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Credit Supply Shocks in the Netherlands

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Abstract

We investigate the role of credit supply shocks in the Netherlands in a structural VAR framework following the identification scheme proposed by Barnett and Thomas (2013). We find evidence that positive credit supply shocks boosted growth before 2007 before adverse credit supply shocks depressed GDP growth between 2008 and early 2012. From late 2012 onwards, credit supply shocks were not important factors behind the sluggish GDP growth in the Netherlands. When looking at which components of GDP are most affected by credit supply shocks, we find evidence that investment is hit considerably harder than consumption, although it recovers more quickly.

JEL Classification: c32; E51; G01
Keywords: Credit supply; Great Recession; VAR models; Sign restrictions; Zero restrictions

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1 Introduction

After the fall of Lehman Brothers in 2008 the Netherlands experienced a deep recession followed by a sluggish recovery with years of low growth. Although such experiences are common after financial crises (Reinhart and Rogoff, 2009), there are many plausible contributory factors other than credit supply shocks that may have been playing a role in the disappointing economic performance in the Netherlands in recent years. Besides restrictions in credit supply, explanations that may account for the sluggish economic performance include fiscal austerity, sluggish external demand, the European debt crisis and the Dutch house price slump. How important credit supply shocks have been compared to these factors is, however, unclear. The main contribution of this paper is to provide some evidence for the macroeconomic importance of credit supply shocks in the Netherlands, whilst also taking account of other contributory factors for the slow growth. Until now, for the Netherlands, there is little quantitative evidence of the role played by credit supply shocks at the macro level and this paper aims to fill that gap. A second contribution of this paper is to look at how credit supply shocks have affected households and firms separately. Both households and firms have complained of restricted access to credit since the fall of Lehman Brothers.

In order to adequately describe the role of credit supply shocks in macroeconomic developments, two conditions must be met. Firstly, exogenous credit supply shocks must be identified. That is, some technique for differentiating between the demand and supply of credit needs to be used as well as distinguishing between endogenous credit supply responses to macroeconomic developments and exogenous shifts in credit supply. Secondly, once credible exogenous shifts in the supply of credit have been isolated, their effects on the macroeconomy need to estimated. Since alternative sources of financing for firms and households are available, credit supply shocks may not have macroeconomic consequences if households and firms can substitute one type of financing for another. To achieve both a credible identification of credit supply shocks and to be able to trace their subsequent macroeconomic effects, we use the structural vector autoregression (SVAR) framework proposed by Barnett and Thomas (2013). Their approach relies on sign restrictions to distinguish between credit supply and demand shocks in combination with the restriction that financial shocks take time to affect the real economy to distinguish real from financial shocks. We impose this combination of zero and sign restrictions with the algorithm of Arias et al. (2014), which ensures they are correctly identified.

We find that the Dutch economy was boosted by credit supply shocks prior to 2007 and was hit by significant adverse credit supply shocks in 2008 and 2011. This covers the period when the first signs of global financial distress were followed by the bankruptcy of Lehman Brothers (Trichet, 2010) and the start of the sovereign debt crisis in Europe (European Central Bank, 2011). From 2012 onwards, however, credit supply shocks had little effect on GDP growth. Looking more closely at how credit supply shocks impact the macroeconomy, we find evidence that most of the effect of credit supply shocks on GDP growth can be attributed to investment, with a smaller share attributable to consumption. Although investment is more sensitive to credit supply shocks than consumption, investment and lending to firms recover faster than consumption and lending to households.

The rest of the paper is structured as follows. Section 2 starts by placing our research on the effects of credit supply shocks in the Netherlands in the context of the existing literature. Section 3 outlines our approach by briefly introducing the algorithm used in this paper and the data we use. Section 4 presents our main results, whilst section 5 presents some robustness exercises. Section 6 extends the analysis by looking at the effects of credit supply shocks on households and firms. Finally, section 7 offers some concluding comments.

2 The importance of credit supply shocks in Europe

Until the fall of Lehman Brothers banks were usually only considered to be part of the propagation mechanism amplifying shocks originating elsewhere. The financial crisis forced a reevaluation of this position and highlighted the importance of disturbances arising *within* financial institutions — that is, shocks to credit supply. These shocks may have many underlying causes such as unexpected contractions in bank capital (Gerali et al., 2009), declines in the value of banks' assets (Adrian and Shin, 2010) or changes in the pricing of default risk by financial institutions (Gilchrist and Zakrajsek, 2011) and these underlying causes are often interlinked. For example, Adrian and Shin (2010) illustrate for five US banks how a worsening of their assets during the financial crisis engendered a negative spiral where deleveraging was followed by further falls in asset prices, which restricted credit supply substantially.

The shocks that originated in the financial sector when Lehman Brothers collapsed were felt in both the US and in Europe. Since then, however, the US economy has recovered much quicker than European economies. Europe has a unique financial architecture and institutional framework which has likely played a role in the sluggish economy. For example, until the start of the European banking union in 2014, the deposit guarantees for european banks were dependent on the financial health of the home country governments (Mody and Sandri, 2002), many of which were wrestling with high public debts and, officially, no lender of last resort (Sims, 2012, and De Grauwe, 2012). This led to many aftershocks in the European financial system as investors regularly reevaluated the health of financial institutions as new information about the fiscal health of their sovereigns came to light. How much these aftershocks have translated into shifts in the supply of credit and impacted real economic activity is open to question. This paper aims to provide some evidence on the size and persistence of credit supply shocks in the Netherlands. We define a credit supply shock as an exogenous change in the supply of loans independent of shifts in aggregate demand and supply. The Netherlands itself is an interesting case: it is a euro area country that, although not directly affected by the sovereign debt crisis, has some characteristics that make it susceptible to spillover effects in a similar way to how it was susceptible to the financial crisis itself (Masselink and Van den Noord, 2009). For example, Dutch financial institutions were heavily dependent on external credit, with foreign claims on Dutch banks amounting to more than 300% of GDP. Furthermore, Dutch households and corporations rely heavily on bank financing. In fact, Dutch households are the most indebted in the euro area with OECD data putting Dutch household debt at almost 300% of disposable income in 2010. These observations suggest the Dutch economy may have been particularly susceptible to spillover effects from the sovereign debt crisis in the periphery countries of the euro area.

There are a number of methodological issues that make it quite challenging to empirically distinguish the effects of credit supply shocks on the macroeconomy. Firstly, it is often difficult to separate movements in the supply of credit from movements in the demand for credit. Secondly, it is also challenging to distinguish exogenous movements in the supply of credit from the endogenous responses of financial institutions to changes in the macroeconomic environment. Thirdly, many studies that successfully look at micro level data do not provide evidence of the effects of credit supply shocks at the macro level, which may be smaller if firms and households have alternative sources of finance.

One strand of literature uses the Bank Lending Survey to identify changes in credit supply. Studies focussing on Europe include Blaes (2011), De Bondt et al. (2010), Cappiello et al. (2010), Ciccarelli et al. (2010), Del Giovane et al. (2011), Maddaloni and Peydró (2013), Altavilla et al. (2015) and Darracq and De Santis (2015). Van der Veer and Hoeberichts (2013) perform a similar analysis for the Netherlands. They show that tight non-price lending standards are behind a large portion of the fall in the growth rate of business lending since 2008, although they find a significant role for contractions in loan demand. Given their micro-approach, Van der Veer and Hoeberichts do not provide information on how credit supply shocks affect macroeconomic variables, and how important they have been in the Dutch economy with respect to other structural innovations, such as loan demand disturbances.

Another strand of literature looks at changes in economic activity at a level of aggregation lower than GDP, for example at industry level, and uses differences in the perceived external finance requirements of each industry to identify the effects of the credit-crisis. A good example of this is Bijlsma et al. (2013), who look at subdivisions of manufacturing in OECD countries and find that the credit crunch slowed industrial growth by 5.5%-points in 2008 and by over 20%-points in 2009. Nonetheless, this type of study does not look at aggregate activity and uses proxies to control for the likely demand for credit.

One class of models that have been employed to trace out the macroeconomic importance of credit supply shocks is structural vector autoregressions (SVARs). SVAR models are a relatively agnostic class of models that allow the data to speak. Conditional on an adequate identification scheme for credit supply shocks they can also trace the effects of these shocks on the macroeconomy. Bijsterbosch and Falagiarda (2015) document the growing literature that has used SVAR models to study credit supply shocks. Of the different approaches to identification, the use of sign restrictions lends itself to the study of credit supply shocks since financial time series are simultaneously determined. Simultaneity makes the more commonly used zero restrictions unsuitable since zero restrictions imply a causal ordering between the variables - assuming that prices or quantities of financial products do not react within a quarter is clearly problematic. Table 1 summarises papers using sign restrictions for the euro area or the Netherlands. Gambetti and Musso (2012) use a time-varying parameter VAR for the euro area identified with sign restrictions and find that credit supply shocks explain about half of the GDP slowdown in 2009. Their sample period ends in 2010 so they have little to say about the role of credit supply shocks in the sluggish recovery. Peersman (2011) also looks at the euro area as a whole and uses a combination of zero and sign restrictions in a constant parameter VAR. He finds that loan supply shocks account for about one-quarter of the drop in economic activity in 2009. Bijsterbosch and Falagiarda (2015) look at individual countries in the euro area with time varying parameter VARs. They find that credit supply shocks account for about one-third of the downturn in the Netherlands in 2009 but have partially supported economic growth since 2010. The final paper in Table 1 is Hristov et al. (2011), who deviate from the other papers by using a constant parameters panel VAR. For the Netherlands, their results also deviate from the rest somewhat: they find that credit supply shocks supported Dutch GDP growth in 2008 and early 2009 before turning negative.

This paper adds to this literature and distinguishes itself by also looking at separate models for households and non-financial corporations. Both households and firms have complained of difficulty securing loans since the fall of Lehman Brothers.

3 Our approach

3.1 VAR models combining zero and sign restrictions

Typically, econometric analysis with VAR models starts with the reduced form[1], where each dependent variable is regressed on its own lags and on the lags of the other variables. In vector notation, this can be expressed by:

$$\mathbf{y_t} = \mathbf{c} + A_1\mathbf{y_{t-1}} + A_2\mathbf{y_{t-2}} + \cdots + A_p\mathbf{y_{t-p}} + \mathbf{u_t} \tag{1}$$

where $\mathbf{y_t}$ represents an $n \times 1$ vector containing the endogenous variables — CPI inflation, GDP growth, a short-term interest rate, the corporate bond spread, lending growth and growth of equity prices — at quarter t, $\mathbf{c}$ is a vector of constant terms, A_p are $n \times n$ matrices of coefficients, $\mathbf{u_t}$ are the reduced-form error terms with zero mean and covariance matrix Σ.[2] However,

[1]For a more detailed introduction to the SVAR (and also VAR) model see Lütkepohl & Krätzig (2004) and Hamilton (1994).

[2]This specification assumes constant parameters across the entire sample period. That is something that is open to some doubt, especially given the financial crisis in the sample period. Practically, however, it appears not to be an important issue for the conclusions we draw since our key results for our baseline specification are similar to the results from a time-varying parameter SVAR reported in Bijsterbosch and Falagiarda (2015).

Table 1: Sign restricted SVAR models of credit supply shocks in the euro area

Paper	Methodology	Data	Variables	Identification scheme[a]	Main results
Gambetti and Musso (2012)	VAR with time-varying parameters and stochastic volatility	Euro Area, 1980-2010, quarterly data.	Real GDP CPI Inflation Loan volume Lending rate Policy rate	Aggregate Supply: +, -, +, +, ? Aggregate Demand: +, +, +, +, ? Loan Supply: +, ?, +, -, ?	Credit supply shocks have a significant effect on economic activity and credit markets (GDP growth and loan growth go up by 0.7 and 0.4 percentage points on impact, respectively). The impact of credit supply shocks seems to have changed in the last 30 years. Credit supply shocks are important in explaining the reduction in real GDP and loan growth occurred around 2009. (Less than) half of the fall in real GDP growth (loan growth) is due to credit restrictions.
Hristov et al. (2011)	Panel VAR	Euro Area countries, 2003-2010, quarterly data.	Real GDP GDP deflator Policy rate Lending rate Loan volume	Aggregate Supply: -, +, +, ?, ? Monetary Policy: -, -, +, ?, ? Aggregate Demand: -, -, -, -, ? Loan Supply: -, ?, -, +, -	Looking at the entire Euro Area, after a typical and adverse loan supply shock both real GDP and the loan volume drop significantly. The Netherlands has experienced favourable credit supply shocks up until 2009Q1, probably due to the large equity injections given by the Dutch government in 2008. Starting from 2009, credit restrictions have started affecting real GDP and loan growth negatively.
Peersman (2011)	VAR model	Euro Area, 1999-2012, monthly data.	Ind. production HICP Loan volume Lending rate Policy rate Loans - M0	Loan Demand: 0, 0, +, +, ?, ? Monetary Policy: 0, 0, +, -, -, ? Loan Supply: 0, 0, +, -, +, +	After a typical and favourable loan supply shock, output and loan volume increase significantly. Loan supply shocks explain about one-quarter of the drop in economic activity during the Great Recession, and most of the pre-crisis boom. Loan supply shocks are related to changes in the risk-taking appetite of banks, triggered by low government bond yields.
Bijsterbosch and Falagiarda (2015)	VAR with time-varying parameters and stochastic volatility	Euro Area countries, 1980-2013, quarterly data.	Real GDP GDP deflator Policy rate Lending rate Credit volume	Aggregate Supply: +, -, ?, ?, ? Aggregate Demand: +, +, +, +, ? Monetary policy: +, +, -, ?, ? Loan supply: +, +, +, -, +	In the Euro Area, there is a high degree of heterogeneity with respect to the post-crisis effect of loan supply restrictions In the Netherlands, loan and GDP growth respond immediately and positively (+1.3 and +0.5, respectively) to a favourable credit supply shock. Credit restrictions have significantly impaired GDP growth during the Great Recession, but partially sustained growth from 2010.

[a] For each shock, the restrictions follow the ordering of the variables shown in the column 'variables'.

to isolate cause and effect requires that we use the structural form rather than the reduced form given in equation (1). The structural form is given by

$$A_0\mathbf{y_t} = \mathbf{k} + A_1^\star \mathbf{y_{t-1}} + A_2^\star \mathbf{y_{t-2}} + \cdots + A_p^\star \mathbf{y_{t-p}} + \epsilon_\mathbf{t} \tag{2}$$

where A_0 is an $n \times n$ matrix containing the contemporaneous reactions of the variables to the structural shocks, $A_p^\star$ are $n \times n$ matrices of structural coefficients for system (1) and $\epsilon_\mathbf{t}$ is an $n \times 1$ vector of structural innovations (or shocks) with $E[\epsilon_\mathbf{t}\epsilon_\mathbf{t}'] = I$. The structural form and the reduced form are related through $A_0^{-1}A_0^{-1'} = \Sigma$. By itself, system (2) is unidentified, the practitioner must use economic theory to apply $\frac{n(n-1)}{2}$ extra restrictions on A_0. The most common form of restricting A_0 is to impose zero restrictions on A_0 (following Sims, 1980) implying one variable only responds to another with a lag. In anything but small systems, however, the number of credible zero restrictions is limited, and for some applications the assumption of a causal order is problematic, since variables often are jointly determined.

Economic theory typically has more to say about the sign of a response rather than the length of time it will take for a variable to respond to a shock. Sign-based restrictions provide an alternative way to do structural inference.[3] These restrictions are based on the expected co-movement of economic variables following a shock. For instance, after a favourable aggregate demand shock, prices and output should both increase whereas supply shocks should move them in opposite directions. The SVAR model can then disentangle aggregate demand and supply disturbances using this information. The standard technique for imposing sign retsrictions is to randomly draw orthogonal matrices, Q, such that $A_0^{-1}Q'QA_0^{-1'} = \Sigma$. By replacing A_0 in equation (2) with A_0Q, the researcher has another model that is observationally equivalent to the reduced form but with different impulse response functions. If the responses from the new model satisfy the sign restrictions, the model is kept, otherwise it is disgarded. This process is repeated until a sufficent number of models is accepted.

Unfortunately, despite their abundance in economic theory, sign restrictions represent only weak information (Fry and Pagan, 2007). As such, they may not reduce the space of acceptable models sufficiently to meaningfully recover the true structural shocks from the data, although Paustian (2007) reports that sign restrictions can recover the structural shocks if sufficient restrictions are employed. In the end, the researcher would ideally like to

[3]Good examples are Canova and De Nicolo (2002) and Uhlig (2005).

impose both the strong information embodied in a limited set of plausible zero restrictions, whilst also being able to analyse a bigger system using sign restrictions. Using both types of restrictions would enable the practitioner to better single out the shock and/or to include additional innovations in the SVAR without imposing incredible restrictions, as in the case mentioned above concerning only zero restrictions. As Paustian (2007) shows it is often important to include other structural shocks in the model to ensure that the shocks of interest truly capture their exogenous component, and not an endogenous response to other disturbances (see also Uhlig, 2005). Unfortunately, combining zero and sign restrictions is not straightforward because, in general, multiplying A_0 by a randomly drawn Q violates whatever zero restrictions the original A_0 matrix embodied.

A number of methods exist in the literautre to combine both sign and zero restrictions. Mountford and Uhlig (2009) use a penalty function approach. Benati and Lubik (2012) is one example of a series of papers that implement both sets of restrictions using special rotation matrices, i.e. the Householder transformation matrix and the Givens rotation matrix. The paper whose identification strategy we follow, Barnett and Thomas (2013) decompose A_0 into blocks before rotating just a subset of the blocks[4]. Finally, the algorithm of Binning (2013) imposes a small number of zero restrictions, leaving the model unidentified and thus allowing the implementation of sign restrictions.

However, except for the block identification approach, which limits where the zero restrictions can be imposed, these approaches to combining zero and sign restrictions may not correctly identify the shocks of interest. According to Arias et al. (2014) they do not provide "any theoretical justification that their algorithms, in fact, draw from the posterior distribution of structural parameters conditional on the sign and zero restrictions". In fact, these methods may lead to biased results by imposing unwanted sign restrictions on the data. In this paper we use the algorithm of Arias et al. (2014), which does not suffer from these shortcomings. The key element of this algorithm is a method for drawing the orthogonal Q matrices without violating the zero restrictions the researcher wishes to impose (for full details of the algorithm see Arias et al., 2014).

[4] Liu et al. (2011) provide a good explanation of this method.

3.2 Identification scheme

Our identifying restrictions are taken from Barnett and Thomas (2013). We impose the restrictions of Barnett and Thomas (2013) on the quarter when the shock occurs. We impose one additional restriction on the quarter following the shock, which we describe below. For all subsequent quarters the model is unrestricted. Although this paper focuses on credit supply shocks, other structural innovations are included in the model since they may help recover true stuctural shocks (Paustian, 2007). Instead of looking at draws that meet only the restrictions of the lending disturbances, the model records a subset of draws that respect the full set of restrictions and thus are better grounded in economic theory (Peersman, 2005).

Table 2: Identification Scheme

Shocks/Variables	Inflation	Output growth	Policy rate	Spread	Lending growth	Equity prices growth
Aggregate Supply	+	-	?	?	?	?
Aggregate Demand	+	+	+	?	?	?
Monetary Policy	+	+	-	?	?	?
Credit Supply	0	0	0	+	-	?
Loan Demand[a]	0	0	0	+	+	?
Equity Price	0	0	0	0	0	1

[a] We also assume that since loan demand shocks lead to extra lending on impact, this extra lending has a positive effect on GDP growth in the following quarter.

Table 2 shows the identifying restrictions that we use. The first three aggregate shocks are considered to be the most important factors in driving economic fluctuations. Hence, they are included in the model to ensure that credit supply shocks are exogenous rather than endogenous responses to macroeconomic conditions. The remaining structural innovations depict credit and financial market disturbances. The shocks will be discussed in turn.

Aggregate shocks

The restrictions used to identify aggregate shocks are well established in the literature (see papers in Table 1 and references therein), on the basis of standard theoretical models (see Peersman and Straub (2006) for a good summary). After an aggregate supply shock, inflation and output move in opposite directions, while they move in the same direction after an aggregate demand shock.[5] Aggregate demand shocks are split into monetary policy shocks and all other aggregate demand shocks. Through various transmission channels of monetary interventions, such as the traditional interest rate channel and balance sheet effects (see Antony and Broer (2010) for an extensive review), a lower policy rate boosts aggregate demand and thus raises both inflation and output growth. Other aggregate demand shocks create inflationary pressures, which the Central Bank reacts to by raising the policy rate.[6]

Credit and financial market shocks

Credit supply and loan demand shocks are distinguished from aggregate shocks with a timing restriction. Innovations in the credit market can be reasonably assumed to take time to impact the real economy. For instance, when there is a contraction in credit supply, firms are not likely to immediately change current production. It is in later periods that investment possibilities will be restricted by a lower availability of funding. This lagged impact is included in the model via the zero restrictions in Table 2, denoting that on impact credit supply and demand shocks do not affect CPI, GDP and the policy rate.

The shocks of central interest in this paper, credit supply shocks, are identified by assuming they move the price of credit, measured by the spread, and the quantity of loans in opposite directions. Loan demand shocks move the price of loans and the quantity of loans in the same direction. Additionally, to better distinguish credit supply and loan demand shocks we impose the restriction that the extra lending growth caused by a loan demand shock in-

[5]What matters are the *relative* sign restrictions imposed on the variables. For instance, an aggregate demand shock can be denoted by all pluses or all minuses. Those identifications do not change the meaning incorporated in the structural shock, and hence are interchangeable.

[6]The Netherlands is a part of the euro area and, as such, doesn't have it's own monetary policy. When setting interest rates the ECB puts only a small weight on events in the Netherlands. Specifying our model with endogenous monetary policy is implicitly assuming that disturbances relevant for monetary policy are sufficiently correlated between the Netherlands and the rest of the euro area. For example, when aggregate demand is low in the Netherlands it is also low in the rest of the euro, so the single monetary policy reacts. This is a fairly common assumption in the literaure - see Bijsterbosch and Falagiarda (2014) for an example.

creases GDP growth in the following quarter. In other words, we assume the extra loans are spent on something, which leads to at least some net extra spending in the following quarter.[7] Finally, the equity price shock reflects movements in equity prices that might induce firms to change their capital structure, which would impact lending volumes without being related to the supply of credit. The zero restrictions in the identification scheme incorporate our assumption that this volatility will not affect any other variable, at least on impact.

3.3 Data

Typically economic theory tells us about relationships between stylised concepts, but when we look at the real world there are a range of options for which data series to use for each of the concepts. This is especially true for the type of financial market data that this paper relies on, where there are a multitude of different variables to choose from. This section details the variables we use in the baseline scenario and presents some arguments why we think they are the most appropriate variables to use. We also refer the reader to the variables we use in various robustness exercises.

We use quarterly data for the Netherlands[8] from the third quarter of 1998 up to the first quarter of 2014. With the exception of the interest rate and spread variables the variables are quarter-on-quarter growth rates. A detailed explanation follows.

Inflation: We use seasonally adjusted CPI inflation (Statistics Netherlands (CBS) data seasonally adjusted by CPB).

Output growth: We use quarterly real GDP growth, seasonally adjusted (CBS). In alternative models discussed later we replace this with activity measures specifically focussed on households and firms — we use consumption growth for households and investment growth for firms (CBS).

[7]The main conclusions regarding the effects of the importance of credit supply shocks are robust to including this extra restriction or not. The extra restriction does, however, result in a more plausible series of credit supply shocks. For more details on the effect of the extra restriction see the technical appendix.

[8]Figure 18 in Appendix A plots all the variables used in the baseline scenario.

Policy rate: In the baseline specification we use the EONIA rate — the overnight reference rate in the Euro Area — as the monetary policy rate, as suggested by Ciccarelli et al. (2010) (from the database of De Nederlandsche Bank (DNB)). This choice, however, is not straightforward since the zero lower bound complicates the measurement of monetary policy interventions. Especially since the crisis, monetary policy in the euro area has been unconventional with much of it's effects seen in longer maturity securities. Therefore, in the following section we also use the 3-5 year government bond yield (DNB), which may be a better representation of monetary policy after the crisis. The expectations hypothesis of the term structure suggests that monetary policy's effects on short-term rates before the crisis should also show up in longer-term rates before the crisis. As the robustness section makes clear, our main conclusions are robust to this choice.

Spread: We use a self constructed corporate bond spread, which uses the Barclays Capital Euro-Aggregate Index for Dutch Corporate Issuers (Datastream: LHANCIE) as a measure of the yield paid by corporations. The series represents the yield paid on financial, industrial and utility bonds that are investment-grade rated and of remaining maturity of more than one year. Taking the difference between this series and 3-5 year government bond yield gives the corporate bond spread. This choice is also not straightforward. Specifically, the corporate bond market in the Netherlands is small and limited to the largest firms. An alternative would be to use actual lending rates to the private sector. However, as mentioned earlier, Van der Veer and Hoeberichts (2013) show that banks in the Netherlands have used non-price lending standard to ration credit (e.g. collateral requirements, non-interest rate charges, etc.). Therefore, loan rates do not fully capture the willingness of financial institutions to supply credit. In contrast, the terms and conditions of corporate bonds are much more stable. Moreover, according to the corporate finance literature, changes in the corporate bond spread can only be partly attributed to actual risk of default (or credit risk). The changes in the spread that are most informative of economic activity can be explained by deviations in the *price* put on risk — the so-called *excess bond premium* (Gilchrist and Zakrajsek, 2011). These deviations denote the degree of risk aversion of marginal investors, i.e. their risk-bearing capacity. Large banks are key players in supplying credit to the private sector and in their role of market-makers for corporate bonds, which makes the price of risk in the economy sensitive to deviations in banks' risk-taking appetites (see, for instance, Adrian and Shin (2009)). In turn, banks' risk taking appetites are linked to the tightness of their balance sheet constraints, which determines their willingness to lend more. In fact, shocks to the profitability of large banks and expansions/contractions in their balance sheet (or changes in lending standards) are the best predictors for the excess bond premium present in the market (see e.g. Adrian et al. (2010)). Using the spread allows this non-price rationing to be captured as a knock-on effect on the price of risk in the economy.

Lending growth: We use the growth of lending to households and non-financial corporations as our measure of credit quantity (DNB data - in subsequent figures we abbreviate non-financial corporations as NFCs and households as HHs). In alternative models discussed later we separate this out for lending to households and lending to non-financial corporations.

Equity price growth: We use the growth in the AEX (Amsterdam Exchange data) index, deflated using the CPI. Following Barnett and Thomas (2013) we include equity prices to control for the choice faced by firms when choosing the type of external finance they want. Changing equity prices changes the relative costs and benefits of debt and equity finance, hence theoretically affecting the demand for loans.

3.4 Methodology

This paper employs an SVAR model of the Dutch economy, using quarterly data of the six variables listed above for the period 1998Q3-2014Q1. The model has two lags[9] and includes a constant term for all six equations in the system. The reduced-form is estimated using Bayesian methods, following Uhlig (2005). His approach specifies a Normal-Wishart prior such that the posterior estimates are equivalent to OLS estimates of the system. This is a very weak prior since it imposes no specific prior knowledge.[10] Given a draw from the posterior distribution of the reduced-form parameters, we use the algorithm of Arias et al. (2014) to collect 1000 draws from the

[9] The Schwarz Information Criterion (SIC) suggested one lag, but to allow more dynamics we chose two. The online appendix shows the results for one lag and our conclusions are robust to the choice of lag length. Choosing one lag makes the credit supply shocks marginally more important in the historical decomposition for lending growth.

[10] See Uhlig (2005) p410 for details.

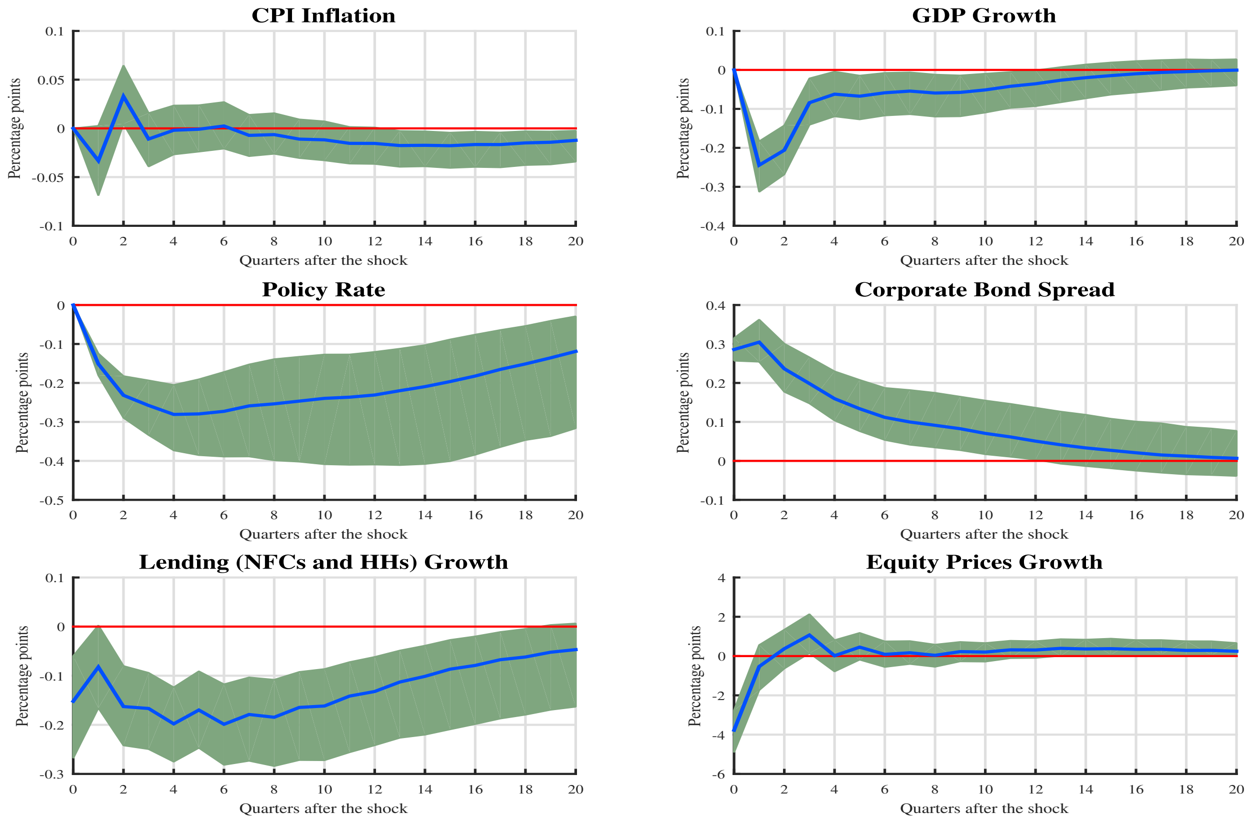
posterior distribution of the structural parameters that satisfy our sign and zero restrictions.

4 Results

This section contains the results for our baseline specification.

4.1 Credit supply and loan demand shocks

Figure 1: Impulse responses to an adverse credit supply shock in the baseline specification



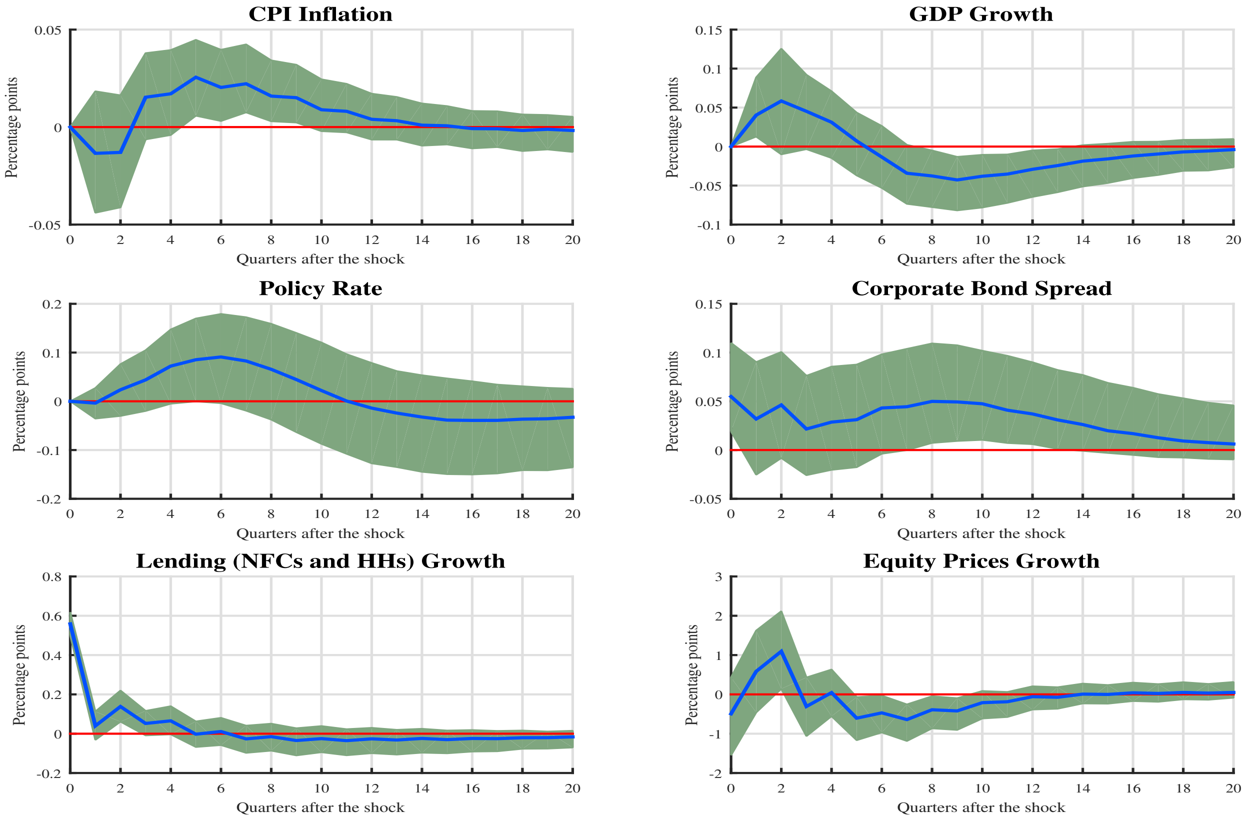
Note: the blue line depicts the median response at each horizon across all accepted models, while the shaded area represents the middle 68% of models.

Figure 1 presents the impulse response functions of the variables in the model to a one standard deviation adverse credit supply shock[11]. A credit supply shock denotes a credit contraction that causes lending growth to decrease and the corporate bond spread to rise. A typical adverse credit supply shock slows lending growth by about 0.15% on impact and depresses lending growth persistently - the median response is still below zero five years after the shock. The corporate bond spread also rises by 30 basis points on impact before slowly returning to baseline. After the credit supply shock, GDP growth falls by about 0.2% points in the first and second quarters following the shock. The effect of the credit supply shock is reasonably persistent: the median response approaches the baseline again only after about 3 years. Such a permanent impact on the level of GDP is consistent with a body of literature looking at the effects of financial crises on economic activity, such as Cerra and Saxena (2008) and Teulings and Zubanov (2013). Interestingly, the credit supply shock has a more persistent effect on lending growth than on output growth, an issue that we will return to when we look at households and firms separately later in this paper. The credit supply shock has little impact on inflation with the response close to zero throughout, with the exception of a small spike in inflation two quarters after the shock. The policy response to an adverse credit supply shock is a clear and persistent easing of monetary policy, with a peak response of almost 30 basis points one year after the shock.

Figure 2 shows the responses to a positive one standard deviation loan demand shock. The positive response of bank lending growth is significant but short-lived, returning to baseline quickly. The effect of a loan demand shock on the corporate bond spread is positive, but the response is only about 5 basis points which is much smaller than the effects of a credit supply shock. GDP growth increases slightly for about a year before decreasing for a similar length of time. This pattern suggests that loan demand shocks only have a transitory effect on the level of GDP. The inflation response is approximately zero throughout.

[11] We have 1000 models that meet our identification criteria. Each of these models has it's own set of identified shock series, impulse response functions and historical decompositions. To summarise the results of these 1000 models we follow convention and display median values across all accepted models. For the impulse response functions that means that the blue line depicts the median response at each horizon across all accepted models, while the shaded area represents the middle 68% of models.

Figure 2: Impulse responses to a positive loan demand shock under the baseline specification



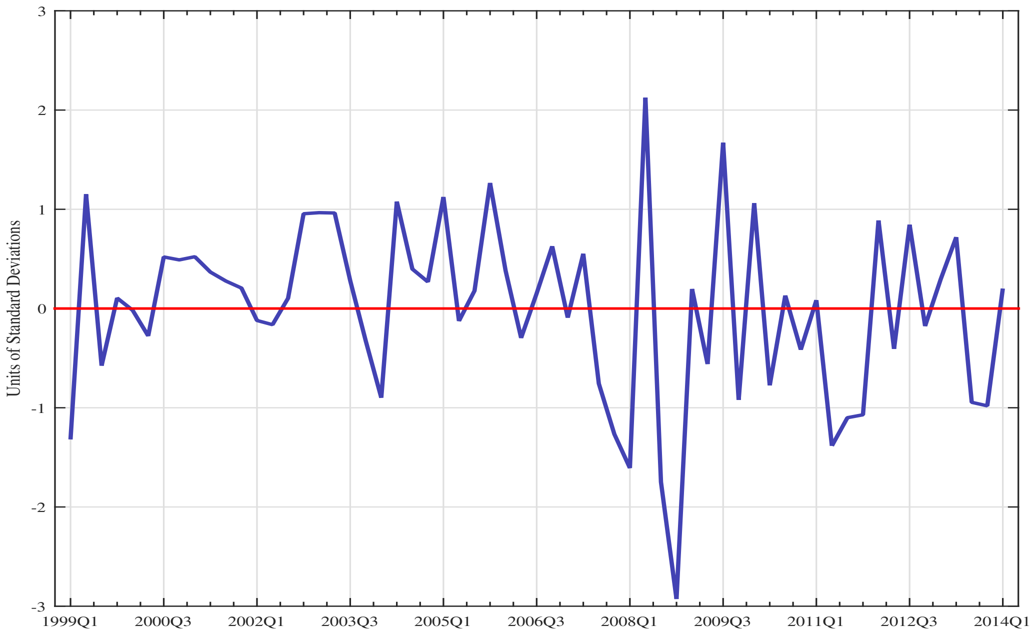
Note: the blue line depicts the median response at each horizon across all accepted models, while the shaded area represents the middle 68% of models.

4.2 Credit supply shocks and their impact on the real economy

Although the impulse reponse functions in Figure 1 depict the responses of macroeconomic indicators to a typical credit supply shock, they are not sufficient to assess the role played by those disturbances around the financial crisis. To do that we also need data on the size of the credit supply shocks that hit the Dutch economy. In this section, we present evidence for the size and timing of credit supply shocks and present historical decompositions of GDP and lending growth.

Figure 3 presents the series of credit supply shocks obtained from our model. In the run-up to the crisis, one can distinguish a series of favourable

Figure 3: Credit supply shocks under the baseline specification



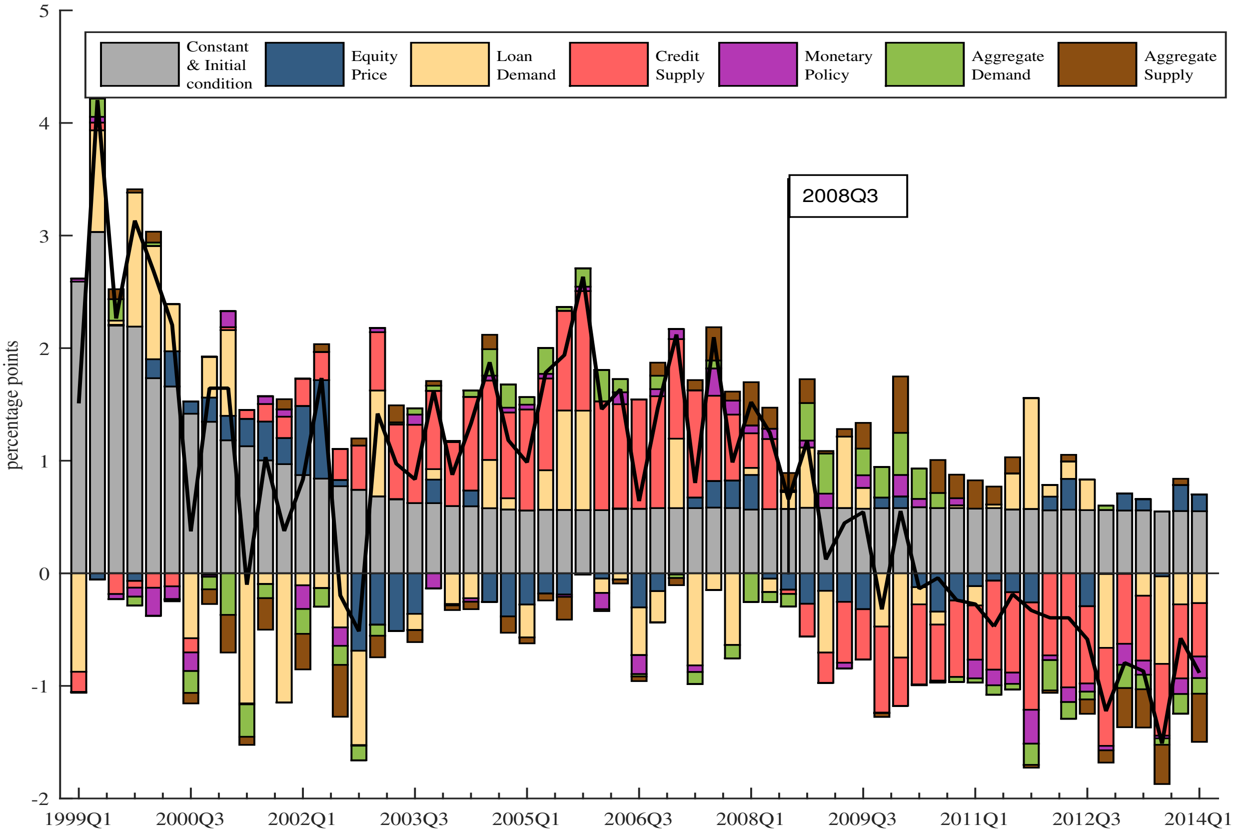
Note: the blue line represents the median credit supply shock across all models that met the identifying restrictions.

credit supply shocks, especially between 2002 and 2006, which is in line with the frequently heard stories of easy credit supply in that period. Concerning the crisis, our series of credit supply shocks already show some signs of stress at the end of 2007 and the start of 2008. The acute phase of the crisis can be seen as two consecutive adverse credit supply shocks in the third and fourth quarters of 2008. Cummulatively these two quarters total just under five standard deviations[12]. Looking carefully, one can also see a series of negative credit supply shocks in 2011 as the euro area sovereign debt crisis took off.

Figure 4 decomposes movements in lending growth into the cumulative effects of the identified shocks. The red bars denote the cumulative effect of credit supply shocks on lending growth. Once again, the credit boom in the mid 2000s is clear to see with a persistently favourable credit supply. The boom continued right up to the fall of Lehman Brothers in 2008Q3, when the effects of credit supply become significantly negative. In 2010, the sovereign debt crisis started in the euro area (European Central Bank, 2011) and the negative effects of credit supply shocks continue through this period playing an important role in depressing lending growth. More recently, the

[12]Just under 2 in 2008Q3 and almost 3 in Q4.

Figure 4: Historical decomposition of lending growth under the baseline specification

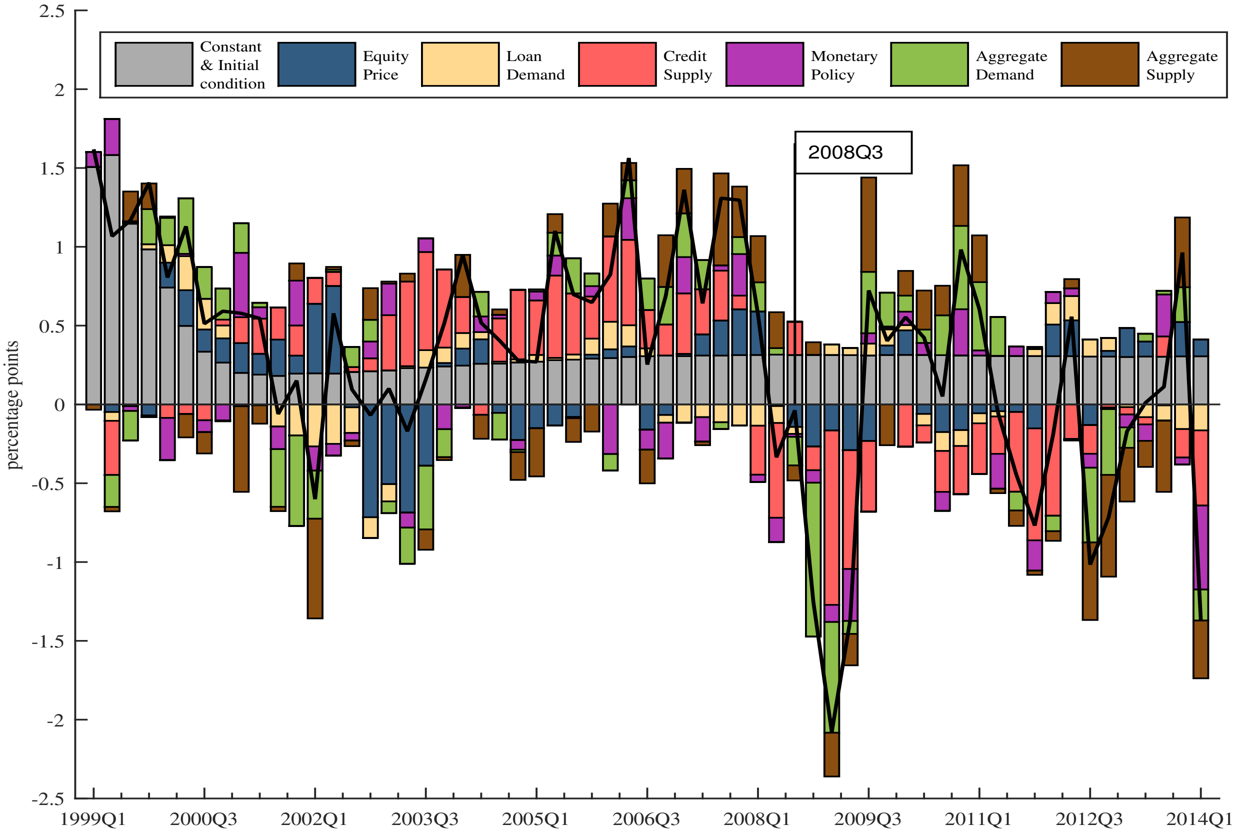


Note: the black line depicts the actual data points. The grey bars represent the constant term and the initial conditions. The coloured bars represent the median across all accepted models of the accumulated contribution to lending growth of all previous shocks of that type.

Netherlands experienced two large falls in lending growth in the last quarter of 2012 and the third quarter of 2013. Our results suggest that these were driven not only by adverse loan supply shocks but also by noteworthy shocks to the demand for loans.

Figure 5 shows the historical decomposition of GDP growth. Once again, the credit boom in the mid 2000s is clear as is the role played by credit supply shocks in the aftermath of the fall of Lehman Brothers. Our identified credit supply shocks account for about half of the below trend growth in 2009. After credit supply shocks, our baseline specification shows a significant role for negative aggregate demand shocks at the end of 2008 and the start of 2009. This coincides with the dramatic falls in world trade that hit the Netherlands

Figure 5: Historical decomposition of GDP growth under the baseline specification



Note: the black line depicts the actual data points. The grey bars represent the constant term and the initial conditions. The coloured bars represent the median across all accepted models of the accumulated contribution to GDP growth of all previous shocks of that type.

hard. Of course, these aggregate demand shocks may reflect the effects of credit supply shocks in other countries, which depress their economies and lower demand for Dutch exports.[13] Adverse credit supply shocks continue to depress economic growth throughout 2010 and 2011. The effect of credit supply shocks is mostly negligible from the end of 2012 onwards. This mirrors the remark we made earlier that the impulse response functions for credit supply shocks show more persistence for lending growth than GDP growth. That our model attributes a large share of the fall in growth in 2012 to adverse aggregate demand shocks is consistent with the stories of declining consumer confidence that translated into low domestic demand (OECD, 2012) and

[13]The adverse credit supply shocks described here should be seen as shocks that directly affect domestic credit supply.

government austerity.

5 Robustness checks

The appropriateness of a given identification scheme or the exact choice of variables is often unclear. This section presents two robustness checks: one for the identification scheme and one for the choice of the monetary policy variable.[14]

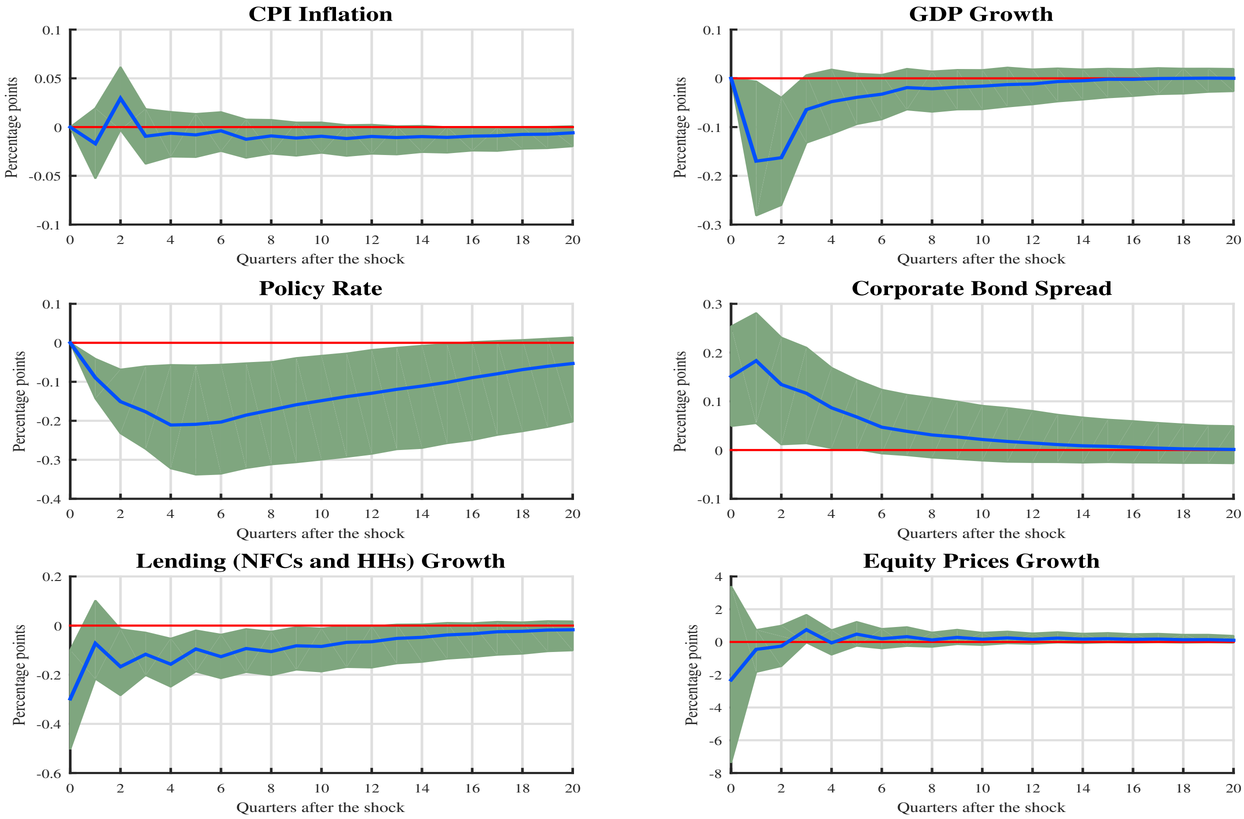
5.1 Partial identification

For partial identification we only impose the restrictions required for the credit supply shock. In terms of the restrictions embodied in Table 2, this translates as keeping the restrictions in the credit supply row whilst leaving all other elements unrestricted. With the sign restrictions methodology this means that with partial identification we reject much fewer of the draws. With full identification, the restrictions imposed to identify the other shocks in the system can potentially alter the space covered by the credit supply shocks, thus impacting our estimates of what credit supply shocks do and their role in the recent past as shown in the historical decompositions. By looking at a partially identified system we can determine if that is likely. The impulse response functions to a credit supply shock under partial identification are shown in Figure 6. Comparing them to those for full identification in Figure 1 shows that the differences are relatively minor. The patterns of the responses are the same except for a large initial impact on lending growth when the other shocks are left unidentified. There is also some variation in the magnitudes of the responses. For example, under partial identification the response of the corporate bond spread is about half the response under the baseline specification. For the other responses, the magnitudes are generally smaller under partial identification although the differences fall within the uncertainty bands of the baseline impulse response functions.

The historical decompositions for lending growth (in Figure 7) and output growth (in Figure 8) also show that our conclusions concerning the timing of the effects of credit supply shocks in the baseline scenario are not dependent on a particular specification of the other shocks. Both decompositions tell

[14]Further robustness checks are available in the technical appendix.

Figure 6: Impulse responses to an adverse credit supply shock under partial identification

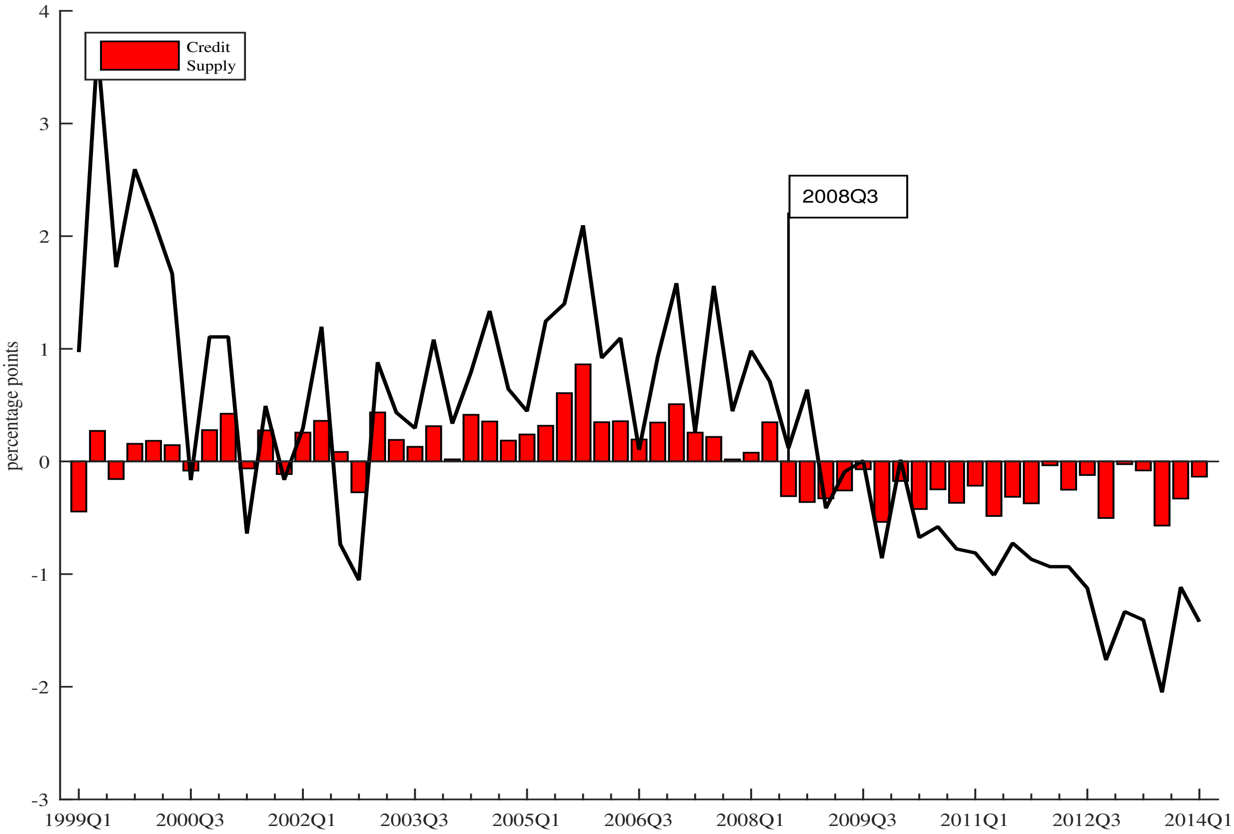


Note: the blue line depicts the median response at each horizon across all accepted models, while the shaded area represents the middle 68% of models.

a very similar story to the baseline specification with credit supply shocks going from having a positive effect on lending growth and GDP growth before 2008 to a negative effect thereafter. At the end of the sample period credit supply shocks are still having an impact on lending growth but not GDP growth. The key difference is the magnitude of the contribution of credit supply shocks, which in line with the evidence from the impulse response functions, is smaller than in the baseline scenario.

Sign restrictions are typically seen as weak information (Fry and Pagan, 2007) and it has been reported that useful structural shocks can only be recovered if enough sign restrictions are imposed (Paustian, 2007). Our partially identified system suggests some useful information can be recovered from a minimal set of restrictions. Specifically, our results suggest the im-

Figure 7: Historical decomposition of loan growth under partial identification



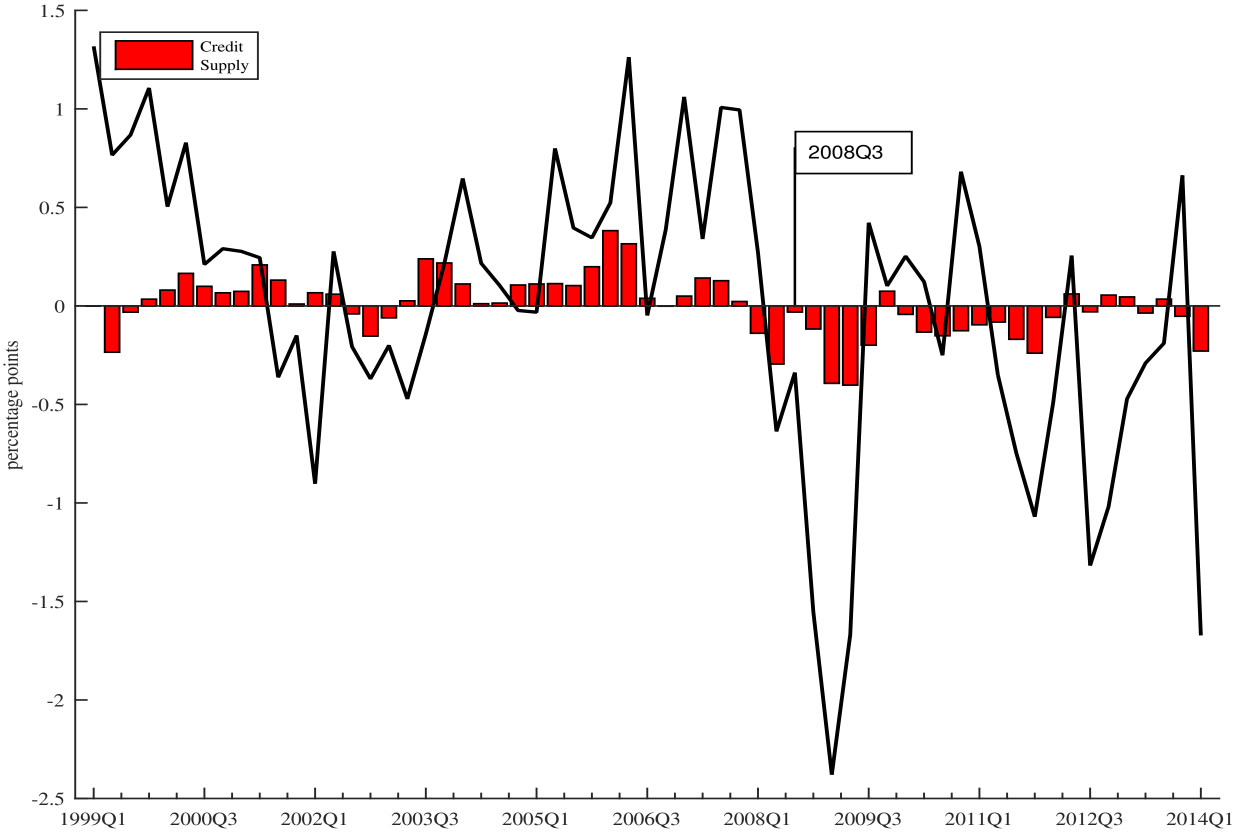
Note: the black line depicts the actual data points. The red bars represent the median across all accepted models of the accumulated contribution to lending growth of all previous credit supply shocks.

pulse response functions are quite similar, although with wider uncertainty bands. It also recovers a similar pattern of shocks and effects as shown in the historical decompositions. The main noteworthy difference is the magnitude of the effects.

5.2 3-5 year government bond yield

As described above, the zero lower bound has complicated the measurement of monetary policy since short term rates, which are stuck near zero, are no longer the sole focus of monetary policy. To try to overcome these problems Barnett and Thomas (2013) use the 10 year government bond yield as their measure of monetary policy. In this section we replace the EONIA rate with

Figure 8: Historical decomposition of GDP growth under partial identification

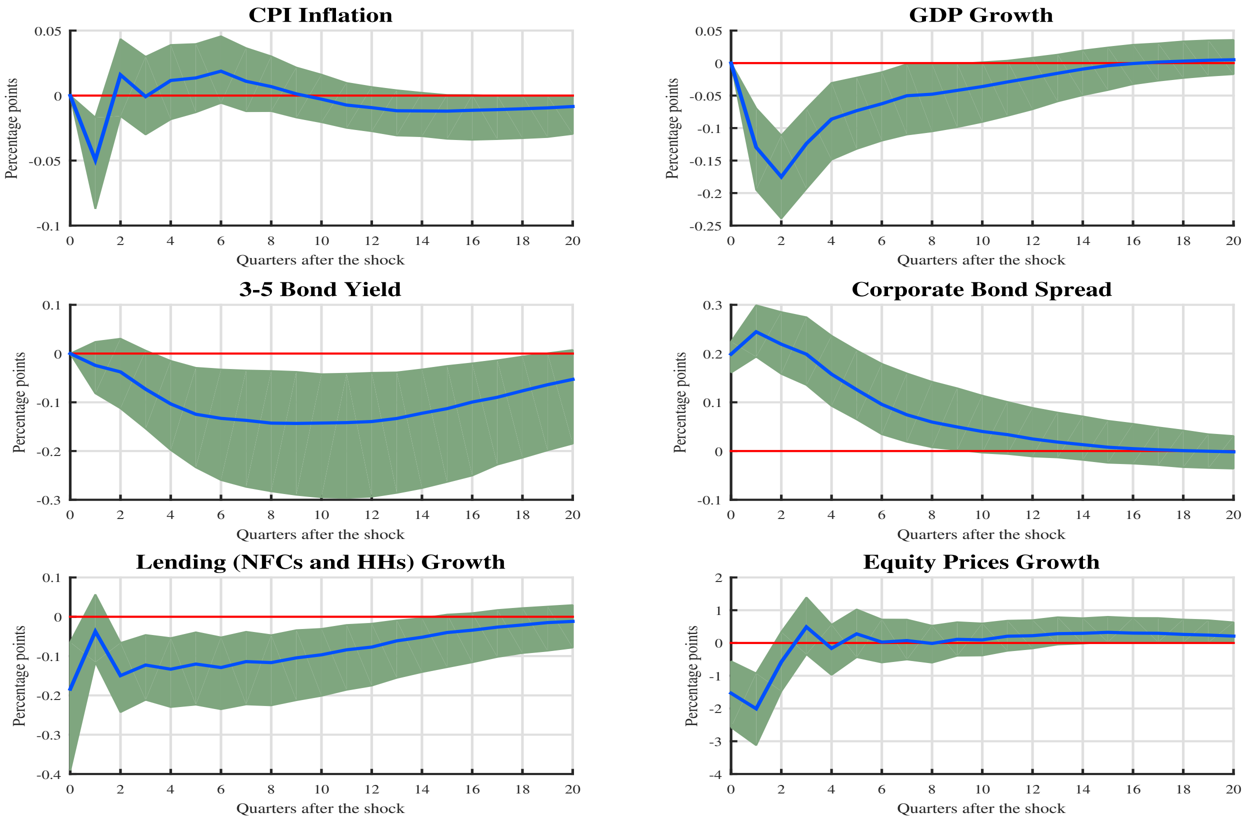


Note: the black line depicts the actual data points. The red bars represent the median across all accepted models of the accumulated contribution to GDP growth of all previous credit supply shocks.

the 3-5 year government bond yield, which does not change our main conclusions. Figure 9 shows the response to a one standard deviation credit supply shock with the 3-5 year government bond yield as monetary policy measure. As with the baseline specification, an adverse credit supply shock decreases lending growth by about 0.15%-points on impact and is persistant. Furthermore, the GDP growth response shows a very similar pattern, although the peak response is slightly smaller than under the baseline specification.

With regards the role of credit supply shocks in economic developments in our sample period, changing the monetary policy measure does not alter our conclusions. Figure 10 again shows the credit boom of the mid 2000s turning to negative credit supply shocks in 2008 with persistent effects thereafter.

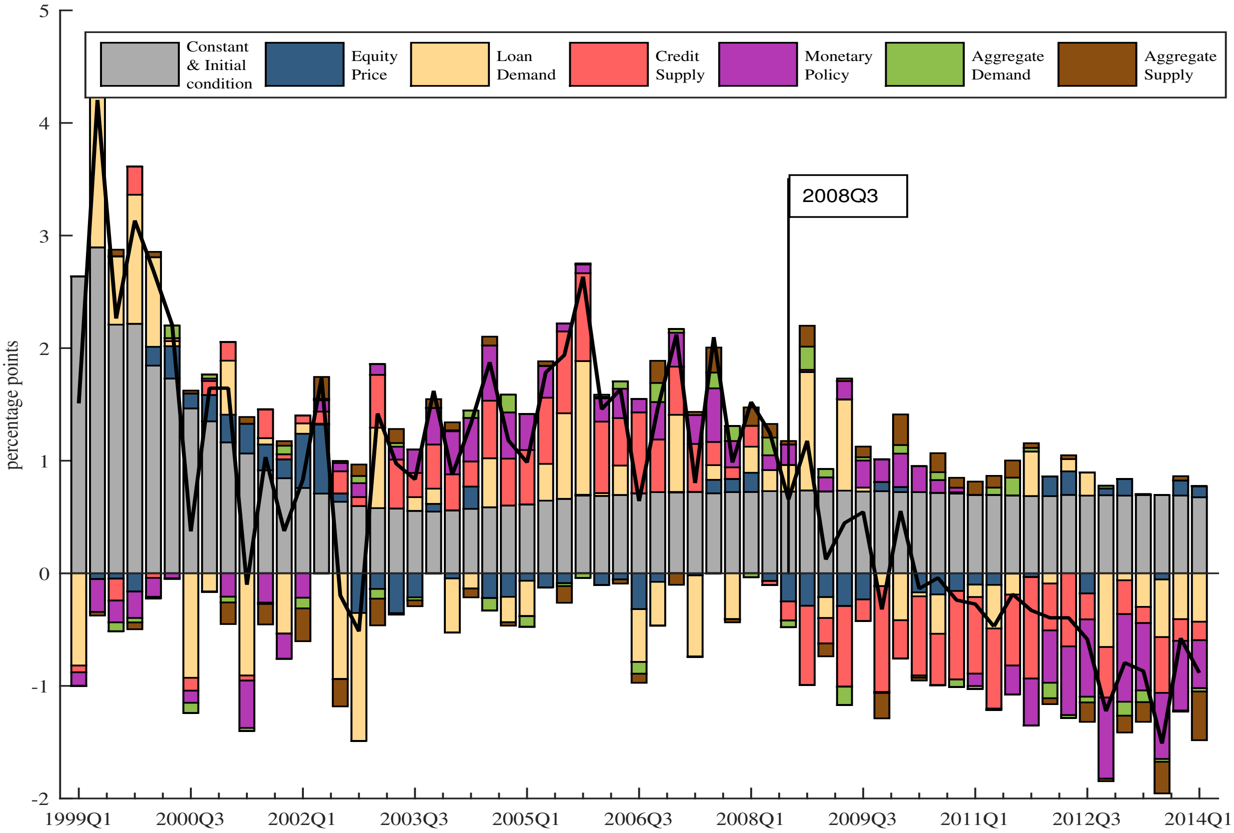
Figure 9: Impulse responses to an adverse credit supply shock with the 3-5 year government bond yield as monetary policy measure



Note: the blue line depicts the median response at each horizon across all accepted models, while the shaded area represents the middle 68% of models.

Figure 11 still shows important effects of credit supply shocks on GDP growth between 2008 and early 2012, with little effect thereafter. One difference with the baseline specification is the increased role of negative monetary policy shocks from 2011 onwards when monetary policy is measured by the 3-5 year government bond yield. In contrast to the EONIA rate, the 3-5 year government bond yield for the Netherlands increases towards the end of our sample reflecting worries about debt sustainability and a possible break-up of the euro area. Nevertheless, our conclusions regarding the importance of credit supply shocks is robust to this specification change too.

Figure 10: Historical decomposition of loan growth with the 3-5 year government bond yield as monetary policy measure



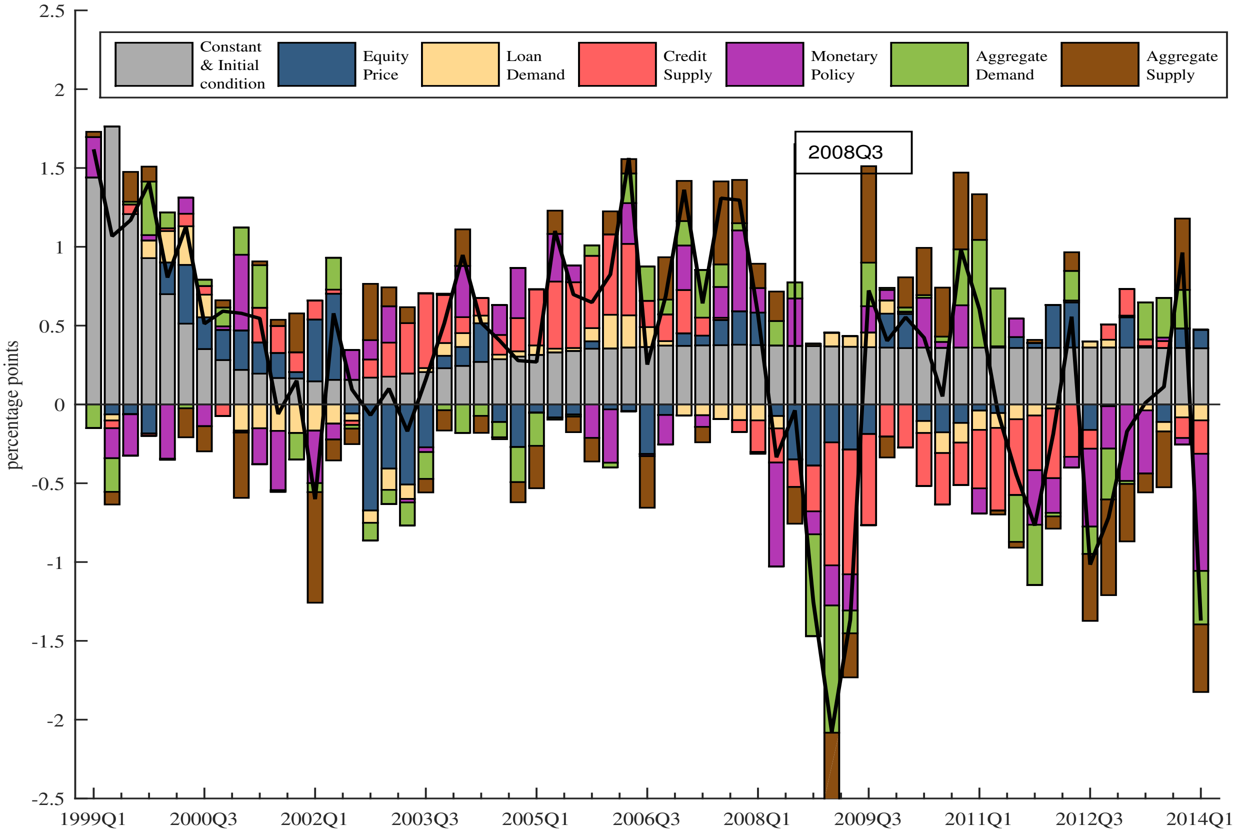
Note: the black line depicts the actual data points. The grey bars represent the constant term and the initial conditions. The coloured bars represent the median across all accepted models of the accumulated contribution to lending growth of all previous shocks of that type.

6 Households and firms

Anecdotal evidence for the Netherlands suggests that small firms and households have been particularly hard hit by the changes in lending standards that the banks have made since the Great Recession. The theory of the credit channel tells us that economic agents without access to other sources of credit will likely be affected more by changes in the lending behaviour of banks (Ramey, 1993). Households in the Netherlands are almost entirely reliant on bank lending for credit, especially for mortgage credit[15]. However,

[15]For example, the three largest mortgage providers are banks: Rabobank, ING Bank and ABN Amro - these three banks alone have typically accounted for about 70% of

Figure 11: Historical decomposition of GDP growth with the 3-5 year government bond yield as monetary policy measure



Note: the black line depicts the actual data points. The grey bars represent the constant term and the initial conditions. The coloured bars represent the median across all accepted models of the accumulated contribution to GDP growth of all previous shocks of that type.

house purchases are not part of GDP so if credit supply shocks only affect the availability of mortgage credit, household consumption may not depend a great deal on credit supply shocks. In comparison to households, firms, especially large firms, are less reliant on bank lending as a source of finance. This section attempts to separate firms and households from the aggregate data by focusing on components of GDP and sector specific lending.

all mortgages (CPB, 2013). However, towards the end of our sample period insurance companies and pension funds have become more important sources of mortgage finance, but they still only account for about 20% of mortgages (IG&H, 2015).

6.1 Households

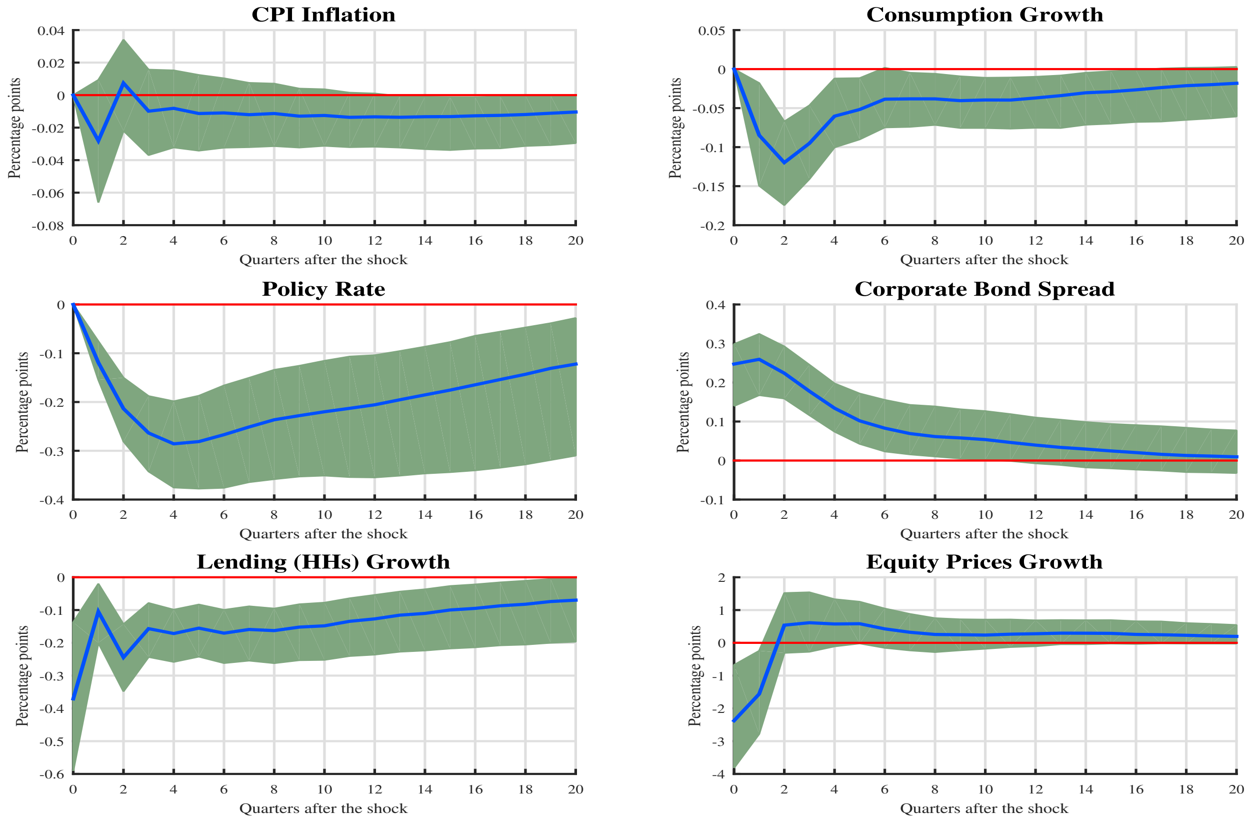
To investigate the role of credit supply shocks on household consumption we replace two of the series in our baseline specification. We replace GDP growth by consumption growth and we replace the growth of lending to households and non-financial corporation with the growth of lending to households only.[16] Figure 12 shows the responses to a one standard deviation adverse credit supply shock. The responses show the same pattern as the baseline specification. The response of the growth of lending to households is similarly persistent with the response staying around -0.2%-points for about 2-3 years. The main difference with the baseline specification is the effect on impact, which is 0.4%-points when looking at lending to households - in fact, this response is very similar to the response under partial identification shown in Figure 6. Consumption growth shows a similar pattern to the response of GDP growth in the baseline specification, except that the magnitude is about half the GDP response. The peak response is at 2 quarters but with a maximum of a little over 0.1%-points.

Figure 13 shows the historical decomposition of the growth of lending to households. The decomposition has many similarities to the baseline specification. For example, before 2008 much of the lending growth was driven by positive credit supply shocks. This was a period where interest only mortgages became the norm in the Netherlands and house prices grew considerably. From 2008, credit supply shocks start depressing lending growth and the size of this effect remains roughly the same until the end of our sample period.

Figure 14 shows the historical decomposition of consumption growth. The effect of credit supply shocks on consumption is noticeably smaller than the effect on lending growth, especially the negative shocks after 2008. We propose two explanations for the limited role of credit supply shocks in explaining consumption. Firstly, in the Netherlands, the vast majority of household credit is mortgage lending, which does not directly enter into the national accounts definition of consumption because purchases of existing houses are not a part of consumption. Secondly, households that have liquid asset holdings can use them to smooth consumption. Both of these reasons would explain why consumption growth responds less to credit supply shocks than GDP

[16] Our measure of the spread stays the same since we are using the corporate bond spread as a general proxy for the willingness to bear risk. In the period following the Great Recession non-price lending standards for loans to households in the Netherlands have changed frequently, often due to changes in financial market regulation.

Figure 12: Impulse responses to an adverse credit supply shock - Households



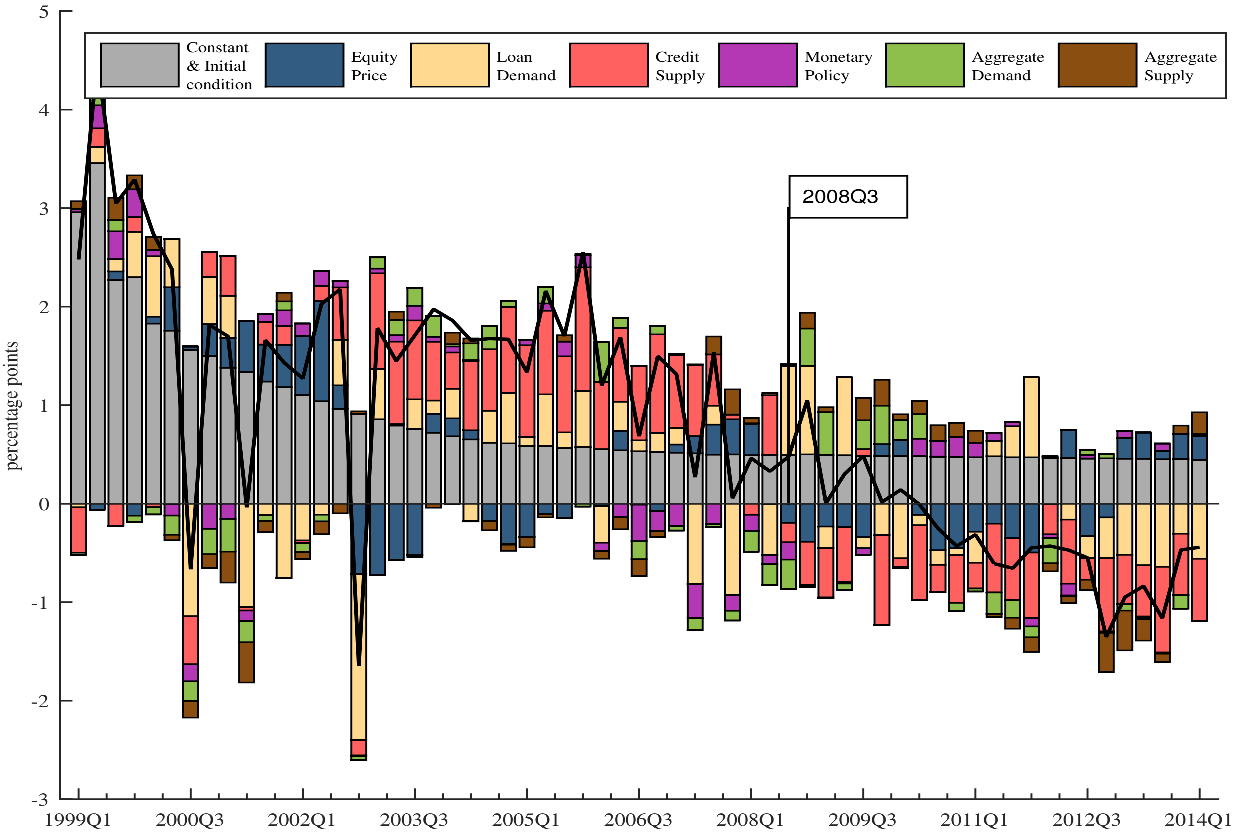
Note: the blue line depicts the median response at each horizon across all accepted models, while the shaded area represents the middle 68% of models.

growth.

6.2 Firms

For looking at the role of firms in the transmission of credit supply shocks we replace GDP growth in the baseline specification with the growth of investment and we replace lending growth to both households and firms with lending to non-financial corporations only. The responses to a one standard deviation adverse credit supply shock are shown in Figure 15. A credit supply shock has a similar impact on lending to firms as it does on lending to households. The peak impact on lending growth to firms, is about 0.4%-points. The credit supply shock also translates into a significant slowdown in investment with a peak impact of nearly 1%-point. However, the invest-

Figure 13: Historical decomposition of the growth of lending to households

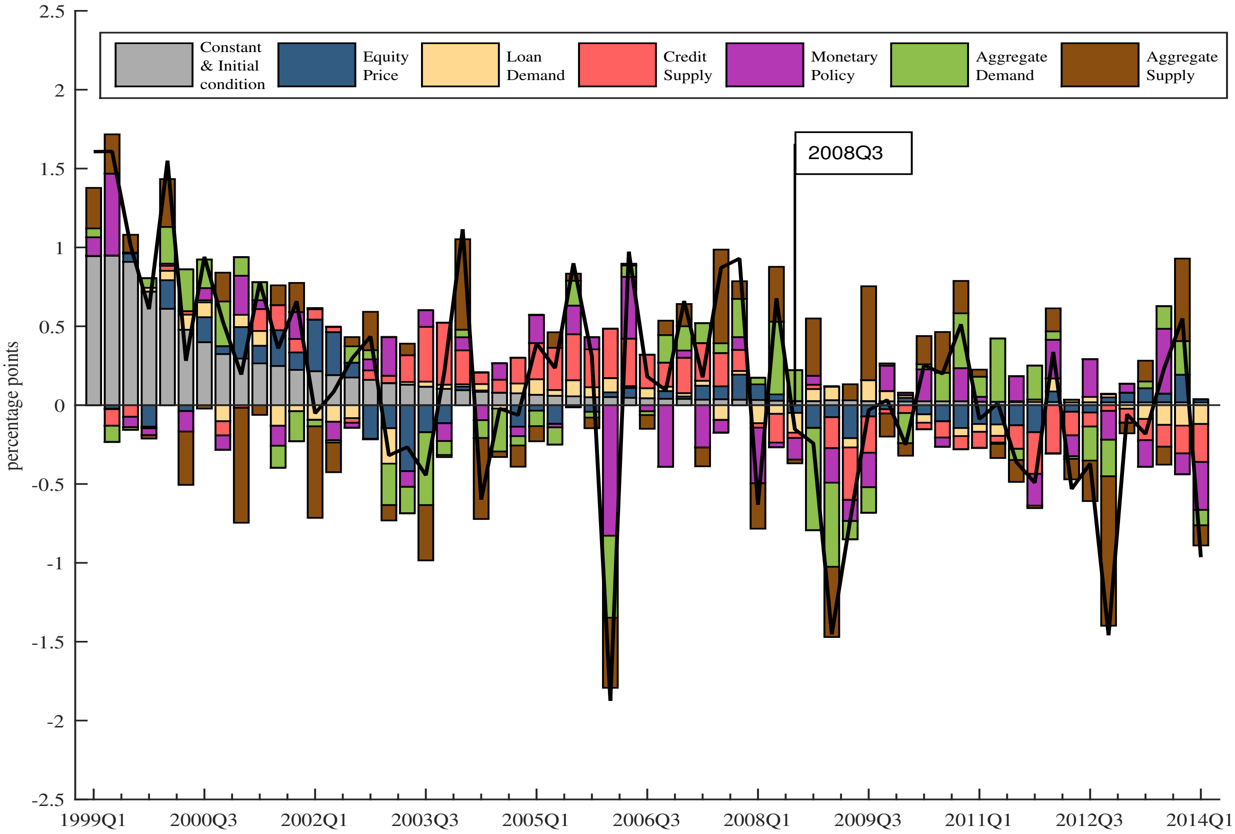


Note: the black line depicts the actual data points. The grey bars represent the constant term and the initial conditions. The coloured bars represent the median across all accepted models of the accumulated contribution to the growth of lending to households of all previous shocks of that type.

ment growth response is much less persistent than the consumption growth response: the median response for investment crosses the baseline after 6 quarters whereas the median consumption response in Figure 12 still hasn't after 20 quarters.

These patterns are also visible in the historical decompositions for the growth of lending to firms and investment growth, which are shown in Figures 16 and 17, respectively. For lending growth, the credit boom is much less visible than for households, with credit supply shocks playing a smaller role than loan demand shocks between 2005 and 2008. Whilst there are a number of large adverse credit supply shocks in 2008 and 2009, these effects are much less persistent over time when compared to household lending. For lending to firms, there are even a number of positive shocks in 2011 and 2012. If we

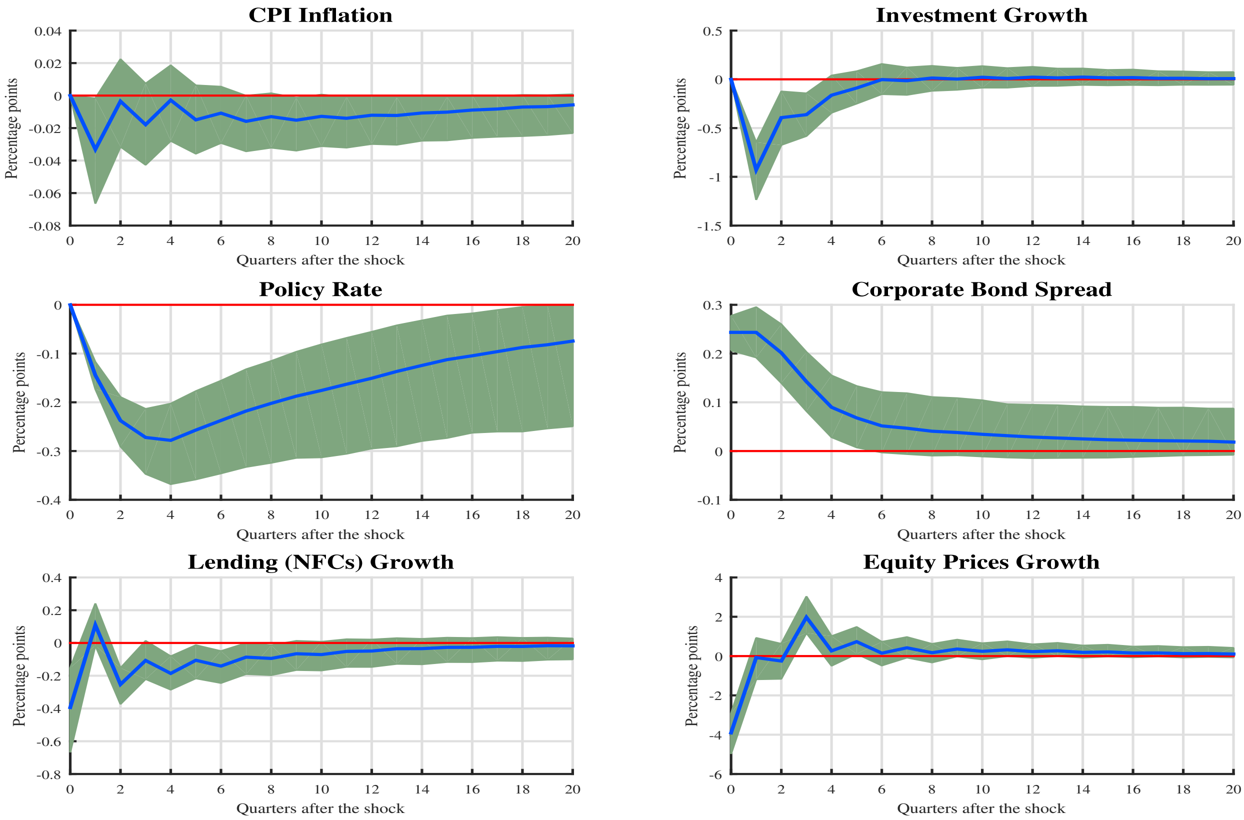
Figure 14: Historical decomposition of consumption growth



Note: the black line depicts the actual data points. The grey bars represent the constant term and the initial conditions. The coloured bars represent the median across all accepted models of the accumulated contribution to consumption growth of all previous shocks of that type.

turn to the decomposition for investment growth we also see that the major negative shocks starting in the first quarter of 2009 die out much sooner than for households. From 2011 onwards the effects of adverse credit supply shocks on investment growth are negligible. When we look at the double-dip recession in 2012, adverse credit supply shocks play no role. Since we have seen in the impulse response functions that investment is sensitive to credit supply shocks, this is further evidence that the main driving factors behind the sluggish growth seen since 2011 are not credit supply shocks.

Figure 15: Impulse responses to an adverse credit supply shock - Non-financial corporations

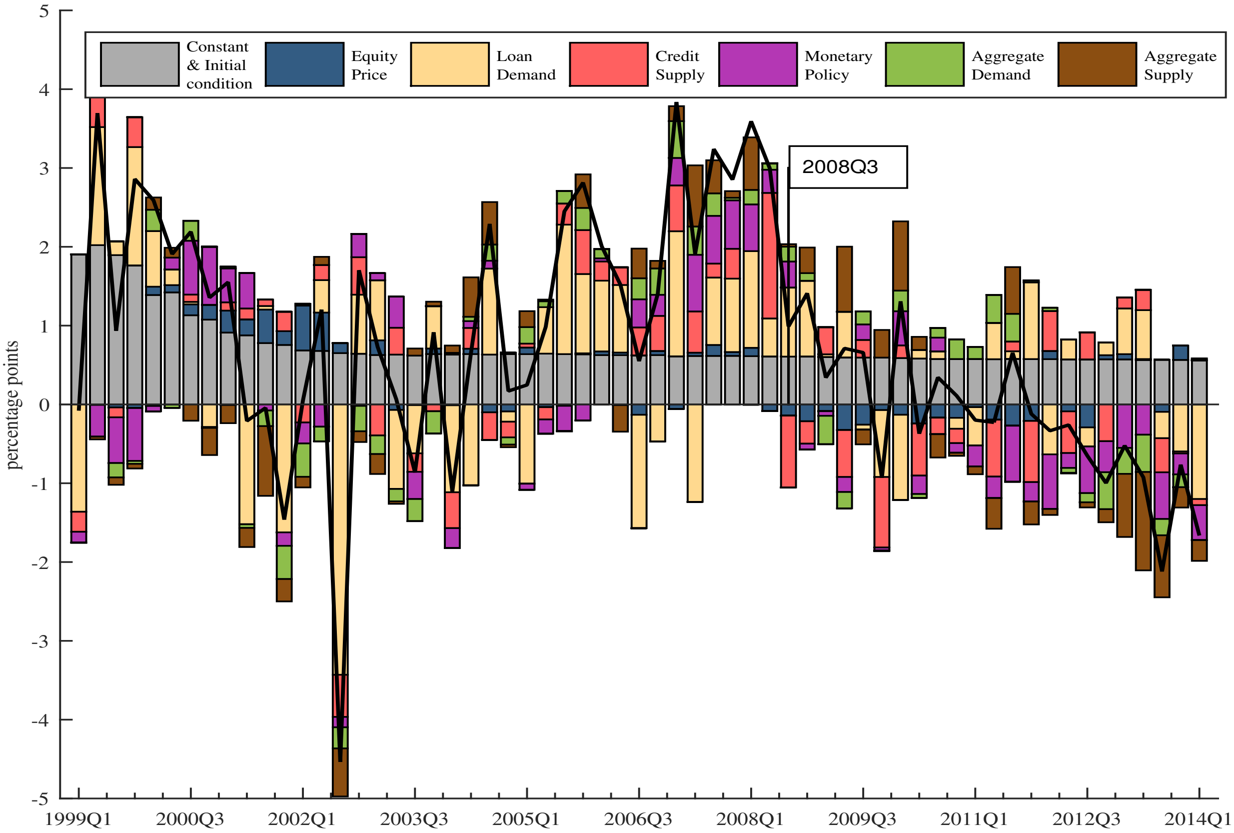


Note: the blue line depicts the median response at each horizon across all accepted models, while the shaded area represents the middle 68% of models.

6.3 Discussion

Credit supply shocks hit investment harder than consumption. Of the 0.2%-points peak impact on GDP growth, a back-of-an envelope calculation attributes almost 0.15%-points of that fall to the drop in investment. About 0.05%-points is attributable to consumption. Our finding that consumption does respond to a credit supply shock contrasts with the findings of Damar et al. (2014) for Canada, where they found that credit supply shocks had an effect on lending to households but no subsequent effect on consumption. They argued that Canadian households use their liquid assets to smooth out the consumption effects of credit supply shocks. Many Dutch households have little or no liquid assets since the vast majority of household's assets in the Netherlands are tied up in compulsory pension schemes or in housing eq-

Figure 16: Historical decomposition of the growth of lending to non-financial corporations

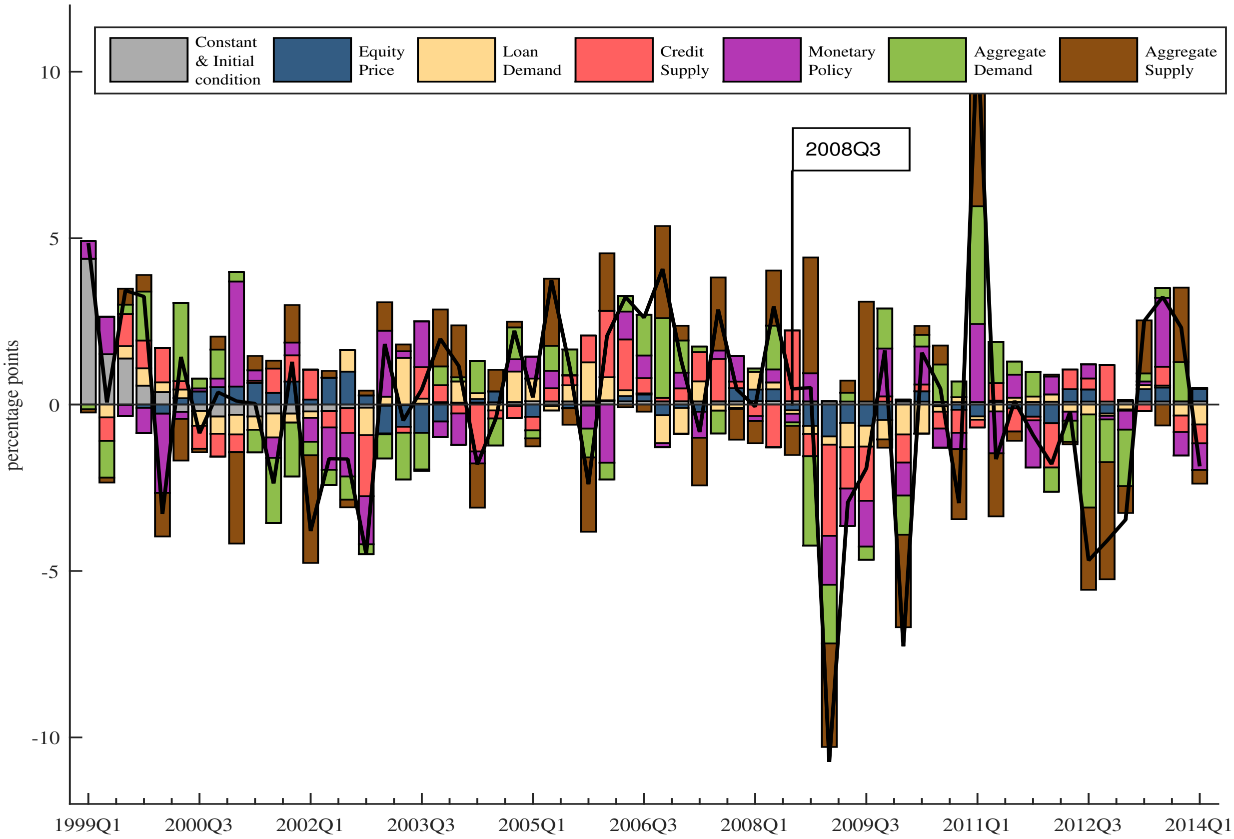


Note: the black line depicts the actual data points. The grey bars represent the constant term and the initial conditions. The coloured bars represent the median across all accepted models of the accumulated contribution to the growth of lending to non-financial corporations of all previous shocks of that type.

uity[17]. That investment growth recovers quickly may be related to the large number of Dutch firms, especially large firms, that have abundant internal funds (Hebbink et al. (2014)).

[17]Warnaar and Van Galen (2012) report that 40% of Dutch households have little or no liquid assets.

Figure 17: Historical decomposition of investment growth



Note: the black line depicts the actual data points. The grey bars represent the constant term and the initial conditions. The coloured bars represent the median across all accepted models of the accumulated contribution to investment growth of all previous shocks of that type.

7 Conclusion

This paper has used an SVAR model identified with zero and sign restrictions to disentangle the role of credit supply shocks in the Dutch economy. The pattern of our series of identified credit supply shocks is largely consistent with other measures of credit supply shifts that have been reported for the Netherlands. A typical, adverse credit supply shock has a persistent effect on lending growth, while the sluggish response of GDP growth lasts more than two years. When we look back at the recent past, bank lending contractions were economically significant in lowering both lending and GDP growth around the fall of Lehman Brothers. Our findings for the role played by credit supply shocks in the Great Recession is similar to that reported by other studies for the euro area. We find that about half of the contraction in GDP growth is attributable to credit supply shocks. From 2012 onwards, our evidence suggests that the effects of credit supply shocks on GDP growth had died out and were not playing an important role in the sluggish GDP growth we have seen.

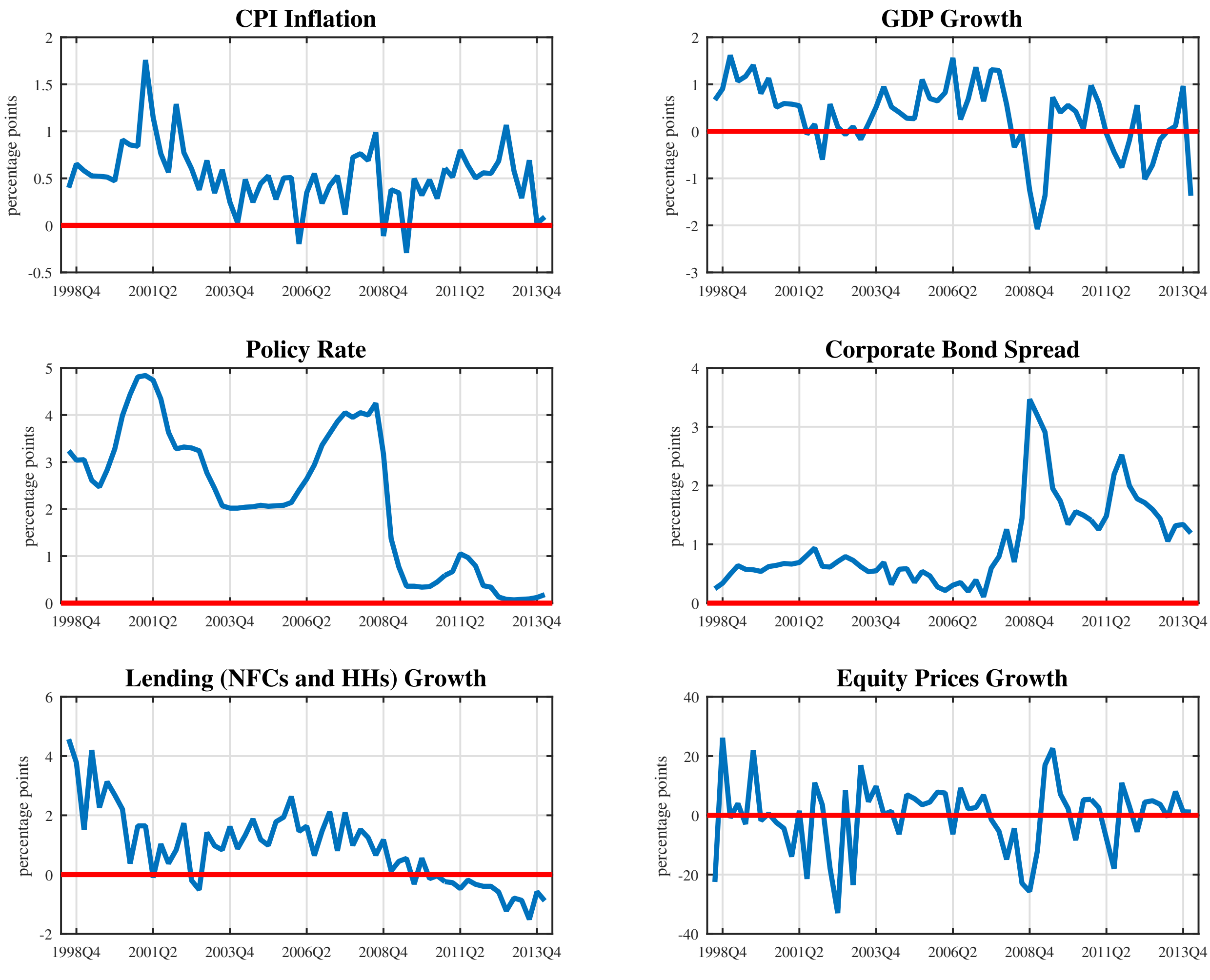
When we extend our baseline analysis by looking at the effects of credit supply on households and firms separately, we find that the peak effect of credit supply shocks on investment is about eight times larger than on consumption, although the consumption response is more persistent. Given that lending to firms has decreased persistently since 2011, this suggest that firms have been able to find sufficient other sources of finance for the investment projects they wished to undertake.

One possible avenue for further research is that a constant parameter VAR model assumes that the important relationships between the macroeconomic time series has remained the same throughout the sample period. That may not be the case with such a large shock as the Great Recession. Combining time-varying parameters with zero and sign restrictions in a framework similar to Bijsterbosch and Falagiarda (2015) might be fruitful for further research. However, the observation that our results for the role played by credit supply shocks are generally consistent with those found using time varying parameters in Bijsterbosch and Falagiarda (2015) and Gambetti and Musso (2012) suggest the distinction might not be so important empirically.

8 Appendix A

Figure 18 contains the time series used in the baseline specification. The key features of the Great Recession are easily seen - the deep recession in GDP growth, the dramatic policy response in the EONIA rate, the jump in the corporate bond spread and the slowdown in lending growth.

Figure 18: Baseline data series



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