104, no. 3, pp. 429-452.

CAMPA, J.M. AND L.S. GOLDBERG (1999): "Investment, Pass-through, and Exchange Rates: A Cross-Country Comparison." *International Economic Review*, vol. 40, no. 2, pp. 287-314.

CHENERY, H.B. (1952): "Overcapacity and the Acceleration Principle." *Econometrica*, vol. 20, no. 1, pp. 1-28.

CLARK, J.M. (1917): "Business Acceleration and the Law of Demand: A Technical Factor in Economic Cycles." *Journal of Political Economy*, vol. 25, no. 3, pp. 217-235.

CUMMINS, J.G., K.A. HASSETT AND S.D. OLINER (2006): "Investment Behavior, Observable Expectations, and Internal Funds." *The American Economic Review*, vol. 96, no. 3, pp. 796-810.

CZECH NATIONAL BANK (2016): *Inflation Report IV/2016*, 10 Nov. 2016. Available from: http://www.cnb.cz/miranda2/export/sites/www.cnb.cz/en/monetary_policy/inflation_reports/2016/2016_IV/download/ir_IV_2016.pdf.

DOAN, T., R.B. LITTERMAN, AND C.A. SIMS (1984): "Forecasting and Conditional Projection Using Realistic Prior Distributions." *Econometric Reviews*, vol. 3, no. 1, pp. 1-100.

ERENBURG, S.J. AND M.E. WOHAR (1995): "Public and Private Investment: Are There Causal Linkages?" *Journal of Macroeconomics*, vol. 17, no. 1, pp. 1-30.

EUROPEAN CENTRAL BANK (2017): "Business Investment in EU Countries." Unpublished preliminary version of the study.

FAZZARI, S.M., R.G. HUBBARD, B.C. PETERSEN, A.S. BLINDER, AND J.M. POTERBA (1988a): "Financing Constraints and Corporate Investment." *Brookings Papers on Economic Activity*, vol. 1988, no. 1, pp. 141-206.

FAZZARI, S.M., R.G. HUBBARD, AND B.C. PETERSEN (1988b): "Investment, Financing Decisions, and Tax Policy." *The American Economic Review*, vol. 78, no. 2, pp. 200-205.

HAYASHI, F. (1982): "Tobin's Marginal q and Average q: A Neoclassical Interpretation." *Econometrica*, vol. 50, no. 1, pp. 213-224.

HOVAKIMIAN, G. (2009): "Determinants of Investment Cash Flow Sensitivity." *Financial Management*, vol. 38, no. 1, pp. 161-183.

HUBBARD, R.G. (1998): "Capital-Market Imperfections and Investment." *Journal of Economic Literature*, vol. 36, no. 1, pp. 193-225.

KAPLAN, S.N. AND L. ZINGALES (1997): "Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints?" *The Quarterly Journal of Economics*, vol. 112, no. 1, pp. 169-215.

KAPLAN, S.N. AND L. ZINGALES (2000): "Investment-Cash Flow Sensitivities are not Valid Measures of Financing Constraints." *The Quarterly Journal of Economics*, vol. 115, no. 2, pp. 707-712.

KOOP, G. (2003): *Bayesian Econometrics*. John Wiley and Sons.

KOYCK, L.M. (1954): *Distributed Lags and Investment Analysis*. Amsterdam: North-Holland.

LITTERMAN, R.B. (1986): "Forecasting with Bayesian Vector Autoregressions – Five Years of Experience." *Journal of Business and Economic Statistics*, vol. 4, no. 1, pp. 25-38.

LÜTKEPOHL, H. (2005): *New Introduction to Multiple Time Series Analysis*. Berlin: Springer-Verlag.

MCDONALD, R. AND D. SIEGEL (1986): "The Value of Waiting to Invest." *The Quarterly Journal of Economics*, vol. 101, no. 4, pp. 707-728.

MACKINNON, J.G., A.A. HAUG, AND L. MICHELIS (1999): "Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration." *Journal of Applied Econometrics*, vol. 14, no. 5, pp. 563-577.

MITRA, P. (2006): "Has Government Investment Crowded out Private Investment in India?" *The American Economic Review*, vol. 96, no. 2, pp. 337-341.

NÁGLOVÁ, Z. AND M. GÜRTLER (2016): "Consequences of Supports to the Economic Situation of Farms with Respect to their Size." *Agricultural Economics - Czech*, vol. 62, no. 7, pp. 311-323.

PINDYCK, R.S. (1988): "Irreversible Investment, Capacity Choice, and the Value of the Firm." *The American Economic Review*, vol. 78, no. 5, pp. 969-985.

PINDYCK, R.S. (1991): "Irreversibility, Uncertainty, and Investment." *Journal of Economic Literature*, vol. 29, no. 3, pp. 1110-1148.

SERVEN, L. AND A. SOLIMANO (1992): "Private Investment and Macroeconomic Adjustment: A Survey." *The World Bank Research Observer*, vol. 7, no. 1, pp. 95-114.

SHAPIRO, M.D. (1986): "Investment, Output, and the Cost of Capital." *Brookings Papers on Economic Activity*, vol. 1986, no. 1, pp. 111-164.

SHARPE, S.A. AND G. SUAREZ (2014): "The Insensitivity of Investment to Interest Rates: Evidence from a Survey of CFOs." *FEDS Working Paper*, no. 2014-2.

STIGLITZ, J.E. AND A. WEISS (1981): "Credit Rationing in Markets with Imperfect Information." *The American Economic Review*, vol. 71, no. 3, pp. 393-410.

SVOBODA, J., J. LOSOSOVÁ, AND R. ZDENĚK (2016): "Subsidies on Investments in the EU

Member States." *AGRIS on-line Papers in Economics and Informatics*, vol. 8, no. 4, pp. 153-162.

ŠPIČKA, J., Z. NÁGLOVÁ, AND M. GÜRTLER (2017): "Effects of the Investment Support in the Czech Meat Processing Industry." *Agricultural Economics - Czech*, vol. 63.

TOBIN, J. (1969): "A General Equilibrium Approach to Monetary Theory." *Journal of Money, Credit, and Banking*, vol. 1, no. 1, pp. 15-29.

XU, X. AND Y. YAN (2014): "Does Government Investment Crowd Out Private Investment in China?" *Journal of Economic Policy Reform*, vol. 17, no. 1, pp. 1-12.

Appendix A: Johansen Cointegration Test

Trace test			
Number of cointegration vectors under H0	Eigenvalue	Test statistic	Probability
0	0.7826	157.59	0.0001
1	0.7159	110.28	0.0034
2	0.5555	71.27	0.0381
3	0.5184	46.14	0.0719
4	0.4092	23.48	0.2231
5	0.1997	7.17	0.5580
6	0.0085	0.27	0.6063
Maximum Eigenvalue test			
Number of cointegration vectors under H0	Eigenvalue	Test statistic	Probability
0	0.7826	47.31	0.0382
1	0.7159	39.01	0.0657
2	0.5555	25.14	0.3758
3	0.5184	22.65	0.1888
4	0.4092	16.31	0.2070
5	0.1997	6.90	0.5005
6	0.0085	0.27	0.6063

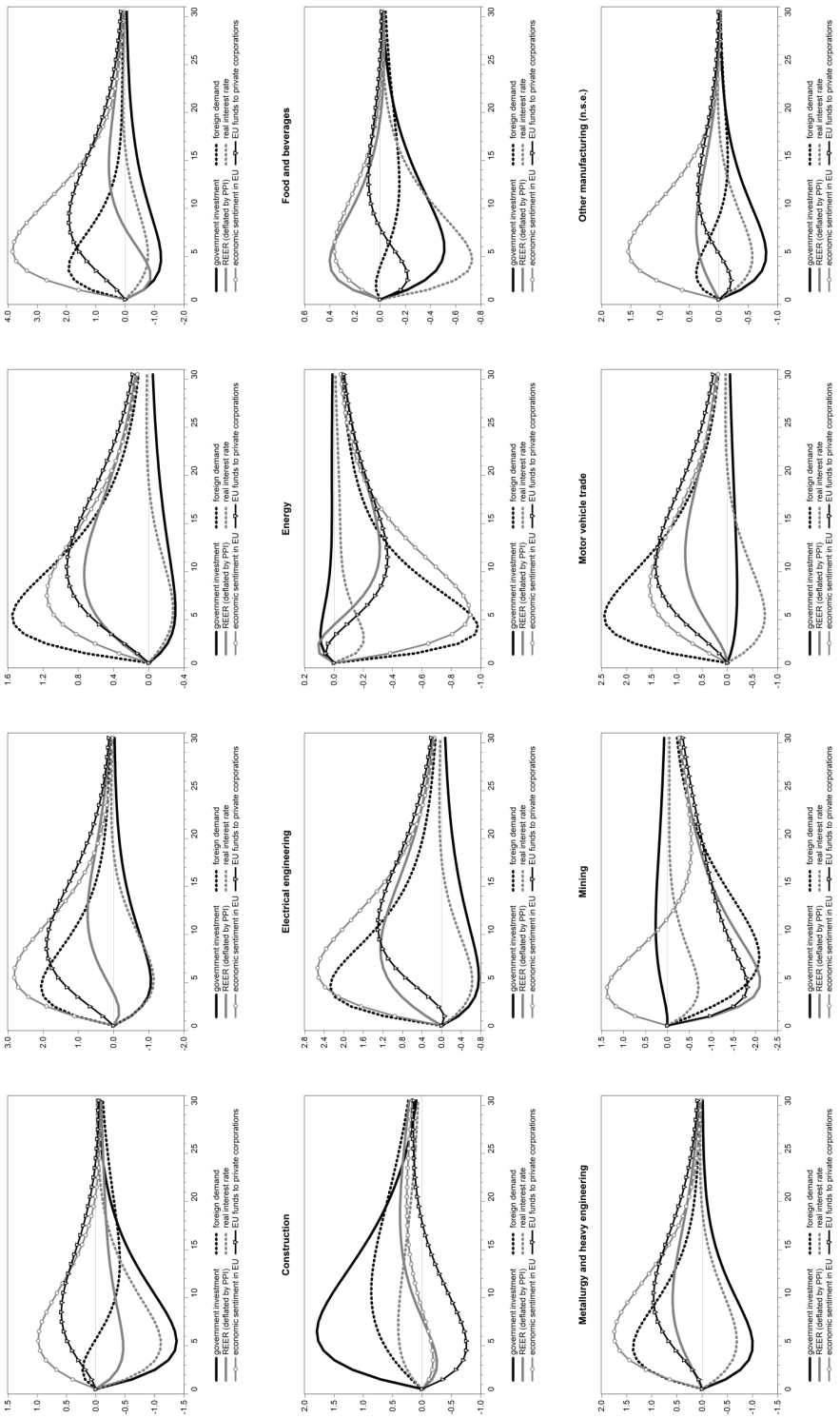
Note: P-values are based on MacKinnon, Haug and Michelis (1999).
Source: Author's computations.

Appendix B: Residuals of the Aggregate Model

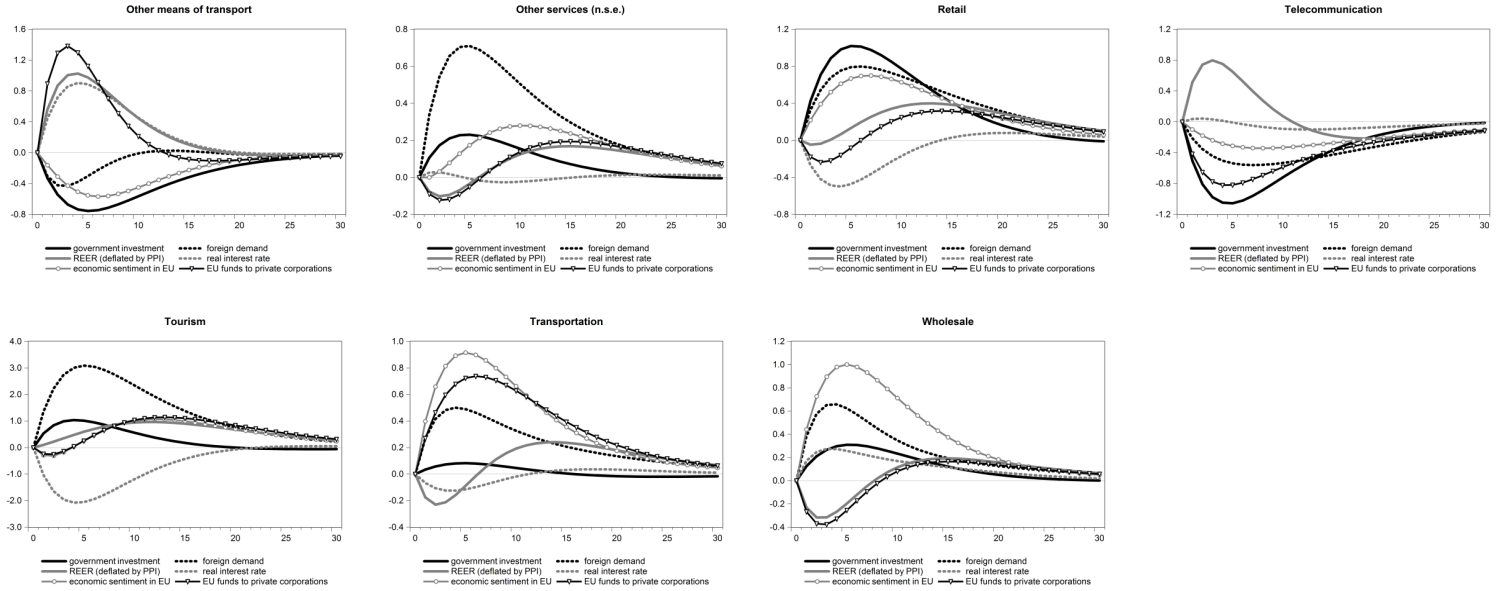
Note: The residuals are from the model, which is estimated on the data for the whole non-financial economy. The two horizontal blue lines indicate the $\pm$ 2 standard deviation bands of the insignificance.

Source: Author's computations.

Appendix C: Responses to a One Std. Dev. Shock



Appendix C: Responses to a One Std. Dev. Shock (continued)

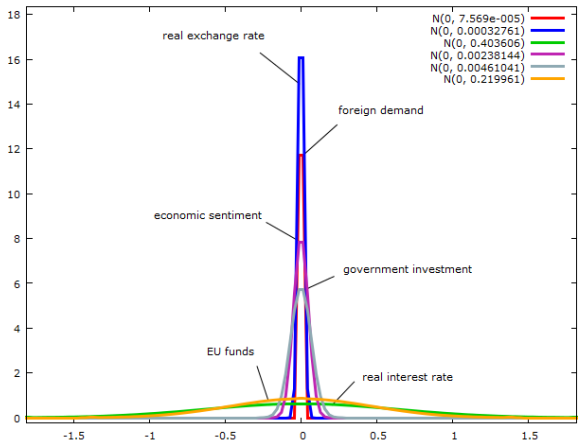


Note: Responses of private investment to shocks to selected macroeconomic covariates. Vertical axis – %; horizontal axis – quarters. To save space, the confidence intervals are not reported.

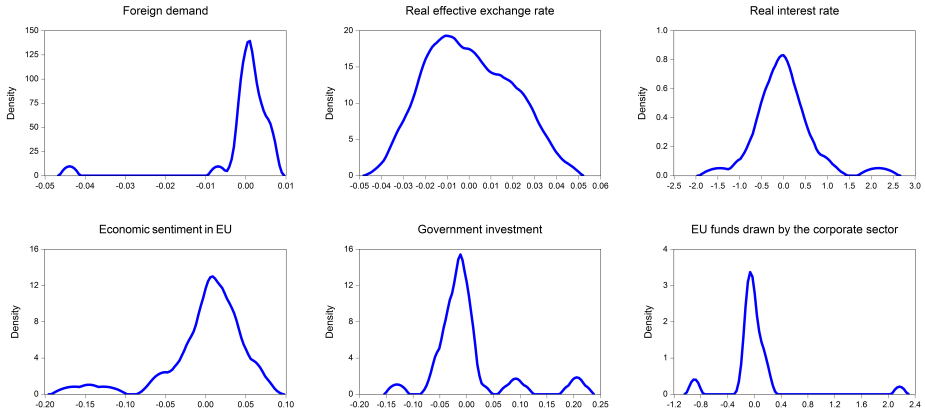
Source: Author's computations.

Appendix D: Distribution of the Shocks

Theoretical Distributions



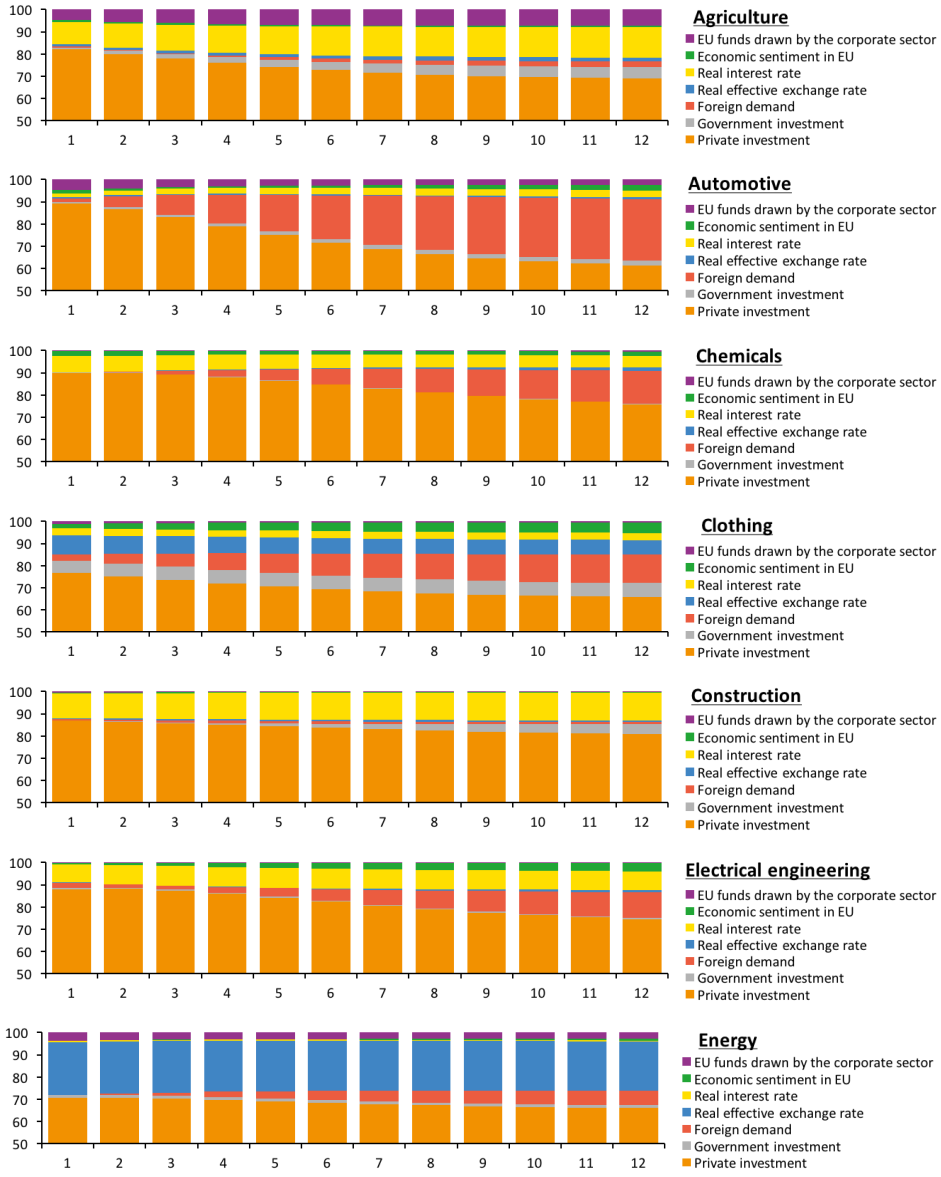
Empirical Distributions



Note: The figure at the top describes the theoretical distributions of the shocks based on the Gaussian p.d.f. – therefore, only the estimation for the first two moments is taken into account. The figures at the bottom show the empirical distributions estimated by means of Epanechnikov kernels.

Source: Author's computations.

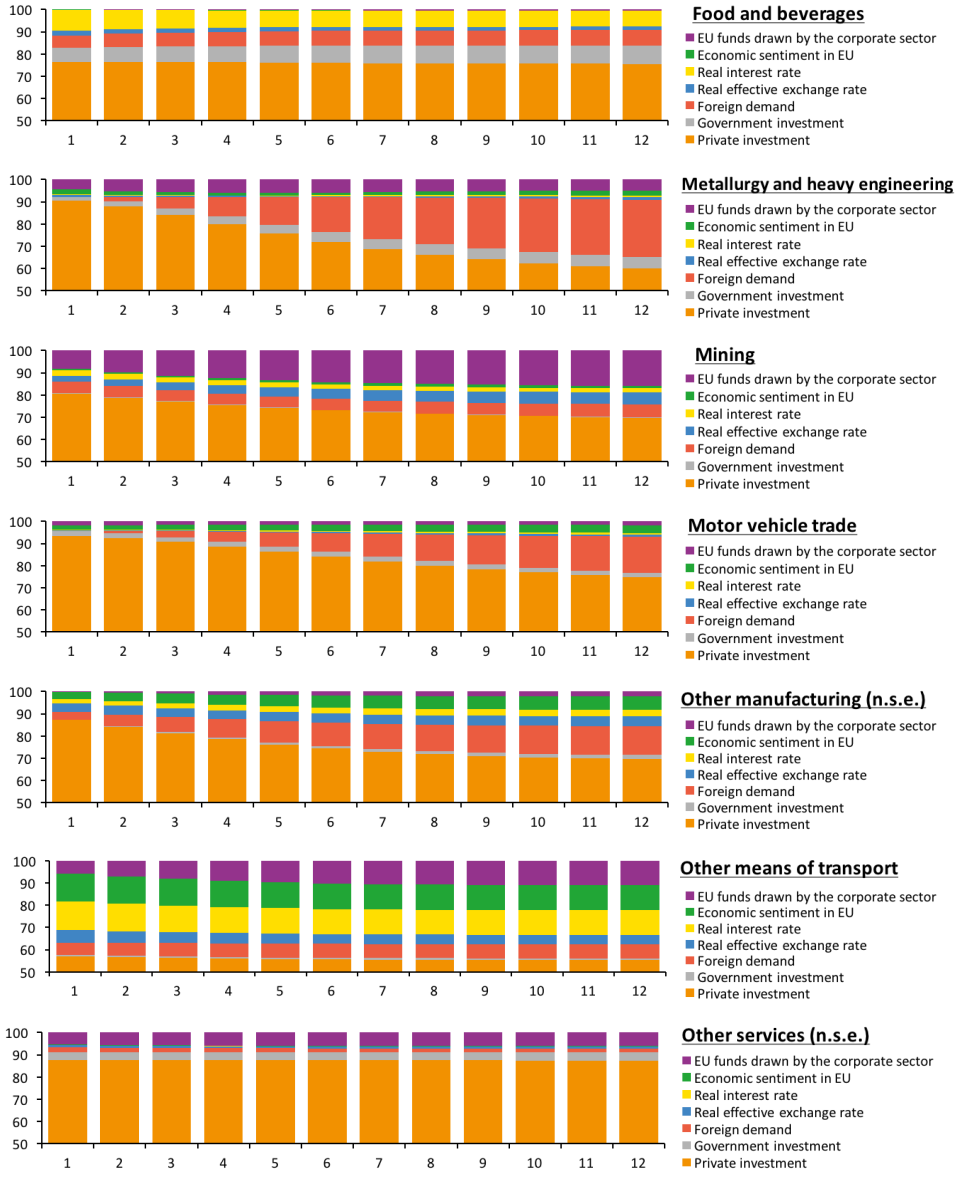
Appendix E: Variance Decomposition



Note: Forecast error variance decomposition of private investment. Vertical axis – %; horizontal axis – time periods.

Source: Author's computations.

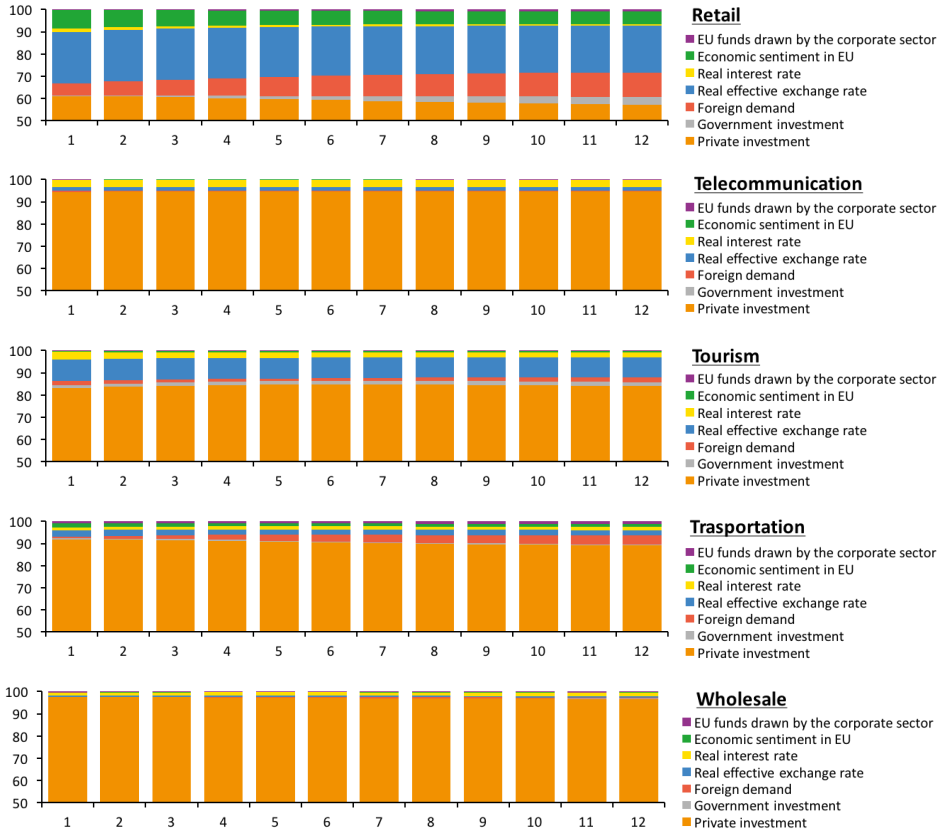
Appendix E: Variance Decomposition (continued)



Note: Forecast error variance decomposition of private investment. Vertical axis – %; horizontal axis – time periods.

Source: Author's computations.

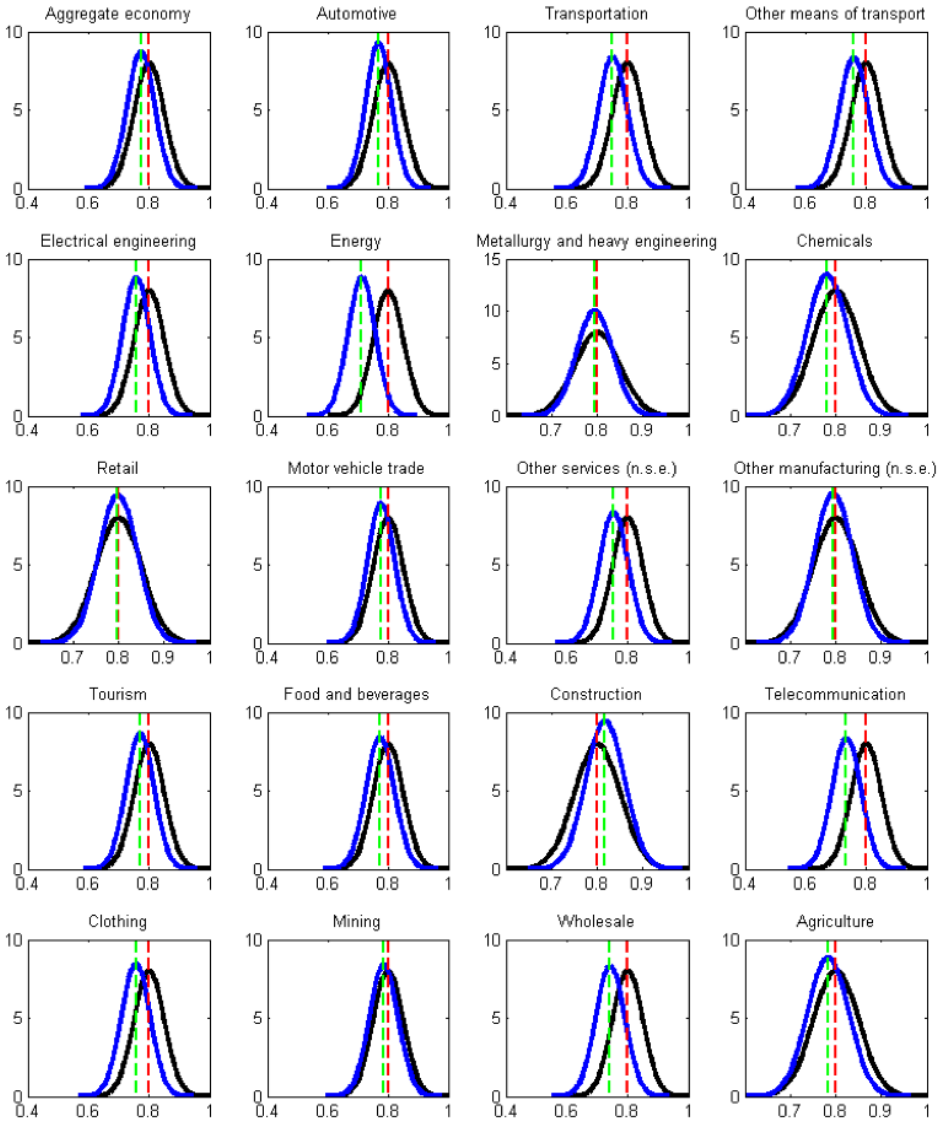
Appendix E: Variance Decomposition (continued)



Note: Forecast error variance decomposition of private investment. Vertical axis – %; horizontal axis – time periods.

Source: Author's computations.

Appendix F: Posterior Distribution of Time-to-Build Coefficients



Note: The posterior density is marked in blue and the prior density in black. The posterior mean is indicated by the green dashed line and the prior mean by the red dashed line.

Source: Author's computations.

Appendix G: Definition of Industries by NACE Classification

Industry	NACE classification
Agriculture	NACE 01, NACE 02, NACE 03;
Automotive	NACE 29;
Chemicals	NACE 17, NACE 19, NACE 20, NACE 21, NACE 22, NACE 23;
Clothing	NACE 13, NACE 14, NACE 15;
Construction	NACE 41, NACE 42, NACE 43;
Electrical engineering	NACE 26, NACE 27;
Energy	NACE 35, NACE 36, NACE 37, NACE 38, NACE 39;
Food and beverages	NACE 10, NACE 11, NACE 12;
Metallurgy and heavy engineering	NACE 24, NACE 25, NACE 28;
Mining	NACE 05, NACE 06, NACE 07, NACE 08, NACE 09;
Motor vehicle trade	NACE 45;

Appendix G: Definition of Industries by NACE Classification (continued)

Industry	NACE classification
Other manufacturing (n.s.e.)	NACE 16, NACE 18, NACE 31, NACE 32, NACE 33;
Other means of transport	NACE 30;
Other services (n.s.e.)	NACE 58, NACE 59, NACE 60, NACE 62, NACE 63, NACE 68, NACE 69, NACE 70, NACE 71, NACE 72, NACE 73, NACE 74, NACE 75, NACE 76, NACE 77, NACE 78, NACE 79, NACE 80, NACE 81, NACE 82, NACE 83, NACE 84, NACE 85, NACE 86, NACE 87, NACE 88, NACE 89, NACE 90, NACE 91, NACE 92, NACE 93, NACE 94, NACE 95, NACE 96, NACE 97, NACE 98, NACE 99;
Retail	NACE 47;
Telecommunication	NACE 61;
Tourism	NACE 55, NACE 56;
Transportation	NACE 49, NACE 50, NACE 51, NACE 52, NACE 53;
Wholesale	NACE 46

Note: n.s.e. – not specified elsewhere.

Appendix H: Distribution of Employment in Each Industry

Industry	< 10	$[10,20)$	$[20,30)$	$[30,40)$	$[40,50)$	≥ 50	Total
Agriculture	8.16	10.65	21.57	15.30	9.91	34.41	100
Automotive	4.19	4.87	10.80	6.82	4.86	68.47	100
Chemicals	4.71	10.94	16.62	10.92	8.57	48.25	100
Clothing	7.81	16.24	21.72	12.26	8.12	33.84	100
Construction	11.93	21.12	26.46	12.11	6.91	21.47	100
Electrical engineering	4.84	12.16	16.89	9.50	7.45	49.16	100
Energy	10.86	13.83	17.33	11.96	7.72	38.31	100
Food and beverages	5.39	13.58	21.09	12.60	8.07	39.27	100
Metallurgy and heavy engineering	4.42	10.89	18.93	12.39	9.17	44.20	100
Mining	6.41	13.66	17.30	10.15	7.44	45.04	100
Motor vehicle trade	7.73	19.06	27.21	12.75	7.98	25.28	100
Other manufacturing (n.s.e.)	6.22	17.79	24.11	11.11	8.34	32.42	100
Other means of transport	3.37	6.19	15.27	9.83	7.86	57.48	100
Other services (n.s.e.)	15.52	19.10	20.37	10.63	6.65	27.72	100
Retail	12.41	28.41	23.40	9.17	5.27	21.34	100
Telecommunication	12.18	20.74	22.49	8.36	5.65	30.57	100
Tourism	11.09	28.12	26.85	11.28	6.25	16.41	100
Transportation	7.62	16.86	22.19	11.73	8.67	32.93	100
Wholesale	17.28	20.83	23.85	11.98	6.98	19.08	100
Total	10.53	17.67	21.81	11.52	7.50	30.98	100

Note: For each industry the table contains the share (in %) of firms with the number of employees in the intervals defined in the first line of the table. For example, 8.16 % of agricultural enterprises in the sample have less than 10 employees and the total number of enterprises with less than 10 employees represents 10.53 % of the firms in the sample.

Source: Author's computations.

Appendix I: Distribution of Firms with a Particular Number of Employees over Industries

Industry	< 10	$[10,20)$	$[20,30)$	$[30,40)$	$[40,50)$	≥ 50	Total
Agriculture	4.34	3.38	5.54	7.44	7.40	6.23	5.60
Automotive	0.56	0.39	0.69	0.83	0.91	3.09	1.40
Chemicals	2.45	3.40	4.18	5.20	6.27	8.55	5.49
Clothing	1.56	1.93	2.09	2.23	2.27	2.29	2.10
Construction	12.49	13.18	13.37	11.58	10.15	7.64	11.02
Electrical engineering	1.19	1.78	2.01	2.14	2.57	4.11	2.59
Energy	2.54	1.93	1.96	2.56	2.53	3.05	2.46
Food and beverages	1.97	2.96	3.72	4.21	4.14	4.88	3.85
Metallurgy and heavy engineering	4.07	5.97	8.41	10.42	11.84	13.82	9.69
Mining	0.21	0.27	0.28	0.31	0.35	0.51	0.35
Motor vehicle trade	1.85	2.72	3.15	2.79	2.69	2.06	2.52
Other manufacturing (n.s.e.)	3.44	5.86	6.44	5.62	6.48	6.10	5.82
Other means of transport	0.11	0.12	0.23	0.28	0.35	0.61	0.33
Other services (n.s.e.)	30.19	22.14	19.13	18.90	18.15	18.33	20.48
Retail	6.70	9.15	6.10	4.53	4.00	3.92	5.69
Telecommunication	0.33	0.33	0.29	0.20	0.21	0.28	0.28
Tourism	4.43	6.68	5.17	4.11	3.50	2.23	4.20
Transportation	3.87	5.10	5.44	5.44	6.18	5.68	5.34
Wholesale	17.70	12.72	11.80	11.21	10.03	6.64	10.78
Total	100	100	100	100	100	100	100

Note: The table contains the share of the industry in a specified category regarding the number of employees (see the first line of the table). For example, 4.34 % of firms with less than 10 employees are in agriculture and agriculture has a share of 5.6 % in the total number of employees of the firms included in the sample.

Source: Author's computations.

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