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Structural Factor Analysis of Interest Rate Pass Through in Four Large Euro Area Economies

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Abstract

In this paper we examine the influence of monetary policy decisions of the ECB on mortgage and business lending rates offered by banks in the four major euro area countries (Germany, France, Italy and Spain). Since there are many different policy measures that have been undertaken, we utilize a dynamic factor model, which allows examination of impulse responses to policy shocks conditioned upon structurally identified latent factors. The distinct feature of this paper is that it explores the effects of three policy transmission lines - short-term rates, long-term rates and perceived risk - ultimately directed towards bank lending rates. The analysis of the pass through is carried out in pre-crisis and post-crisis sub-samples to demonstrate the changing influence of different policy measures on lending rates.

JEL: C32, C53, E43, E4

Keywords: monetary policy, dynamic factor models, interest rates, pass through

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1 Introduction

The European Central Bank (ECB) has faced 'intense scrutiny' over its policies in recent years. Since the global financial crisis it has implemented monetary policy in three phases - to provide ample liquidity and thereby to avoid fire sales of assets; to address funding problems and impaired markets in individual countries; and to support the weak recovery - but there is a deep inquiry concerning whether these policies have had their intended effects, Praet (2017a, 2017b). The ECB widened the range of acceptable collateral, undertook longer duration liquidity operations, offered forward guidance on future short term rates and took several separate decisions to make outright purchases of government bonds, covered bonds and asset backed securities, see Angelini et al. (2011), Beirne et al. (2011), Brunetti et al. (2011), Szczerbowicz (2015), and ECB (2016). It has also allowed short-term rates to enter negative territory. Perhaps the intervention that captured the imagination more than any other was the Outright Monetary Transactions (OMT) announcement in June 2012, when ECB President Mario Draghi indicated he would do 'whatever it takes', making outright monetary transactions if necessary.[1] This put monetary policy in the spotlight as never before and particularly in terms of its ability to influence bank funding costs and retail lending rates.

Many papers make important contributions to the understanding of specific unconventional policy actions by the ECB. For example, ECB policy effects in money and capital markets have been explored by Giannone et al. (2011, 2012), ECB (2010a, 2010b, 2012, 2015a, b) and Altavilla and Giannone (2016), while the papers by ECB (2013), Hristov et al. (2014), Illes et al. (2015), Altavilla et al. (2015, 2017) and von Borstel et al. (2016) have considered the effects of particular policies on banks' funding costs. Vari (2019) shows how positive and negative fluctuations in liquidity have had a direct impact on interbank rates, which have then pushed rates faced by all agents in the economy away from the level set by the central bank. Distortions to rates at the country level reflect country-specific risks such as sovereign risk as well as the risks of more general nature, e.g. possible breakup of the euro.

The novel feature of our paper is that it explores the effects of these monetary policy actions over a longer period to emphasize the transmission paths - through short-term rates, long-term yields and perceived risk - ultimately directed towards bank lending rates in a structurally

[1] ECB Executive Board member Peter Praet (2017a) notes that "negative interest rate on the ECB deposit facility has ... contributed to flattening the short to medium end of the yield curve, thereby easing broader financing conditions", while "the asset purchase programme (APP) of private and public sector securities has helped further depress the term structure of interest rates by compressing risk premia out along the yield curve.".

identified model. We break new ground by using a structurally identified dynamic factor model – with its foundations in Bernanke et al. (2005) [hereafter BBE] – loading on many correlated variables, to evaluate the effects of monetary transmission.[2] We aim to verify whether the different instruments of policy cited by Praet (2017a) had an influence over lending rates that can be identified in an econometric model through short-term rates, long-term yields and risk factors. This leads us to propose the use of a structurally identified dynamic factor model to make three main contributions to the understanding of monetary transmission to lending rates in the period after the crisis.

First, the application of new methodology based on Stock and Watson (2005), Yamamoto (2016) and Bai and Ng (2013) provides economically meaningful identification of the latent factors by means of suitable restrictions on the loading matrices of the factors as described in Section 4 below. This allows us to separate the impact of policy using conventional and unconventional approaches. Of several identification schemes proposed in Stock and Watson (2005) we select the one most useful for our purposes. To our knowledge this is the first application of this methodology to the understanding of interest rate setting behaviour of banks.

Second, conditional on this identification of the latent factors we illustrate and explain the transmission lines through the responses of key bank lending rates to structural shocks in the identified latent factors. The BBE methodology assumes that the main source of monetary policy shocks is the short term policy rate, but, clearly, in our post-crisis sample period the policy rate was close to its effective lower bound.[3] Our innovation over the previous literature is to explore the extent to which conventional and unconventional episodes of policy created shocks to global risk perceptions, changes in long-term yields and short-term market rates that feed through to bank lending rates.

Third, we analyze structural changes in monetary policy over the period of the crisis using estimation of factor-augmented VARs to generate impulse response functions and variance

[2]The BBE approach allows examination of impulse responses to a policy shock conditioned upon factors, but does not provide structural identification of latent factors. Examples of the BBE approach include use of large macroeconomic datasets (e.g. Boivin and Giannoni, 2008), or large financial datasets (e.g. De Nicolo and Lucchetta, 2012; and Eickmeier and Hofmann, 2013). Buch et al. (2014) have taken this a step further using microlevel data for banks to augment a model of output, inflation, house price inflation and short-term policy rates in the United States from 1985q1 - 2005q2 using bank level data from Call Reports submitted to the Federal Reserve.

[3]This does not mean that there have been no policy shocks to consider; on the contrary, unconventional monetary operations have been used to make adjustments to expected future short-term rates to long-term bond yields, and global risks have provided new sources of shocks to examine.

decompositions of the variation in corporate and mortgage lending rates for less vulnerable and vulnerable euro area countries. These show that while short term rates continued to influence lending rates, they did so with less impact in the post-crisis period compared to earlier years confirming the findings of other studies c.f. ECB (2013), Hristov et al. (2014), Altavilla et al. (2015) and Altavilla et al. (2017). Unconventional monetary policies averted a credit crunch according to Cahn et al (2017) and raised output and inflation, as documented by Gambacorta et al. (2014). We show that the effects of long-term yields and financial or credit risks became more influential over lending rates than they had been previously (as implied by Garcia de Andoain et al. (2014), Bleaney et al. (2016), Gilchrist and Mojon (2018) and Vari (2019)). This seems consistent with the shifting emphasis of policy away from adjustment in short-term rates and towards the use of liquidity operations, forward guidance and the balance sheet, which affected banks through long-term yields and financial risk factors.[4]

The data used in the estimation are drawn at a monthly frequency from the harmonized monetary and financial institutions' interest rate (MIR) dataset over the sample January 2000 - June 2016 for Germany, France, Italy, and Spain. Other variables capturing the macroeconomy (as detailed in the data appendix) are obtained from EUROSTAT.

The paper is organized as follows. Section 2 contains a brief review of the literature, Section 3 offers a summary of European monetary policy actions. Next, in several sub-sections, Section 4 explains the methodology employed including identification, estimation, bootstrapping for confidence intervals and the estimation procedure. Section 5 describes the data. Section 6 discusses all the results of the procedures using sub-sample estimates. Section 7 concludes. All tables and figures are given at the end of the paper and brief appendices list the data sources used and provide an outline of the technical details of the bootstrapping algorithm used.

2 A Brief Review of the Literature

The transmission lines from ECB monetary policies to financial markets are discussed in detail in Giannone et al. (2011, 2012), ECB (2010a, 2010b, 2012, 2015a,b), Altavilla et al. (2015) and Altavilla et al. (2017). These include the effects of (a) liquidity injections on money market rates through "fixed rate/full allotment" tendering procedures of longer term refinancing operations, (b) acceptance of a wider range of eligible collateral for these operations, (c) forward guidance

[4]We regard Germany and France as examples of less vulnerable countries and Italy and Spain as vulnerable countries, using the definition employed in ECB (2016).

over future short term rates, (d) announcements of readiness to implement outright monetary transactions, (e) purchases of covered bonds and asset backed securities, and most recently (f) the asset purchase programme. Conditional forecasts from their models explain how policy might have evolved in the absence of unconventional policy. By making comparison with the actual out turn of events, they are able to determine whether the timing of unconventional policy measures coincides with deviations of actual data from their conditional forecasts. Their findings confirm the finding of others that liquidity operations affect the short-term interbank rates directly, see ECB (2010a,b) and Beirne et al. (2011), and asset purchases affect the longer term yields, c.f. ECB (2015a, b) and Praet (2015). In Altavilla et al. (2017) the focus is on the impact of monetary policy after June 2014 – specifically the Targeted Long-term Refinancing Operations (TLTRO) and Asset Purchase Programme (APP) – on individual banks, sometimes grouped into stressed and less-stressed groups. This makes a significant contribution to the understanding of bank level responses, and controls for many bank characteristics, such as sovereign exposures, capital ratios, stable funding ratios and non-performing loan levels. Our paper takes a different approach based on a BBE model with structural identification of all ECB unconventional monetary policies and concentrating on the differences in the effects on lending rates at higher frequencies than is possible with bank level data, focusing instead on responses at the country level.

BBE provide a justification in the context of US monetary policy for the use of factor models summarizing a large set of data as an improvement on structural VARs proposed by Sims (1992) and Bernanke and Blinder (1992) that typically suffer from "sparse information sets". These limited datasets may lead to three problems. First, the central bank and the private sector may respond to information not included in a small-dimensional VAR, which will result in the mismeasurement of responses to policy shocks in the small-dimensional VAR because the shocks may not be identified properly. Second, there is a degree of arbitrariness in the measurement of latent variables essential to the problem, such as the natural rate of output and the equilibrium real rate of interest, that exacerbate the measurement problems. Third, we can only observe impulse responses for the small set of variables included in the VAR, when we may have an interest in the response to a wider range of shocks. These points are particularly relevant when we consider unconventional monetary policy that operates through many different instruments, some of which are hard to measure or are unmeasurable, e.g. announcements of policy intentions and have many potential channels of transmission. The BBE approach using factor-augmented VAR (FAVAR) methodology deals with many of the problems that can emerge in modeling monetary transmission. The effective use of large data sets facilitates the measurement of complete transmission of policy shocks and allows analysis of a wider range of shocks-

Stock and Watson (2005) discuss BBE and a few alternative approaches to identification of structural shocks in FAVARs. These alternative approaches include procedures which directly identify structural shocks to unobservable common factors. Yamamoto (2016) uses three types of restrictions originally described in Stock and Watson (2005) and proposes bootstrap procedures for making inference about impulse response functions. Bai and Ng (2013) discuss the identification of common factors, estimated by principal components, without modelling factor dynamics in a FAVAR model. Bai et al. (2016) propose a procedure to identify latent factors in a framework where some factors are observable and the joint dynamics of latent and observable factors can be described by a VAR model. However, none of these papers actually uses identified factors for policy analysis since the global financial crisis.

A very different approach has been proposed by Lombardi and Zhu (2014), which makes use of a dynamic factor model, but it does so to construct a "shadow policy rate" which is intended to represent the stance of monetary policy when nominal interest rates are at the zero lower bound. The shadow rate, originally proposed by Black (1995), has recently received significant attention as a way of resolving the issue of how to measure the stance of monetary policy in the aftermath of the global financial crisis, see inter alia, Krippner, (2014), Christensen and Rudebusch (2016) and Wu and Fan (2016). In Lombardi and Zhu (2014) the shadow rate is computed using the Expectation Maximization algorithm in a dynamic factor model where the nominal interest rates at the zero bound are substituted with missing values. The derived measure has an appealing economic interpretation and can be used in a VAR model as a policy variable. However, this measure is not a common factor; by design, it does not have to contribute much to the estimated common factor space. It is also the case that it is a proxy for the different instruments used by the ECB, and rather than identifying the effects of these instruments on short rates, long-term yield and risk perceptions, it summarizes their effects in one shadow rate.

von Borstel et al. (2016) provide a FAVAR analysis of the pre-crisis period (2003-mid 2007) and the sovereign debt crisis period (2010-2013) omitting the global financial crisis (mid 2007-2010). They estimate two separate FAVAR models for each episode, to compare the transmission of monetary policy pre- and post-crisis to bank lending rates. The model includes observable and latent factors, extracted from a large macroeconomic and financial data set. The novelty in von Borstel et al. (2016) is the use of an "effective monetary stimulus (EMS)" measure which is designed as an improvement of the shadow rate proposed by Krippner (2014). The EMS approximates monetary policy by current and expected future short rates relative to a neutral rate derived from the 2-factor Nelson-Siegel model of the yield curve even in negative territory when the zero lower bound constrains the nominal rate to be positive. They estimate the response functions to an EMS shock. Their conclusion is that the transmission of monetary policy in the second sovereign debt crisis period was weaker than in the pre-crisis period. In other words, there was a larger spread between lending rates and policy rates, which they speculate could be due to higher borrower risks, tighter supply constraints on credit, or reduced cross-border competition between banks. The fact that their paper is directed to the explanation of interest rate pass through implies some overlap with our paper, however, our approach draws on a different technology to explain interest rate pass through.

We complement the papers by Lombardi and Zhu (2014), Wu and Fan (2016) and von Borstel et al. (2016) that impute the effects of unconventional monetary policy on a shadow short rate by using further economic factors in the spirit of BBE. Our approach therefore provides identification of the impact of unconventional monetary policy shocks through short-term rates, long-term yields and financial risk measures. In this respect we aim to offer a structural factor interpretation and more detail about the transmission lines, which then allows us to explore the effects of monetary policy cited by Praet (2017a).

3 Timing of Events

3.1 European Monetary Policy Actions

The actions of the ECB during the last decade can be summarized by six types of policy that influenced short-term money market and longer term bond yields, directly or indirectly. First, from October 2008 banks in the euro area had access to excess liquidity because the ECB offered tender operations with fixed rate full allotments. The liquidity reached a peak of 812 billion euro (March 2012) as two 3-year Long-Term Refinancing Operations (LTROs) in December 2011 and February 2012 were made available to the banks. This had direct effects on very short-term interest rates, since the provision of excess liquidity through LTROs caused the euro overnight index average (EONIA) to drop from close to the main refinancing rate to the ECB deposit facility rate (the lower bound of the corridor for overnight interest rates). Only after the option was offered in 2013 for weekly repayment did banks reduce this liquidity.

Second, from July 2013 the ECB's Governing Council offered forward guidance on the path of interest rates subject to their the outlook on inflation. This provided communication over future short rates and by implication the longer maturity rates further along the yield curve.

Third, the first two actions were supplemented by an OMT announcement in July 2012, which was sufficient to lower long term borrowing costs for government and banks, even though it has not been implemented to date. The flatter yield curve has lowered the cost of medium and longer term borrowing for banks when issuing senior unsecured bonds at maturities 1-5 years, while liquidity operations have also made cheaper short-term funding available at maturities up to 3 years.

Fourth, in June and September 2014 the ECB used balance sheet policies to offer credit easing, using four Targeted Long-Term Refinancing Operations (TLTROs) to provide long-term funding at relatively low rates to the banks that met certain conditions for up to 4 years, to support lending to the real economy. They also purchased assets in the two Covered Bond Purchase Programmes (CBPP1, CBPP2) and a Securities Markets Programme (SMP) set up to buy government bonds from the secondary market.

Fifth, in October and November 2014 the ECB announced and implemented an Asset Backed-Securities Purchase Programme (ABSPP) and a third Covered Bond Purchase Programme (CBPP3) to implement further easing of monetary policy.

Finally, in November 2014 the ECB began an Asset Purchase Programme (APP) to directly purchase 60 billion euro of government bonds each month till the end of September 2016. By August 2015 the ECB had purchased 414.3 billion euro under the entire APP, including 291.7 billion euro under the Public Sector Purchase Programme (PSPP), 111.5 billion euro under the Covered Bond Purchase Programme (CBPP3) and 11.1 billion euro under the Asset-Backed Securities Purchase Programme (ABSPP). As a consequence, Peter Praet in a speech dated 30 June 2015 noted "On the bank side, the APP seems to have been effective in further reducing wholesale funding costs, as portfolio rebalance effects have led to a compression of, for example, bank bond yields. Consequently, while the cost of borrowing from banks for households and firms has been declining since mid-2014, the pace of the decline has increased in recent months."

3.2 Effects of Monetary Policy on the Composition and Cost of Funding for Banks

The composition and costs of funding for banks have been influenced by monetary policy, macroeconomic conditions, the balance-sheet strength of sovereigns or banks themselves and by regulatory policy according to ECB (2016). The differences in interest rate setting by banks across countries reflects these differences in funding costs and risks. To a large extent these differences split along the lines of less vulnerable and vulnerable countries (the latter are defined as Cyprus, Greece, Ireland, Italy, Portugal, Slovenia and Spain by ECB, 2015b). And therefore, to a large degree the unconventional policies implemented by the ECB from 2012 onwards were a direct response to perceived funding problems in vulnerable countries, in order to avoid disorderly responses in certain funding markets and to prevent forced deleveraging by banks, Praet (2017a, b).

Since the crisis, the transmission of monetary policy has relied less on the interest channel via short-term market rates and to a larger extent on the signaling channel, the expectations channel and the portfolio rebalancing channel, as well as through credit channels via bank lending and balance sheet, as discussed by Constâncio (2015).

Prior to the crisis, banks in the major euro area countries raised the majority of their funds from retail deposits of households, government and non-financial firms, which were large and stable. These were supplemented by wholesale markets offering deposits of banks, and funds raised in various securities markets. Immediately after the crisis, funding from wholesale markets became more expensive and less reliable and banks in the euro area shifted their funding away from wholesale markets towards retail funding, see van Rixtel and Gasperini (2013). This was much more noticeable in the vulnerable countries than elsewhere, see ECB (2016). While banks were able to continue to issue securities (with government guarantees) even after the Lehman crisis, this became more difficult for vulnerable countries as markets became more concerned about sovereign debt levels between 2010-2012. Even retail deposits in vulnerable countries began to ebb away in this period, as depositors moved accounts to countries with lower debt levels, and cross-border holdings of deposits in euro area banks by non-residents were reduced, see Forster et al. (2011). Banks at this time were forced to rely more heavily on central bank liquidity operations as described above. For the euro area as a whole, ECB (2016) shows that reliance on retail funding increased after the crisis (comparing figures for January 2005 versus September 2015) and funding from wholesale markets, securities and external liabilities fell. The effects were more substantial for vulnerable countries compared to less vulnerable countries. The introduction of the APP has further increased the levels of deposits in the banking system, although the effects differ across countries according to quarterly bank lending surveys conducted by the ECB.

The cost of bank funding has also risen since the crisis, especially in the vulnerable countries. Credit risk increased due to perceptions of risk associated with the banks themselves, but further increases in the cost of funds resulted from the perception that sovereign risk had increased in some countries, and this reached a peak in 2012, see Gilchrist an Mojon (2018). These factors contributed to higher yields on securities in vulnerable and less vulnerable countries and to elevated rates on interbank borrowing as documented by Vari (2019). Only with the intervention of the ECB through unconventional policies - particularly the OMT announcement in July 2012 - did these interbank rates subside, and bond yields only completely converged at the start of the asset purchase programme as it reduced long term rates, see Altavilla et al. (2015), Constâncio (2015), and ECB (2016).

The cost of retail deposits also increased in the period 2008-2012 for vulnerable countries, since the reduction in monetary policy rates was not fully passed through to depositors, and banks relied more heavily in these countries on retail funding. After the OMT policy was announced in July 2012 the dispersion of deposit rates has fallen across euro area countries. ECB (2015b) shows the composite funding costs of banks declined from 2012 and that TLTRO, ABSPP and CBPP3 and APP programmes all contributed to this decline.[5]

Our concern is how these changes in composition and cost of funds impacted lending rates. Even though policy succeeded in compressing funding costs, lending rates were sticky and slow to adjust between 2011-2014. ECB (2015b) shows that banks that participated in at least one of the first four TLTRO programmes were more likely to lower their lending rates than non-participants. However, once again, whether the banks were located in vulnerable or less vulnerable countries was important, since variation in lending rates by banks in vulnerable countries did not appear to be linked to participation. Median lending rates in vulnerable countries fell from 3.89% to 2.44% from September 2011 to July 2015, while in less vulnerable countries they fell from 3.21% to 1.76%.

Our analysis is designed to evaluate the effects of different monetary policy operations through various channels, and we turn now to the methodology to explain how we identify the

[5]Surprisingly, France had the highest composite cost of bank funding among the major euro area countries from 2008-2012, but Italy and Spain had higher costs from 2012 -2015. Germany consistently had the lowest cost of funds from 2008 - 2015.

effects in a structural dynamic factor model.

4 Econometric Methodology

This section discusses the details of estimation, structural identification, and the computation of impulse response functions. Of particular note is (8), which provides the identification scheme of latent factors. The application we have in mind is to the lending rates offered on mortgages and corporate loans, which are explained by seven factors representing real and nominal variables such as output, prices, exchange rates, monetary variables, the volatility of the stock market and long and short interest rates.

4.1 The Reduced-Form Model

The analysis is based on the dynamic factor model in static form as in Stock and Watson (2005):

$$X_t = \Lambda F_t + e_t,\ t = 1, \ldots, T; \tag{1}$$

where $X_t = (X_{1t}, \ldots, X_{Nt})'$ is an $N \times 1$ vector of (standardized) informational variables, $F_t = (F_{1t}, \ldots, F_{rt})'$ is an $r \times 1$ vector of latent factors ($r << N$), $\Lambda = (\lambda_1, \ldots, \lambda_N)'$ is an $N \times r$ matrix of loadings, and $e_t = (e_{1t}, e_{2t}, \ldots, e_{NT})$ is an $N \times 1$ vector of idiosyncratic shocks. The factors are assumed to be generated by a stable VAR model:

$$\begin{aligned} &F_t = A_1 F_{t-1} + A_2 F_{t-2} + \ldots + A_p F_{t-p} + u_t, \text{ or} \\ &A(L)F_t = u_t,\ A(L) = I - A_1 L - A_2 L^2 - \ldots - A_p L^p, \end{aligned} \tag{2}$$

which admits a moving-average representation:

$$F_t = \Phi(L)u_t,\ \ \Phi(L) = I_r + \Phi_1 L + \Phi_2 L^2 + \ldots,\ \ \Phi(L) = A(L)^{-1}. \tag{3}$$

Let X_{it} be a variable of interest:

$$X_{it} = \lambda_i' F_t + e_{it},\ t = 1, 2, \ldots, T. \tag{4}$$

This can be an informational variable or an additional variable, which is not included in the data set for computing latent factors. In our application X_{it} is a bank lending rate to households or firms.

The objective is to identify the latent factors and make inference about responses of X_{it} to structural shocks in the factors, where these factors may be taken as proxies for the real and nominal variables such as output, prices , exchange rates, money balances, the volatility of the stock market and long and short interest rates (as detailed below).

4.2 Structural Identification

Using an $r \times r$ invertible matrix S, we let the structural factor model be defined as (see Stock and Watson, 2005 or Yamamoto, 2016):

$$\begin{aligned} X_t &= \Lambda^s F_t^s + e_t, \\ F_t^s &= A_1^s F_{t-1}^s + A_2^s F_{t-2}^s + \ldots + A_p^s F_{t-p}^s + v_t, \end{aligned} \tag{5}$$

where $\Lambda^s = \Lambda S$, $F_t^s = S^{-1} F_t$, $A_k^s = S^{-1} A_k S$, and $v_t = S^{-1} u_t$ is a structural innovation. The moving-average representation of the structural factor VAR is given by

$$F_t^s = \Psi(L) v_t,\ \Psi(L) = I_r + \Psi_1 L + \Psi_2 L^2 + \ldots,\ \Psi(L) = S^{-1} \Phi(L) S. \tag{6}$$

Invertibility of matrix S allows us to examine the impact of the innovations (or shocks) to the factors on the interest rates that banks set for households and firms as we now explain.

Consider a matrix form of model (1)-(2)

$$X = F\Lambda' + e,$$

$$F = ZA + u,$$

where X is the $T \times N$ matrix of observed variables (e.g. bank lending rates), e is the $T \times N$ matrix of idiosyncratic shocks, $F = (F_1, F_2, \ldots, F_T)'$ is the $T \times r$ matrix of factors, $Z =$

$(F_{(-1)}, F_{(-2)}, \ldots, F_{(-p)})$ is $T \times rp$ matrix of factor lags, $F_{(-k)} = (F_{1-k}, \ldots, F_{T-k})'$, and $A = (A_1, \ldots, A_p)'$ is $rp \times r$ matrix of parameters. For the structural model (5), the matrix form is

$$X = F^s \Lambda^{s'} + e,$$

$$F^s = Z^s A^s + v,$$

where $F^s = F[S^{-1}]'$, $\Lambda^s = \Lambda S$, $Z^s = Z\,[I_p \otimes [S^{-1}]']$, $A^s = \left[I_p \otimes S'\right] A[S^{-1}]'$, and $v = u[S^{-1}]'$. We work with these to identify the structure of the relationships between the factors and the interest rates that banks set for households and firms in each country.

Statistical identification, implemented in the method of principals components, is achieved by imposing orthonormality of factors, $F'F/T = I_r$, which implies $(r^2 + r)/2$ restrictions, and diagonality of $\Lambda'\Lambda$, which implies $(r^2 - r)/2$ restrictions, for the total of r^2 restrictions.

Structural restrictions, imposed in this paper, are similar to short-run restrictions in Stock and Watson (2005) and Yamamoto (2016). Firstly, the covariance matrix of structural shocks $E(v_t v_t')$ is assumed to be diagonal. This implies $(r^2 - r)/2$ restrictions. Secondly, the matrix Λ^s is assumed to be composed of two sub-matrices:

$$\Lambda^s = \begin{bmatrix} \Lambda^s_{1:r} \\ \Lambda^s_{r+1:N} \end{bmatrix}, \text{ where } \Lambda^s_{1:r} = \begin{bmatrix} 1 & 0 & \ldots & 0 \\ \lambda^s_{21} & 1 & \ldots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ \lambda^s_{r1} & \lambda^s_{r2} & \ldots & 1 \end{bmatrix}. \tag{7}$$

This implies $(r^2+r)/2$ restrictions on the matrix Λ. The identification of factors depends on the choice and ordering of the first r variables in the data matrix X. For the first r informational variables

$$\begin{aligned} &X_{1t} = F^s_{1t} + e_{1t}, \\ &X_{2t} = \lambda^s_{21} F^s_{1t} + F^s_{2t} + e_{2t}, \\ &\vdots \\ &X_{rt} = \lambda^s_{r1} F^s_{1t} + \lambda^s_{r2} F^s_{2t} + \ldots + F^s_{rt} + e_{rt}. \end{aligned} \tag{8}$$

The first variable instantaneously responds to a shock in the first structural factor only: a unit shock in the first factor implies a unit shock to the first variable. The second variable instantaneously responds to shocks in structural factors 1 and 2. The response of the second variable to a unit shock in the second structural factor 2 is equal to one, and so on. This ordering is important in the context of the effects we intend to measure and in the identification of the role played by the various factors in influencing lending rates. A discussion of these issues is provided below in Sections 5 and 6.

The application we consider has seven common factors ($r = 7$), which are estimated for each country, and the structural identification scheme just described is implemented. The choice of the number of common factors is based on a heuristic criterion of marginal R^2 (see Forni and Reichlin 1998). Figures 1-4 show marginal R^2 values for each structural factor in regressions of individual variables onto factors. Each structural factor is strongly correlated with a set of variables which characterize the sector of the economy associated with the corresponding identifying variable. Factors 1-4 are correlated with production indices, price indices, exchange rates and monetary aggregates correspondingly. Factors 5-7 are correlated with short-term rates, long-term rates and financial market indicators. It is interesting to note that Figures 1 - 4 of the 'factor loadings' demonstrate how well particular groups are correlated with the identified factors, although these partial correlations are not used for factor identification. That is, although a lower triangular structure is employed to identify factors, (X_{1t} corresponding to IP.Manuf, X_{2t} to HICP. and so on for the seven variables in Table 1 below), there is little or no contemporaneous correlation of identified factors with other groups of variables: each factor is strongly correlated with that group of variables to which an identifying variable belongs (e.g. Factor 6 identified with the help of the 10-year swap rate is only strongly correlated with long-term rates, although no restriction is imposed on its correlation with short-term rates.)

The variables in the Table below therefore justify the identification of factors for two reasons: they offer the possibility of a structural interpretation of common factors and have a high correlation with the principal components.

The lower-triangular ordering adopted may be justified following BBE's seminal contribution, subsequently adopted by much of the literature. Interest rates are ordered after indicators of production and prices. This ordering is based on the assumption that production and prices cannot respond contemporaneously (within a period) to shocks in interest rates. The ordering of real and nominal variables before financial variables and interest rates is consistent with BBE. Within the latter group however it may be possible to think of different ordering - for example ordering long rates before short rates - and we have experimented with different orderings without the main conclusions being altered.

Table 1: Selection of Identifying Variables

#	Mnemonic	Description	Transformation
1	IP.Manuf	index of industrial production, manufacturing	log-difference
2	HICP.All	index of consumer prices, all items	log-difference
3	REER42	real effective exchange rate	log-difference
4	M2	monetary aggregate M2	log-difference
5	EURIBOR3M	3-month Euribor	difference
6	SWPSPR10Y	10-year swap spread	difference
7	VSTOXX	EURO STOXX 50 volatility index	difference

Taking the factors in reverse order, a shock to Factor 7, identified using VSTOXX, can be interpreted a shock to stock volatility which has no contemporaneous (within a period) effect on other sectors of the economy. A shock to Factor 6 implies a shock to swap spreads which has no contemporaneous effect on Factors 1-5 and a shock to Factor 5 implies a shock to short-term rates which has no contemporaneous effect on Factors 1-4. In the results section we consider responses of bank lending rates to shocks in Factors 5-7 in detail.

4.3 Impulse Response Functions

For the moving-average form of equation (4),

$$X_{it} = \lambda_i' \Phi(L) u_t + e_{it},$$

the reduced-form impulse response of variable X_{it} to a shock in Factor j ($j = 1, 2, \ldots, r$) at horizon h ($h = 1, 2, \ldots$) is

$$\phi_{ijh} = \frac{\partial X_{it+h}}{\partial u_{jt}} = \lambda_i' \Phi_h^{(j)},$$

where $\Phi_h^{(j)}$ is the jth column of matrix Φ_h. The impulse response of variable X_{it} to a shock in structural factor j at horizon h is

$$\psi_{ijh} = \frac{\partial X_{it+h}}{\partial v_{jt}} = \lambda_i' S \Psi_h^{(j)}, \tag{9}$$

where $\Psi_h^{(j)}$ is the jth column of matrix Ψ_h. From this information we can analyse the monetary transmission channels and consider the stability of the relationships.

4.4 Sign Restrictions

Sign restrictions are imposed on immediate responses of retail rates, $h = 0$ as described in Table 1. The sign restrictions on Factors 6 and 7 are consistent with a higher corporate and mortage lending rates associated with higher long-term yields or greater financial market volatility and *vice versa*:

Table 2: Sign Restrictions

Rate / Factor	F1	F2	F3	F4	F5	F6	F7
Corporate	·	·	·	·	·	≥ 0	≥ 0
Mortgage	·	·	·	·	·	≥ 0	≥ 0

To impose sign restrictions onto impulse responses in the FAVAR, structural shocks are transformed by a rotation matrix $Q(\theta)$, where θ is a vector of rotation angles and $Q(\theta) \times Q(\theta)' = I$. For structural impulse responses these are represented by

$$\psi_{ijh} = \frac{\partial X_{it+h}}{\partial v_{jt}} = \lambda_i' S \Psi_h^{(j)} Q(\theta). \tag{10}$$

In order to impose sign restrictions, bootstrap simulations of the estimated FAVAR are carried out. For each iteration of the bootstrap procedure θ is drawn from the uniform distribution on the interval $[0, \pi]$. The resulting rotation matrix has the form

$$
Q = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \cos(\theta) & -\sin(\theta) \\ 0 & 0 & 0 & 0 & 0 & \sin(\theta) & \cos(\theta) \\ \end{bmatrix}
$$

If the sign restrictions are satisfied, the draw is retained. Otherwise, the draw is rejected. The bootstrap procedure is summarized by quantiles: 16th percentile, median, and 84th percentile. As it is noted in Gambacorta et al. (2014), the resulting impulse response bands reflect both model uncertainty (draw of θ) and sampling uncertainty (bootstrapping draw), and should not be interpreted as conventional confidence bands.

4.5 Estimation Procedure

The estimation is carried out in two sub-samples: pre-crisis (2000:1-2007:6) and post-crisis (2009:7-2016:6). It follows five simple steps.

1. **Standardization and Estimation of Statistical Factors:** In order to maintain a stationarity assumption, information variables are transformed either by differencing or log-differencing. Model (1) is specified and estimated for standardized data: $X_{it} = (Z_{it} - \hat{\mu}_i)/\hat{\sigma}_i$ for each $i = 1, 2, \ldots, N$ and $t = 1, 2, \ldots, T$, where Z_{it} is the original (unstandardized) variable, $\hat{\mu}_i$ is the sample mean and $\hat{\sigma}_i^2$ is the sample variance of Z_{it}. The principal components estimator of F, denoted by $\tilde{F}$, is a $(T \times r)$ matrix composed of $\sqrt{T}$ times the eigenvectors corresponding r largest eigenvalues of the matrix XX'/NT (arranged in decreasing order), where the normalization $\tilde{F}'\tilde{F}/T = I_r$ is used. Then $\tilde{\Lambda} = X'\tilde{F}/T$ is a $(N \times r)$ matrix of estimated loadings.

2. **Estimation of the FAVAR model:** The model (2) is estimated by OLS and the moving average parameter matrices $\hat{\Phi}_j$, $j = 1, 2, \ldots,$ are derived recursively.

3. **Identification of Structural Factors:** The structurally restricted estimators $\hat{F}^s$ and $\hat{\Lambda}^s$, are obtained using a LDL' decomposition of $\hat{\Lambda}_{1:r}\hat{\Sigma}_u\hat{\Lambda}'_{1:r}$. The decomposition yields $\hat{\Lambda}_{1:r}\hat{\Sigma}_u\hat{\Lambda}'_{1:r} = LDL'$, where L is a unitary lower triangular matrix and D is a diagonal matrix. Then the identification matrix is

$$\hat{S} = \hat{\Lambda}_{1:r}^{-1} L \tag{11}$$

and the submatrix $\hat{\Lambda}_{1:r}^{s}$ of the loadings matrix of structural factors is

$$\hat{\Lambda}_{1:r}^{s} = \hat{\Lambda}_{1:r}\hat{S} = \hat{\Lambda}_{1:r}\hat{\Lambda}_{1:r}^{-1} L = L. \tag{12}$$

For the covariance matrix of structural shocks we have

$$\hat{\Sigma}_{v} = L^{-1}\hat{\Lambda}_{1:r}\hat{\Sigma}_{u}\hat{\Lambda}_{1:r}' \left(L^{-1}\right)' = D. \tag{13}$$

The estimated structural shocks to factors, $\hat{v}_t = \hat{S}^{-1}\hat{u}_t$, are restricted to be orthogonal, though the estimated structural factors, $\hat{F}_t^{s} = \hat{S}^{-1}\hat{F}_t$, are not restricted to be orthogonal. The moving-average parameter matrices of the structural VAR model are $\hat{\Psi}_j = \hat{S}^{-1}\hat{\Phi}_j\hat{S}$, $j = 1, 2, \ldots$.

4. **Computation of Rotated Impulse Responses:** Structural impulse responses are computed using equation (10).

5. **Bootstrap Procedure for Impulse Responses:** Bootstrap draws are generated using Procedure B from Yamamoto (2016). The procedure accounts for uncertainty in the estimators of the Factor VAR and loadings. The details of the procedure are reported in Appendix A.

5 Data Description

The data set for each country comprises various macroeconomic and financial indicators including indices of industrial production, price indices, exchange rates, stock and credit market indices, and interest rates (see Appendix B). The time span of the data is from January 2000 to June 2016. Before factor estimation, the data are transformed to ensure stationarity and to remove seasonal effects and outliers.

The retail (lending) rates studied here are total (all maturities) new business rates on mortgage loans (loans for house purchases) and corporate loans (loans to non-financial corporations). The ECB classifies the retail rate on new business by the period of initial rate fixation. The structure of loans differs across countries with respect to the period of initial rate fixation: while a large share of loans in Germany and France has a period of initial rate fixation over 1 year, a dominant share of loans in Italy and Spain has either floating rates or rates with a period of initial rate fixation of under 1 year. After the sovereign debt crisis, the share of loans with a period of initial rate fixation of over 1 year has shrunk further in these countries resulting in erratic behaviour of retail rates with a period of initial rate fixation of over 1 year, as these rates are computed on the basis of a small number of transactions. Using retail rates with a period of initial rate fixation of over 1 year would provide little information about pass-through for Italy and Spain. In order to overcome these difficulties, and retain comparability across countries, we have chosen to work with somewhat aggregate measures of these rates, although our methodology can be applied to any desired level of disaggregation.

6 Results:

6.1 Pass Through in Four Euro Area Countries

Since our main focus is on interest rate setting, we concentrate our discussion on the structurally identified effects of Factors 5-7. Factor 7 is associated with a positive, unexpected permanent shift in the volatility index (VSTOXX), while a positive shock to Factor 6 is associated with a shift in medium to long-term yields, and a shock to Factor 5 implies a shift in short-term interest rates. We will refer to the selected factors in order, and consider the results for lending rates to non-financial companies and to households for house purchases. We split the sample, evaluating the pre-crisis sub-sample and then compare these with the results from the post-crisis sub-sample.

It is apparent from Figures 5-8 that the initial impact of a positive shock to short term interest rates (a conventional monetary policy tool) in the pre-crisis sub-sample results in a positive response in lending rates to firms and households. While the magnitudes vary between countries and between loan types, which incidentally will also vary by maturity, the pre-crisis response lies between 0.35 and 0.7 after a 1 percentage point shock. The response in the shorter maturity loan product to firms is generally larger than in the longer maturity loans to households (except for France). By contrast, in the post-crisis sub-sample results, while we still observe a positive response in lending rates to firms and households, we see the magnitude of the initial response is much lower. In many cases it is more than 50% lower, for example, in Spain the initial impact is 66% lower, and in Italy the impact disappears altogether. This supports a widespread finding in the literature that pass through of short-term interest rates declined in the post-crisis period. Without further monetary policy action it is apparent that the monetary policy transmission mechanism would have been impaired and there would have been limited pass-through of monetary policy. This helps explain how we should understand the remarks of Constâncio (2015). However, our findings also show that impaired transmission of monetary policy through short-term interest rate adjustment persisted beyond the financial and sovereign debt crises, and was observable in our post-crisis sample that extends to mid-2016. Hristov et al (2014) were the first to detect this effect using data collected immediately after the crisis.

The initial impact of a shock to long-term rates in the pre-crisis sub-sample had a much smaller positive response in lending rates to firms and households compared to the effect of short-term rates. The magnitudes range from 0.1 - 0.4 after a 1 percentage point shock for loans to firms and below 0.1 for mortgages, except in Germany. For most countries the impact fell almost by 50% in the post-crisis period on loans to firms. For mortgage rates the impact of long-term rates increased by 100% in France and Italy and by 200% in Spain from very low pre-crisis levels. This implies that long-term rates influenced by unconventional policies were transmitted to mortgage rates offered to households but not to lending rates offered to firms. The maturity of mortgages is longer than the maturity of loans to firms, and matches more closely the maturity of long-term funding. As the funding costs associated with long term yields fell in the post crisis period there was a strong incentive to fund mortgages in this way.

Exploring the impact of the risk factor, we see that it hardly changes for corporate loans in Germany, which has faced the least instability during the financial and sovereign debt crises, and slightly falls for mortgages. The pass through of the risk factor to loans for business has not changed, but it has had a greater effect on mortgages in the post crisis period in France. There is a slight increase in the pass through of risk for business loans in Italy and a similar increase for mortgages. For Spain, pass through of risk has increased for loans to businesses but (surprisingly) has had less effect on mortgages. Undoubtedly, the sovereign debt crisis has impacted Italy and Spain more than Germany and France, as evidenced by the increase in the sovereign bond yields relative to German Bunds, see Gilchrist and Mojon (2018), and some aspects of interest rate pass-through from risk factors as discussed by Vari (2019) follows this systematic pattern e.g. the increase in pass-through of risk to corporate loans in Italy and Spain but not in Germany and France. But the lesson from the detailed study of von Borstel et al (2016) is that intervention by the ECB reduced risk factors in the vulnerable countries during the sovereign debt crisis, which might explain the muted response to risk factors reported here. This is confirmed by Praet (2017a) who notes “ECB pass-through models show that, since the launch of our credit easing package, the decline in lending rates in Spain and Italy in particular has been much stronger than can be explained by falling market rates alone. Tightening sovereign spreads help explain much of the observed fall.”

Our results show that while short-term rates continued to influence lending rates, they do so with less impact in the post-crisis period compared to earlier years confirming the findings of other studies c.f. ECB (2013), Hristov et al. (2014) and Altavilla et al. (2015, 2017). As described by Praet (2017a), unconventional monetary policy through the APP took effect via long-term yields and financial risks, and all told, long-term yields and financial risks became relatively more influential over lending rates than they had been previously. In a reference to evidence from Altavilla et al. (2015) and De Santis (2016), Praet (2018) says “model-based counterfactual simulations attribute more than half of the 126 basis point decline in lending rates to non-financial corporations since June 2014 directly to our non-standard measures” and “Banks themselves – when asked to assess the effects of our measures on their intermediation business – have reported that the APP has positively impacted their market financing conditions”. This seems consistent with the shifting emphasis of policy away from adjustment in short-term rates and towards the use of liquidity operations, forward guidance and the balance sheet, which affected banks through long-term yields and financial risk factors.

6.2 Variance Decompositions

There are a number of findings that stand out from our variance decompositions. First, collectively the contribution of the Factors 5-7 representing short term rates, long term yields and risk factors, respectively, is far greater than the other four factors to the explanation of the variance of lending rates. This is not surprising, and it is economically plausible if lending rates are determined by a markup and the underlying funding costs driven by short rates, long term yields and risk factors. Second, in the pre-crisis period the factor representing short-term rates explains the largest share of the variance of lending rates, and again this is plausible since policy was conducted in this period using short-term interest rates in a conventional monetary policy framework, therefore variation in lending rates would be driven mostly by variations in short rates. Third, we note that in post-crisis period the importance of Factors 6 and 7, representing long-term yields and risk factors, increases for France, Italy and Spain, and in some cases explains as much of the variation in lending rates as does Factor 5. This reveals a shift from conventional monetary policy to unconventional policy, which alters the emphasis of monetary policy from short-term rates to long-term yields, and risk factors as country-specific credit risks increased in the post-crisis environment. The reduction in variance of lending rates explained by variation in Factor 5 is consistent with the reduction in interest rate pass through observed earlier in the results. Finally, we see that the variation that is unexplained is quite large and grows larger still in the post-crisis period. A similar result was observed for different variables in the post-crisis period by Gambacorta et al. (2013) and it may reflect an inability of models more generally to explain the variability observed in the data after the crisis.

These results support our earlier findings that shifting emphasis of policy away from conventional adjustment of short-term rates and towards the use of liquidity operations, forward guidance and the balance sheet affected banks through long-term yields. More emphasis on financial risk factors reflects greater heterogeneity at the country level in response to the crisis. A larger share of the variance of lending rates can be explained using variance of long rates and risk factors than was the case before the crisis.

7 Conclusions

Monetary policy is under scrutiny as never before, and particularly in terms of its ability to influence bank funding costs and retail lending rates. This is because so much credit for real activity in the euro area is intermediated through the banking system. In this paper we make use of a new structurally identified dynamic factor model to explain the impact of monetary policy on lending rates. This is a step forward from the Bernanke et al. (2005) FAVAR model used prior to the financial crisis to improve structural VARs, and extended by others to explore episodes when short policy rates were at the zero lower bound. With our new methodology based on Stock and Watson (2005) and Yamamoto (2016) applied to this issue for the first time, we are not restricted to exploring the impact of short-term policy shocks or a single summary measure of monetary policy since this becomes increasingly difficult to reconcile with the many unconventional monetary policy actions of the European Central Bank. From our analysis, a picture emerges of lower point estimates of pass through of short-term interest rates during and after the global financial crisis, but long-term yields played a greater part than before. We show that the impact of policy was nevertheless swift for factors picking up short-term interest rates and slightly slower and more persistent for factors picking up the effects of long-term yields and financial risks. Our results captured by the impulse responses using sub-sample estimation illustrate the differential impact of monetary policy between countries and over different episodes of the financial and sovereign debt crises. A particular advantage of using structurally identified factors corresponding to rates and risk factors is that we can confirm the effects of new monetary policy instruments used by the ECB verifying that the monetary transmission channels cited by Praet (2017a, 2018) did influence interest rate pass through.

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Appendix A: Outline of Bootstrap Procedure

For each bootstrap iteration $k = 1, 2, \ldots, K$

(1) Resample the (centered) residuals $\{\hat{e}_t\}$ and $\{\hat{u}_t\}$ with replacement and label them $\{e_t^{(k)}\}$ and $\{u_t^{(k)}\}$; generate bootstrap samples $\{F_t^{(k)}\}$ and $\{X_t^{(k)}\}$ from

$$\begin{aligned} F_t^{(k)} &= \tilde{A}_1 F_{t-1}^{(k)} + \tilde{A}_2 F_{t-2}^{(k)} + \ldots + \tilde{A}_p F_{t-p}^{(k)} + u_t^{(k)}, \\ X_t^{(k)} &= \hat{\Lambda} F_t^{(k)} + e_t^{(k)} \end{aligned}$$

(2) Get estimates $\hat{\Lambda}^{(k)}$ by the OLS

(3) Use the bootstrap factors $F_t^{(k)}$ to get (bias-corrected)* estimates of parameters of the bootstrap factor VAR model, $\hat{A}_1^{(k)}, \hat{A}_2^{(k)}, \ldots, \hat{A}_p^{(k)}$ and $\hat{\Sigma}_u^{(k)}$

(4) Compute the bootstrap matrix of structural restrictions $\tilde{S}^{(k)}$; compute and store the bootstrap impulse responses $\hat{\psi}_{ijh}^{(k)}$.

Sort the bootstrap impulse responses $\{\hat{\psi}_{ijh}^{(k)}\}_{k=1}^{K}$ and for given $\alpha \in (0, 1)$ select $100\%\alpha$ and $100\%(1-\alpha)$ percentiles $(\hat{\psi}^{\alpha}, \hat{\psi}^{1-\alpha})$. The resulting $100(1-2\alpha)$ confidence interval for ψ_{ijh} is $(\hat{\psi}_{ijh} - \hat{\psi}^{1-\alpha}, \hat{\psi}_{ijh} - \hat{\psi}^{\alpha})$

Bias correction is carried using Kilian (1998) procedure as implemented in Yamamoto (2016).

Appendix B: Data Description

Table: Data Description

Mnemonic	Description	Data Source	SA*	TC**
IP.Manuf	Manufacturing, volume index of production	Eurostat	Yes	2
IP.Total	Industry, volume index of production	Eurostat	Yes	2
IP.Constr	Construction, volume index of production	Eurostat	Yes	2
IP.Non.Dur	Non-durable consumption goods, volume index of production	Eurostat	Yes	2
IP.Dur	Durable consumption goods, volume index of production	Eurostat	Yes	2
IP.Interm	Intermediate goods, volume index of production	Eurostat	Yes	2
IP.Cap	Capital goods, volume index of production	Eurostat	Yes	2
Exports	Total exports, current prices, EUR mln	Eurostat	Yes	2
Imports	Total imports, current prices, EUR mln	Eurostat	Yes	2
HICP.Goods	Harmonized index of consumer prices, goods	Eurostat	Yes	2
HICP.ALL	HICP, all items	Eurostat	Yes	2
HICP.XE	HICP, all items, excluding energy	Eurostat	Yes	2
HICP.XEF	HICP, all, excluding energy and food	Eurostat	Yes	2
HICP.Serv	HICP, services	Eurostat	Yes	2
CCI	Consumer confidence indicator	OECD	Yes	2
BCI	Business confidence indicator	OECD	Yes	2
YUANEUR	Exchange rate, YUAN	ECB	No	2
USDEUR	Exchange rate, USD	ECB	No	2
NEER42	Nominal effective exchange rate - 42 trading partners	Eurostat	Yes	2
REER42	Real effective exchange rate - 42 trading partners	Eurostat	Yes	2
M1	M1 Stock	National CB	Yes	2
M2	M2 Stock	National CB	Yes	2
M3	M3 Stock	National CB	Yes	2
EONIA	EONIA, overnight rate	No	1	
EURIBOR3M	EURIBOR, 3 Months	ECB	No	1
EURIBOR6M	EURIBOR, 6 Months	ECB	No	1
EURIBOR12M	EURIBOR, 12 Months	ECB	No	1
SWR2Y	Swap rate, 2 years	Bloomberg	No	1
SWR5Y	Swap rate, 5 years	Bloomberg	No	1
SWR10Y	Swap rate, 10 years	Bloomberg	No	1
TBSPR2Y	Treasury bond yield, 2 years	Bloomberg	No	1
TBSPR5Y	Treasury bond yield, 5 years	Bloomberg	No	1
TBSPR10Y	Treasury bond yield, 10 years	Bloomberg	No	1
CDS.GVT	CDS spread, 5 years, Government	Bloomberg	No	1
DAX/CAC/FTSE/IGBM	Country-specific stock exchange index	Yahoo!Finance	No	2
EUROSTOXX	EUROSTOXX 50 index	ECB	No	2
SP500	US stock exchange index	Yahoo!Finance	No	2
VSTOXX	EUROSTOXX volatility index	STOXX	No	1
VIX	CBOE volatility index	Yahoo!Finance	No	1
Gold.Price	London Gold Price, USD/troy ounce	BoE	No	2

*Seasonal adjustment: Yes - series was adjusted, No - series was not adjusted

**Transformation code: 1- difference, 2 - log-difference

Figure 1: Factor Loadings, Germany

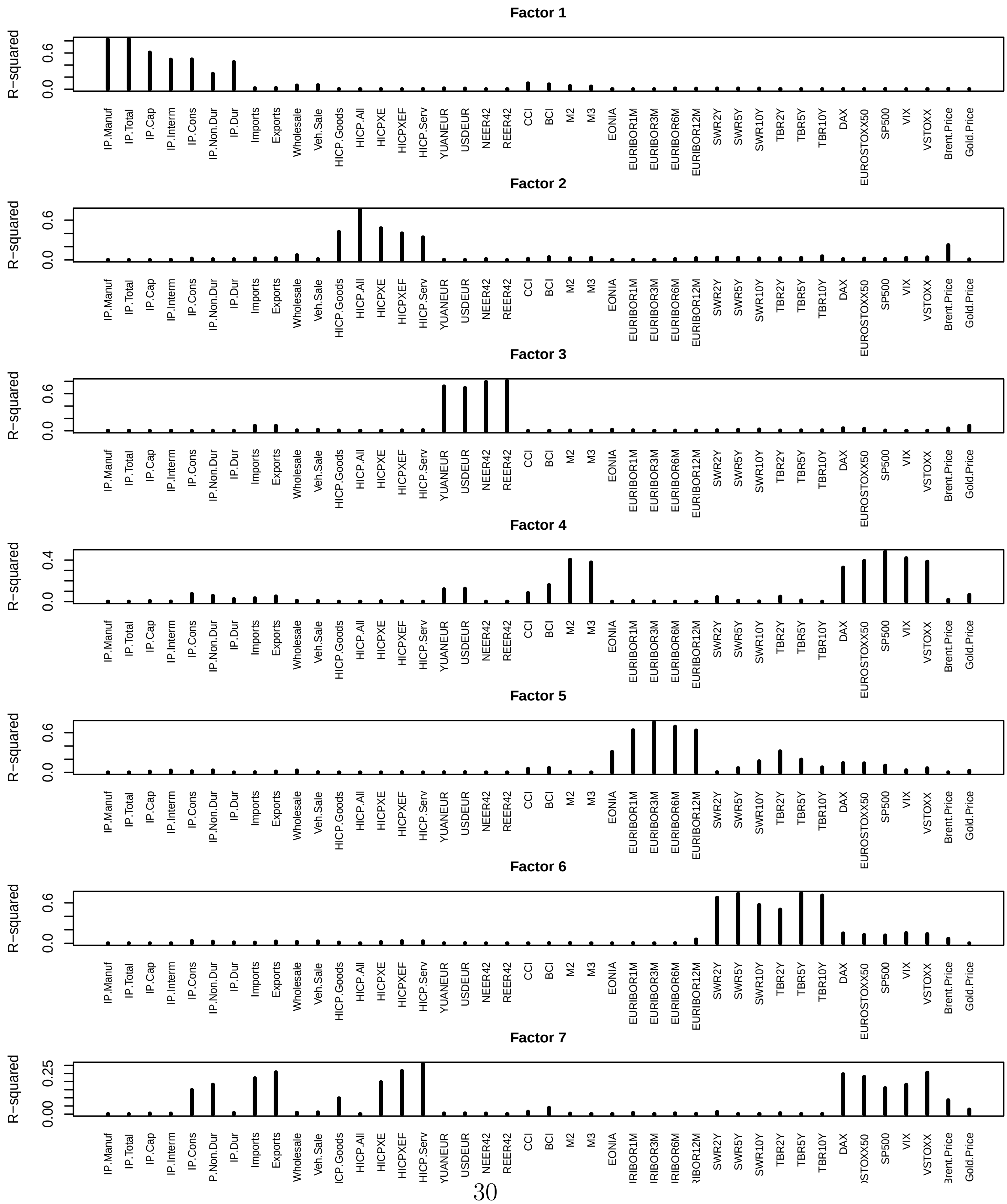


Figure 2: Factor Loadings, France

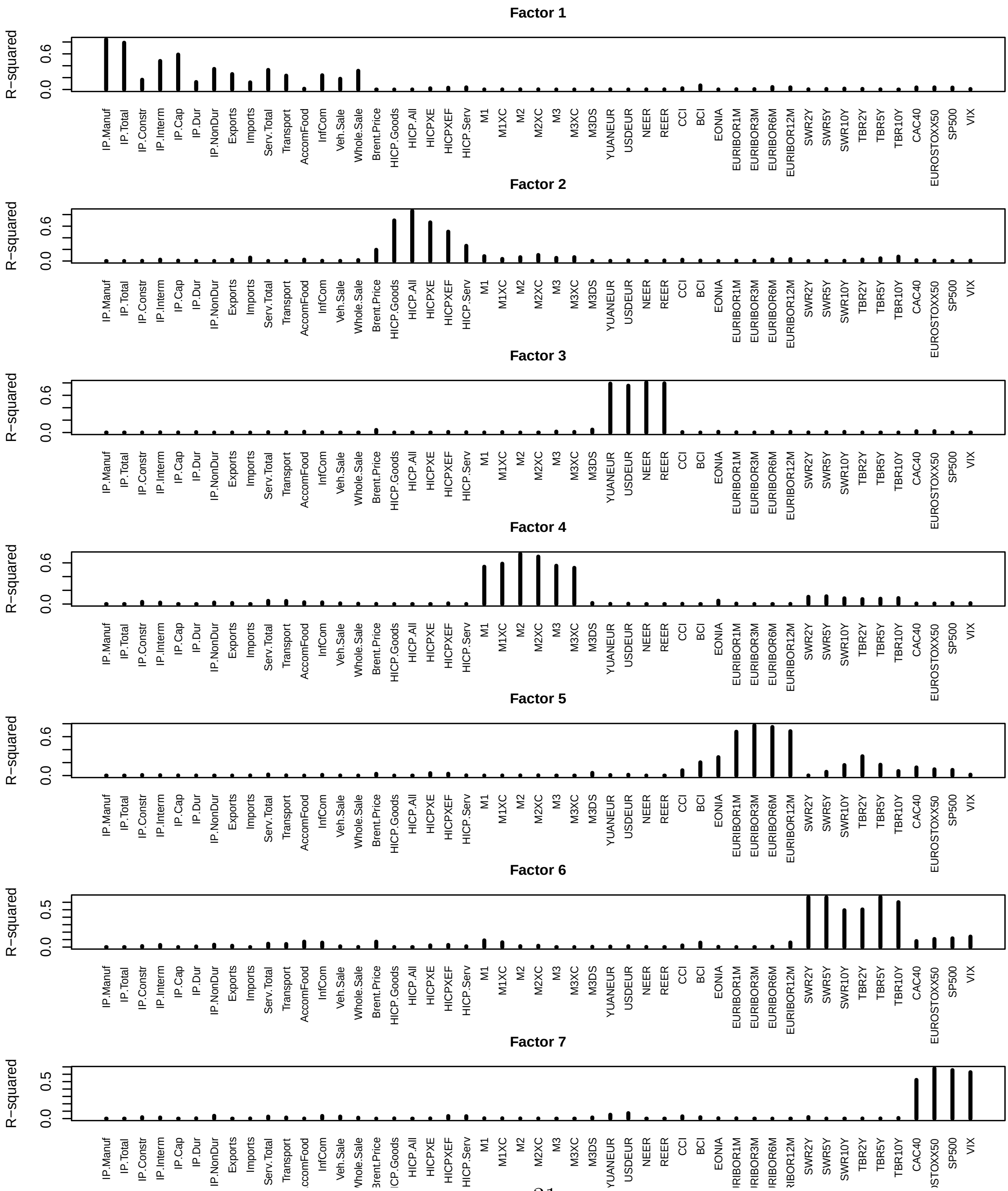


Figure 3: Factor Loadings, Italy

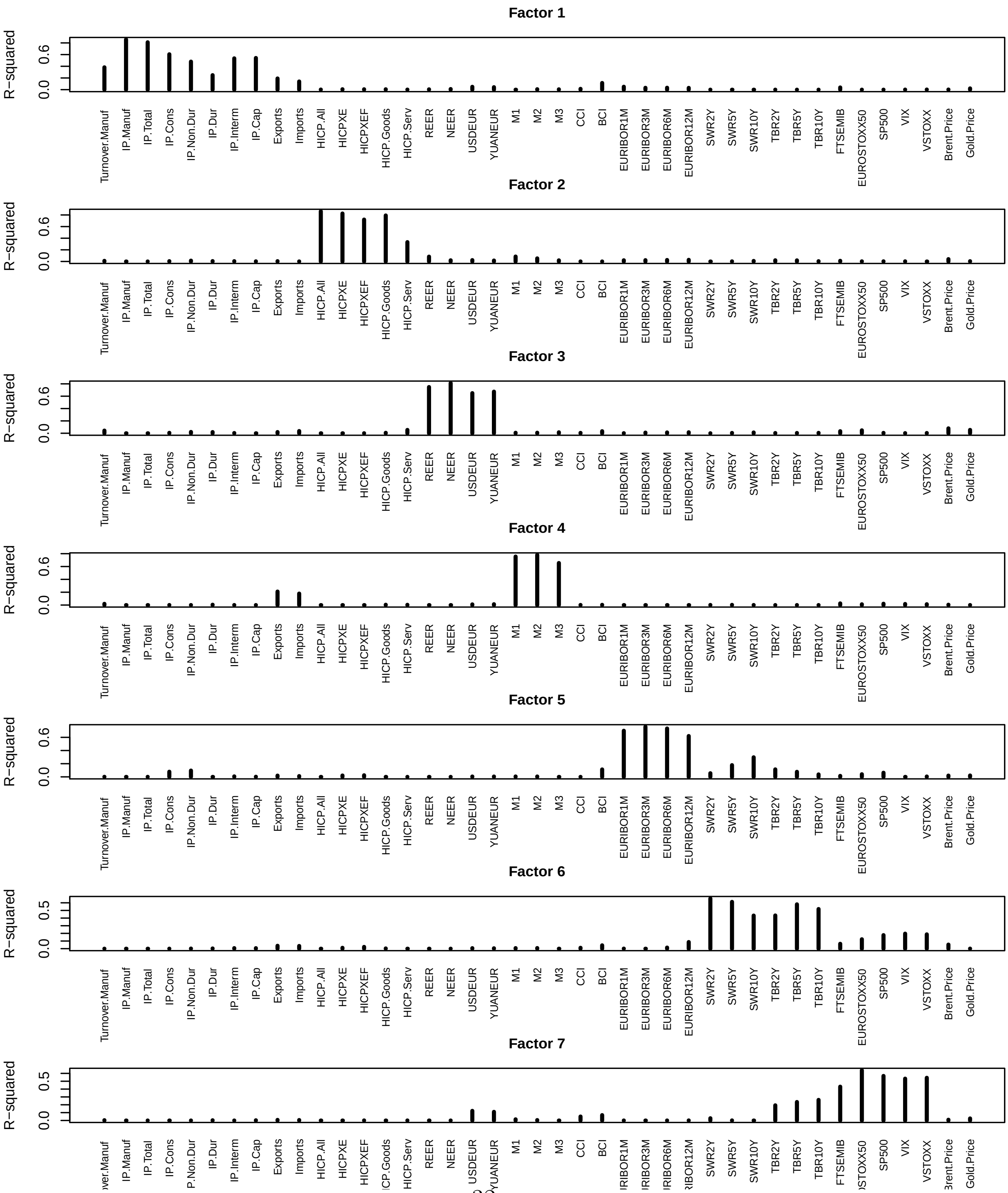


Figure 4: Factor Loadings, Spain

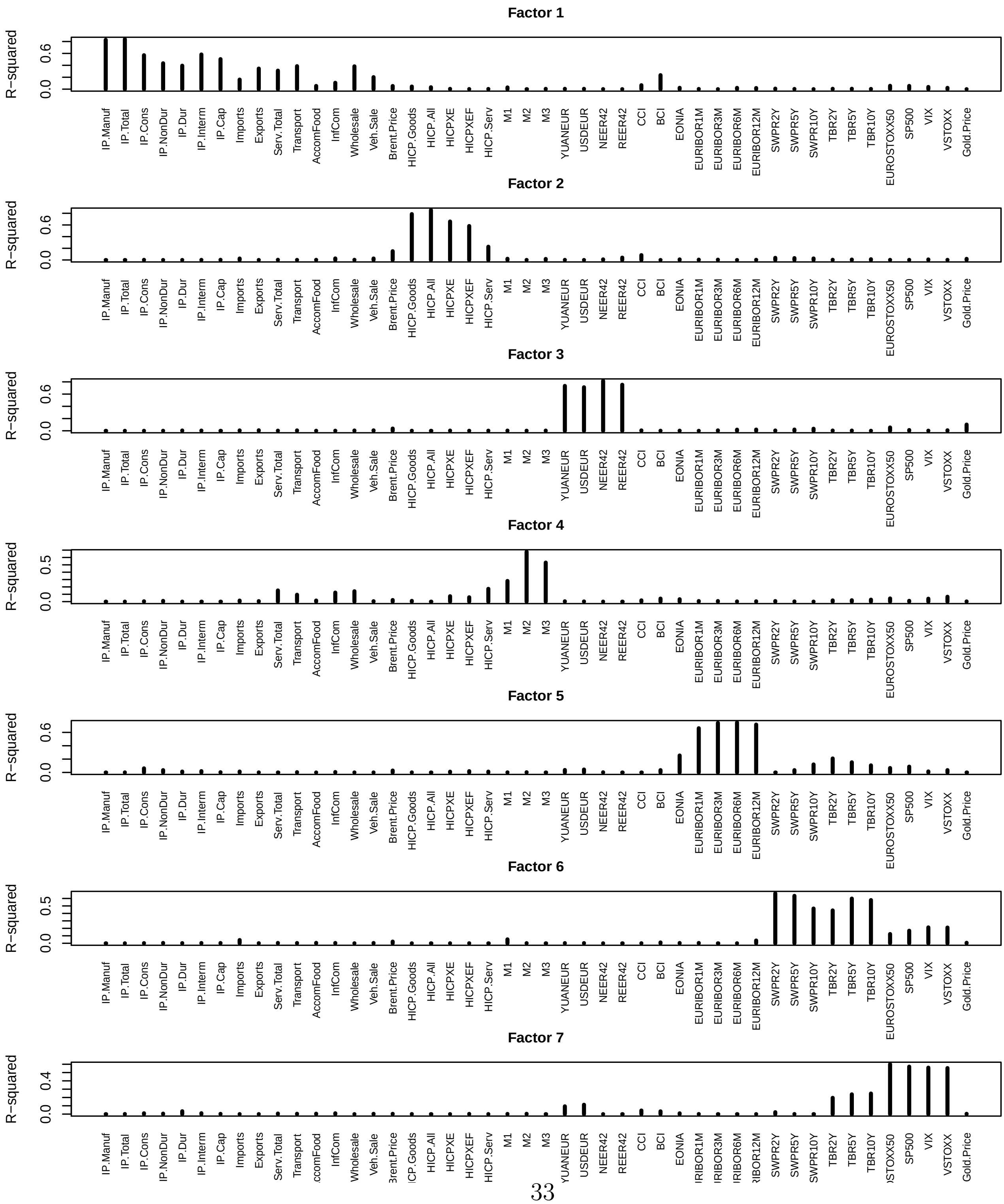
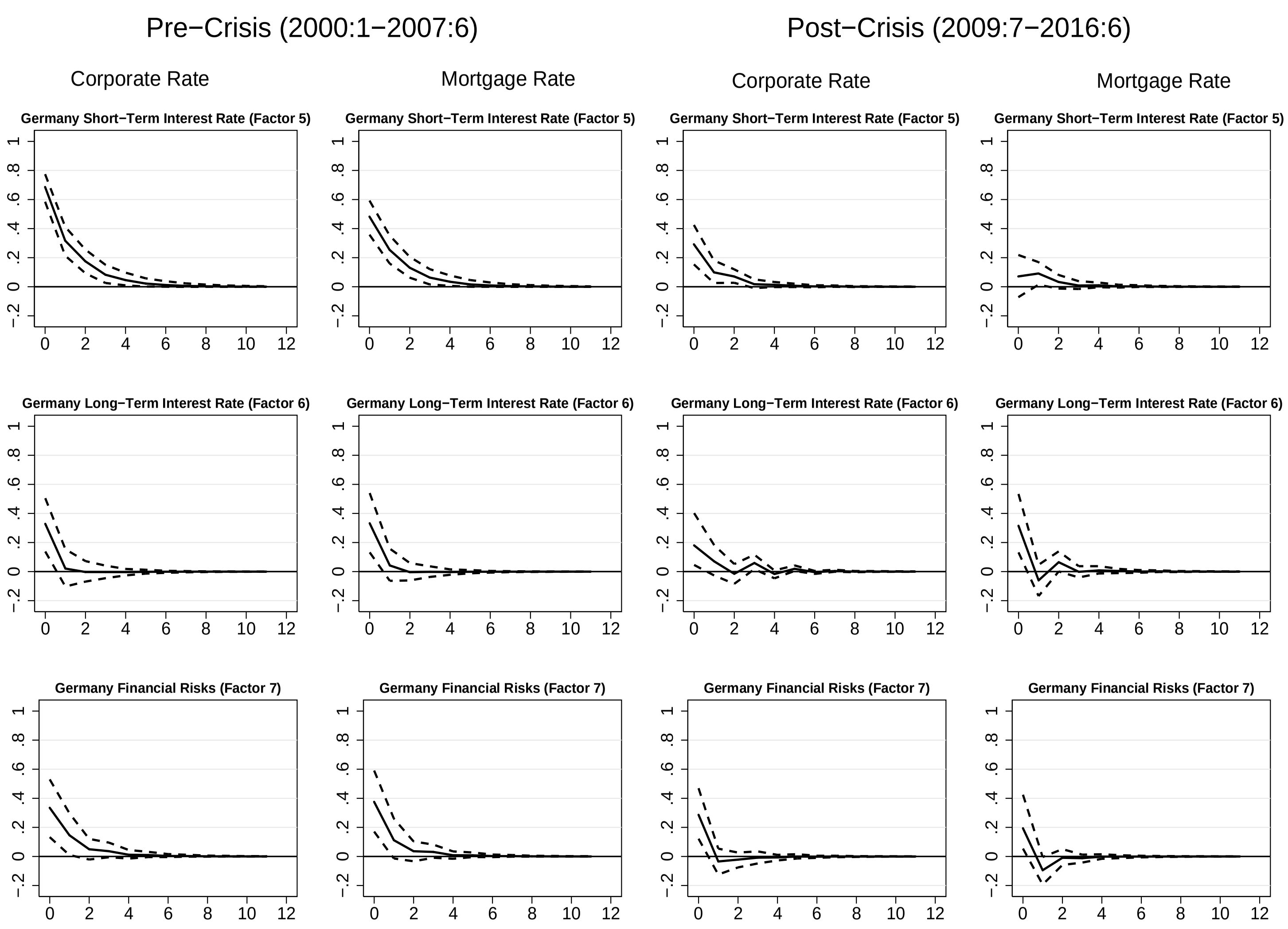
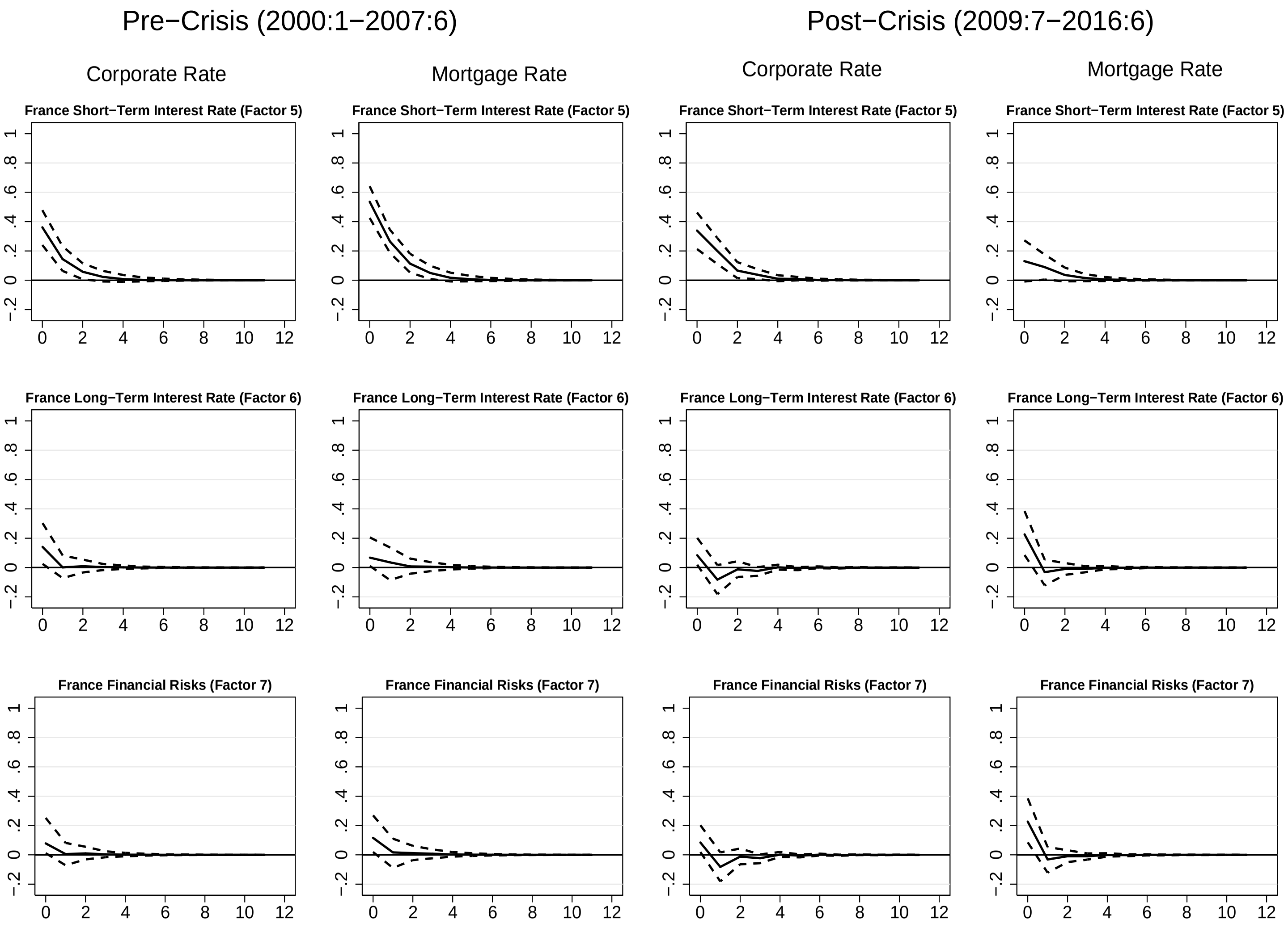


Figure 5: Impulse responses of lending rates to shocks in Factors 5-7, Germany



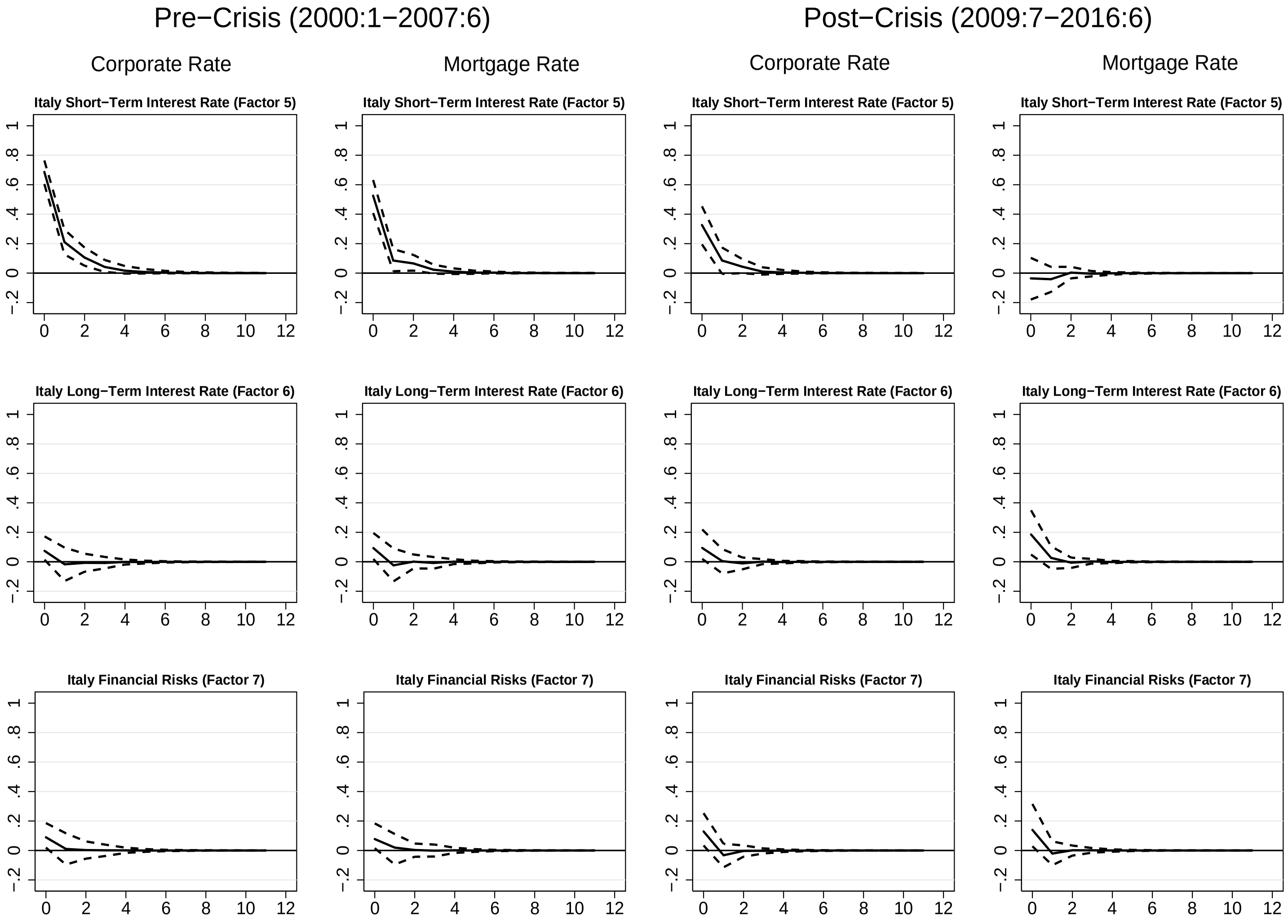
(Dashed lines represent 16 and 84 percent quantiles of bootstrapped impulse responses)

Figure 6: Impulse responses of lending rates to shocks in Factors 5-7, France



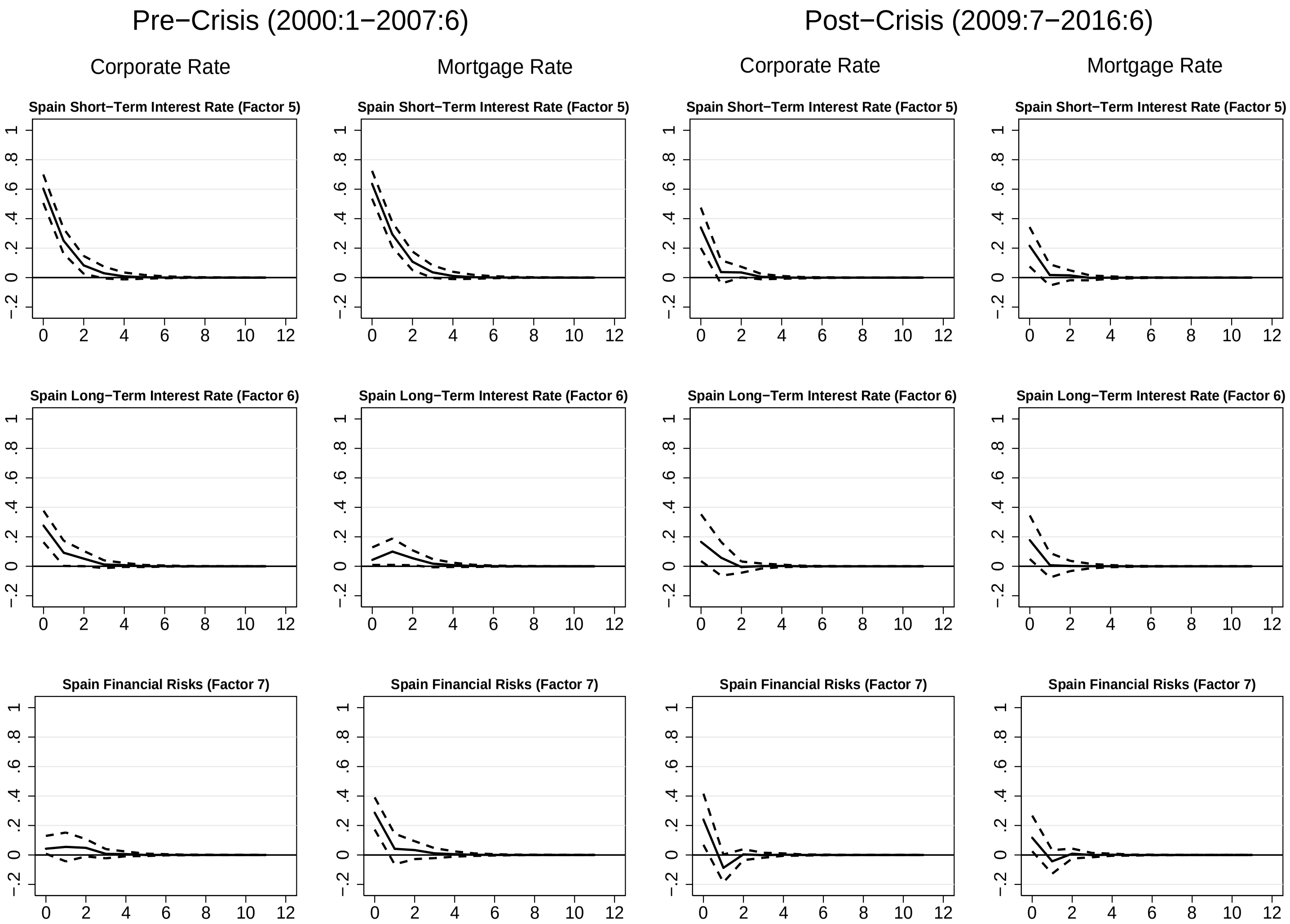
(Dashed lines represent 16 and 84 percent quantiles of bootstrapped impulse responses)

Figure 7: Impulse responses of lending rates to shocks in Factors 5-7, Italy



(Dashed lines represent 16 and 84 percent quantiles of bootstrapped impulse responses)

Figure 8: Impulse responses of lending rates to shocks in Factors 5-7, Spain



(Dashed lines represent 16 and 84 percent quantiles of bootstrapped impulse responses)

Figure 9: Forecast Error Variance Decomposition, Factors 5-7, Germany

Pre-Crisis (2000:1-2007:6) Post-Crisis (2009:7-2016:6)

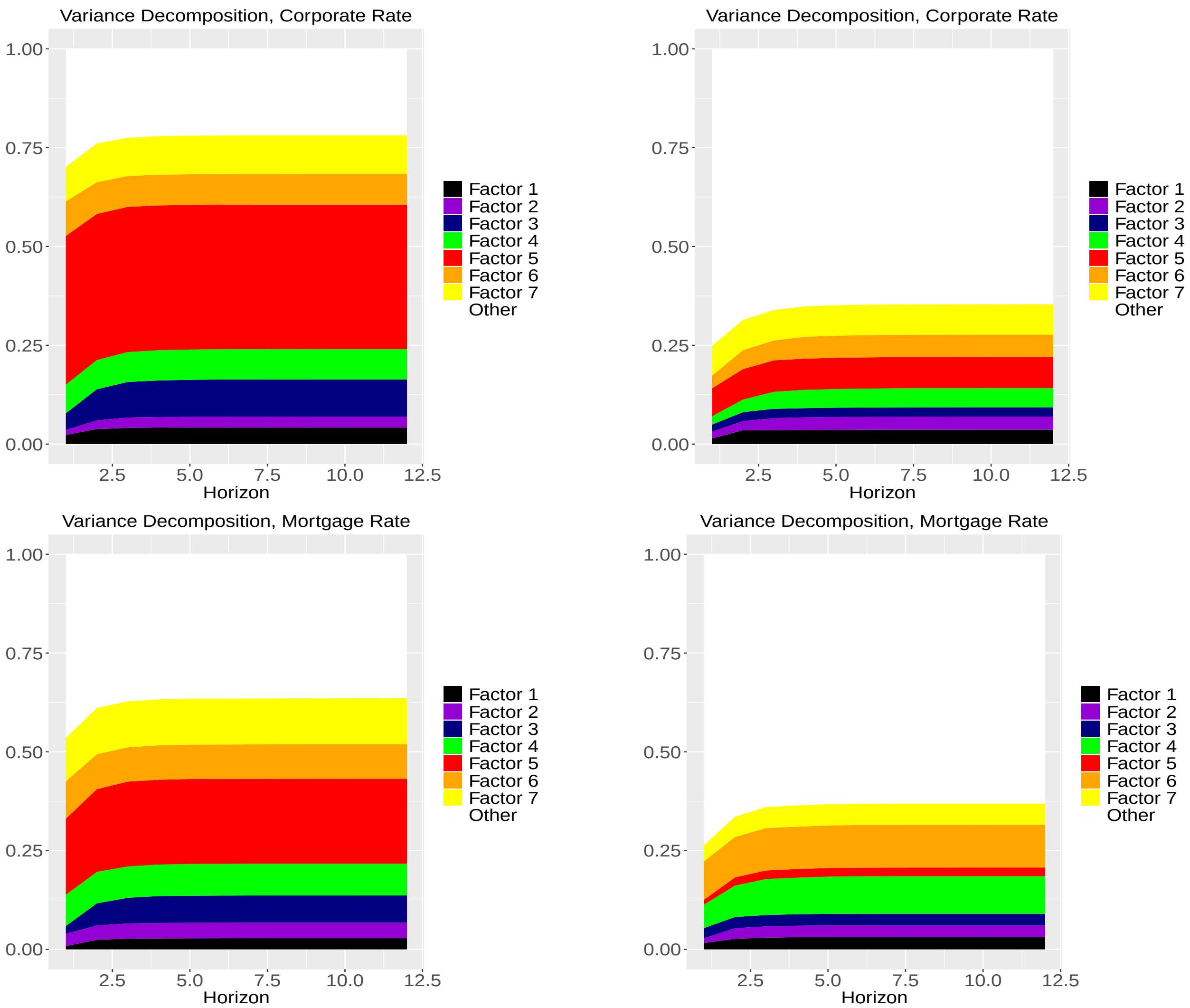


Figure 10: Forecast Error Variance Decomposition, Factors 5-7, France

Pre-Crisis (2000:1-2007:6) Post-Crisis (2009:7-2016:6)

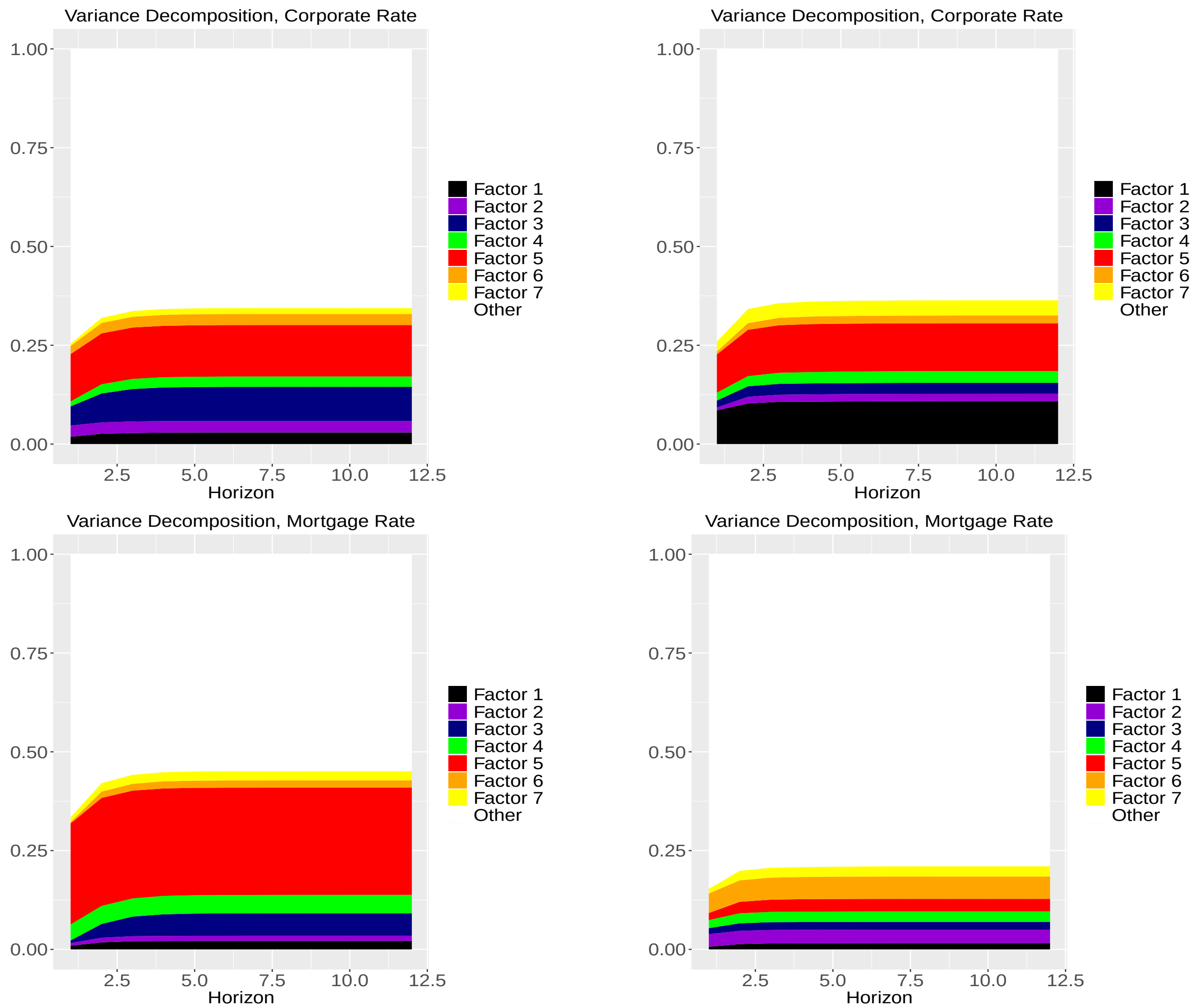


Figure 11: Forecast Error Variance Decomposition, Factors 5-7, Italy

Pre-Crisis (2000:1-2007:6)

Post-Crisis (2009:7-2016:6)

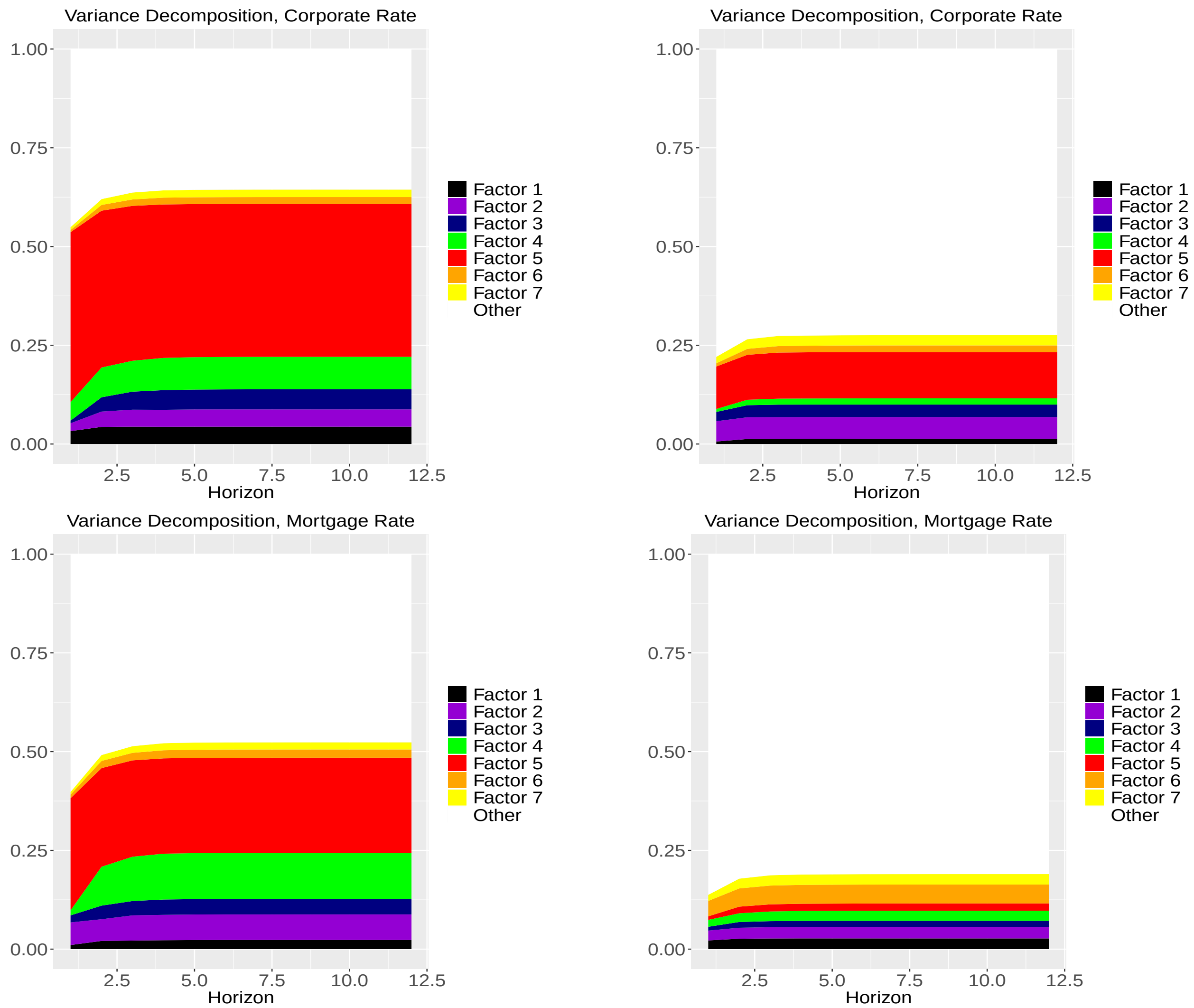


Figure 12: Forecast Error Variance Decomposition, Factors 5-7, Spain

Pre-Crisis (2000:1-2007:6) Post-Crisis (2009:7-2016:6)