Online Appendices for 'Business Cycle Implications of Mortgage Spreads'

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A Appendix with additional results and interpretation

A1. Parameter uncertainty in baseline specification

The second and third column of Table A.1 documents the uncertainty in the estimated elasticities.

Variable	Median	68% band (84%, 16%)	90% band (95%, 5%)
Consumption	-1.6	(-1.0,-2.3)	(-0.5,-2.9)
Residential investment	-6.2	(-1.9,-10.8)	(0.9,-14.5)
GDP	-1.9	(-1.2,-2.7)	(-0.8,-3.2)
Policy rate	-1.8	(-1.5,-2.2)	(-1.3,-2.5)
House prices	-2.6	(-1.5,-3.8)	(-0.8,-4.6)

Table A.1: Elasticity of variables to mortgage spread shocks. Computed as max (response of variable)/standard deviation of shock. Baseline specification. US 1983q1-2011q4.

To complement the point estimates in Table 4, Figure A.1 documents the uncertainty in the variance decomposition by showing the 68 percent and 90 percent probability intervals, in addition to the median estimates.

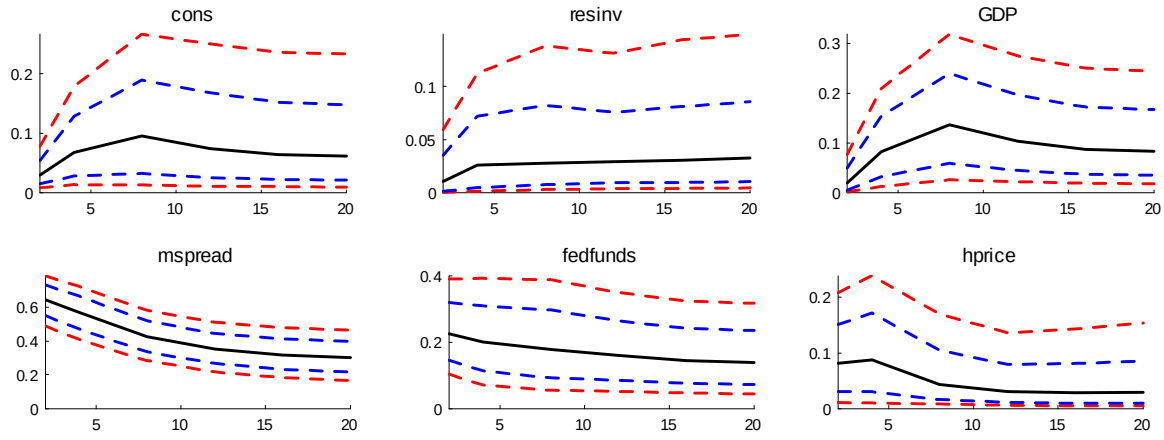

Figure A.1: Variance decomposition including median, 68% and 90% probability intervals. US 1983q1-2011q4.

A2. Monetary policy shocks in baseline specification

For comparison, we display the variance contribution of monetary policy shocks in Table A.2. Compared to mortgage spread shocks (documented in Table 4), monetary policy shocks explain less of the variance in GDP for horizons up to 12 quarters, and in house prices at

the shortest horizons. For the remaining aggregate quantities and horizons, monetary policy shocks are more important than mortgage shocks.

Variable \ Horizon in quarters	2	4	8	12	16
Consumption	6	6	10	13	16
Residential investment	5	8	17	20	20
GDP	2	3	4	10	14
Mortgage spread	1	4	6	7	8
Policy rate	37	31	26	24	23
House prices	3	6	16	22	24

Table A.2: Variance decomposition - fraction of variance, in percent, explained by monetary policy shock. US 1983q1-2011q4. Median.

A3. Detailed international results

A3.1. Results for the UK

In Figure A.2, we plot the impulse responses for a shock to the mortgage spread in the UK. The results are similar to the corresponding IRF for the US in that we obtain a drop in all aggregate quantities, the policy rate and house prices. The 90 percent probability band of the responses is below zero for some quarters for all these variables, except for consumption. The strongest responses for residential investment and GDP occur after 2-4 quarters, considerably faster than in US. On the other hand, the policy rate response is slower: it reaches its trough after 5 quarters compared to 1 quarter for the US. In this context, it is worth recalling that mortgage maturities are substantially shorter in the UK (median maturity $\approx$ 2 years) than in the US, which could explain the faster macroeconomic impact of spread shocks.

Note that the standard deviation of the UK mortgage spread shock, 36 bps, is twice as large as in the US. This is the reason that the amplitudes of the IRFs are larger. Table A.3 documents elasticities to mortgage spread shocks for all three countries. Comparing the results to the US analogue, we note that the elasticity for consumption and the policy rate in the UK are lower by roughly a factor two. GDP also has a slightly lower elasticity than in the US. Residential investment and house price elasticities are similar in the US and the UK. Given the stronger policy rate response in the US, it appears that the larger US elasticities for aggregate quantities are not due to differences in monetary policy. Theoretically, we would expect that the shorter maturity of mortgages in the UK (and Sweden) compared to the US induces faster and stronger impact of mortgage spread shocks on consumption and other variables. We do find a faster response in UK and Sweden. But the elasticity of consumption to mortgage spread shocks is highest in the US. The reason for this cross-country relationship is probably institutional differences. E.g. it is easier and cheaper to obtain home equity lines of credit in the US.

Regarding the monetary policy shock (not plotted), the spread has an elasticity of 0.3 and remains positive for many years. The entire 90 percent probability interval is above zero

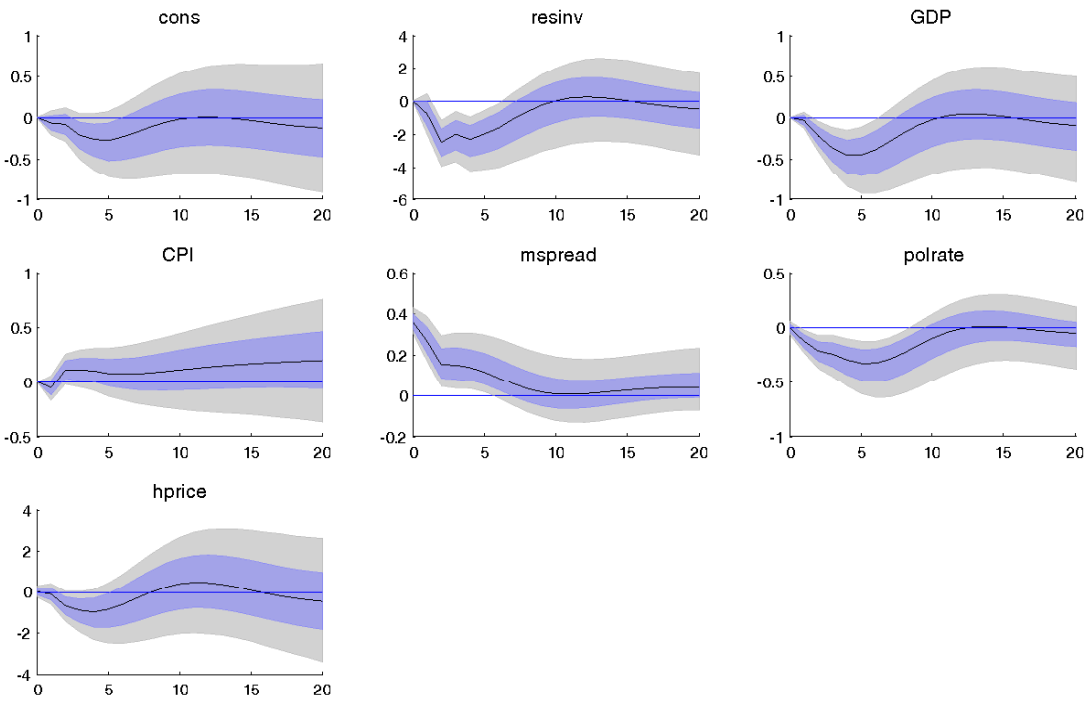

Figure A.2: IRF to mortgage spread shock. UK 1995q1-2011q4. See Figure 3 for units etc.

for short horizons. In other words, the spread dynamics appear to amplify the monetary transmission mechanism. This is in line with a "balance sheet channel" for housing.

Variable	US	UK	Sweden
Consumption	-1.6	-0.8	-1.2
Residential investment	-6.2	-6.9	-18.1
GDP	-1.9	-1.3	-2.7
Policy rate	-1.8	-0.9	-0.7
House prices	-2.6	-2.7	-7.2

Table A.3: Elasticity of variables to mortgage spread shocks. Computed as max (response of variable)/standard deviation of shock. Median.

In Table A.4, we document the importance of the spread shock in terms of variance decomposition for the UK. We note that the shock is more important in the UK than in the US. This difference is most pronounced for residential investment. The exception is consumption for which the spread shock is less important in the UK. This is consistent with the lower elasticity of UK consumption to spread shocks reported above. As in the US, the policy rate is the variable most affected by the mortgage spread shock.

Figure A.3 documents the historical decomposition for the UK.

To summarize the UK results, we find that mortgage spread shocks play an important role for some business cycle variables. Compared to the US, the key difference is the faster effect from the mortgage shock on residential investment and GDP. The volatility of the UK mortgage shock is higher than in the US, but the effect of a unit-sized shock on aggregate variables is smaller. Related to the higher volatility and the faster effect, the mortgage spread shock is more important in the UK in terms of variance decomposition.

Variable \ Horizon in quarters	2	4	8	12	16
Consumption	2	5	7	7	8
Residential investment	15	23	22	20	18
GDP	5	15	17	15	14
Mortgage spread	68	61	52	47	43
Policy rate	12	21	32	29	28
House prices	5	8	7	8	8

Table A.4: Variance decomposition - fraction of variance, in percent, explained by mortgage spread shock. UK 1995q1-2011q4. Median.

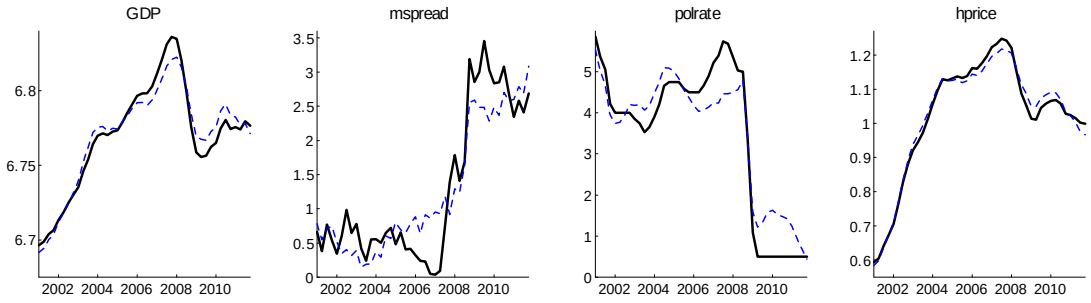

Figure A.3: UK 2001q1-2011q4. Historical decomposition. Solid line is data, dashed line time series where mortgage spread shock is turned off.

A3.2. Results for Sweden

The mortgage shock IRFs for Sweden are plotted in Figure A.4 and the elasticities to the mortgage spread shock are reported in the last column of Table A.3.[25] The results are quite similar to the US and the UK: a gradual drop in all aggregate quantities, the policy rate and house prices. The entire 90 percent probability band of the responses is below zero for some quarters for all these variables, except for consumption and the policy rate. The peak responses for residential investment and GDP occur with roughly the same speed as in the US, that is, after approximately one year. The two notable differences in the dynamics

[25] For Sweden, we impose stationarity of the VAR dynamics using a Gibbs sampler, as the impulse response functions otherwise are explosive for any lag length above 1.

are that the mortgage spread itself is more persistent and that the policy rate adjusts by less than half as much as in the US. Given these two characteristics, it is not surprising that all variables, except consumption, respond more and remain depressed for a longer time. Differences are largest for residential investment and house prices that respond almost three times as much in Sweden. Put differently, the Swedish responses are very similar to the US responses when the monetary policy rate is held fixed (see the second column of Table 3).

Switching to the monetary policy shock (not plotted), the mortgage spread has an elasticity of 0.3 and is positive at all horizons, which differs from the US dynamics but is very similar to the UK.

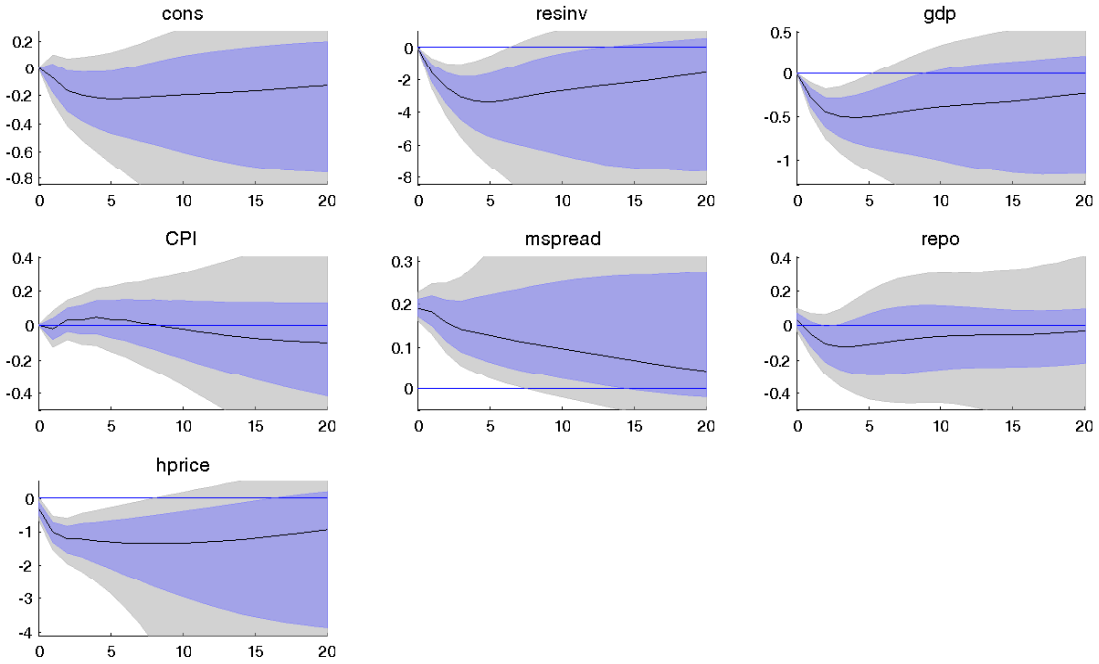

Figure A.4: IRF to mortgage spread shock. Sweden 1995q1-2011q4. See Figure 3 for units etc.

In Table A.5, we display the variance decomposition for Sweden. Residential investment is explained by mortgage shocks to a higher degree than in the US, and very similarly to the UK. For GDP and house prices, the mortgage shock is more important in Sweden than in either the US or the UK. The opposite is true for the policy rate, where the mortgage shock is less important in Sweden.

Figure A.5 documents the historical decomposition for Sweden.

To summarize the results for Sweden, the mortgage spread shock is more persistent and the policy rate offsets it less than in the US or in the UK. Thus, the remaining variables react more strongly and the effects are more long-lasting. These differences are largest for residential investment and house prices.

Variable \ Horizon in quarters	2	4	8	12	16
Consumption	3	7	10	12	14
Residential investment	13	22	25	24	25
GDP	14	21	19	18	19
Mortgage spread	55	48	42	39	38
Policy rate	3	5	10	12	14
House prices	26	29	27	26	26

Table A.5: Variance decomposition - fraction of variance, in percent, explained by mortgage spread shock. Sweden 1995q1-2011q4. Median.

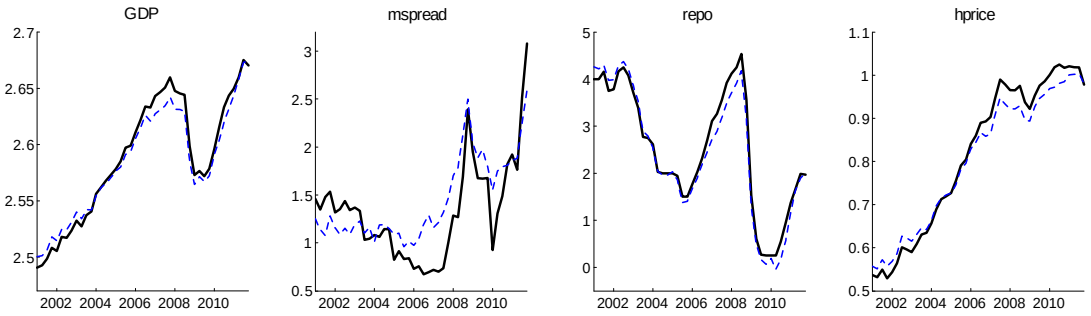

Figure A.5: Sweden 2001q1-2011q4. Historical decomposition. Solid line is data, dashed line time series where mortgage spread shock is turned off.

A4. Additional tables for robustness exercises documented in the body of the paper

	Restriction	Horizon
Mortgage spread	+	1-2 quarters
House prices	-	1-2 quarters
Policy rate	-	1-2 quarters
GDP,Cons,Resinv	0	Infinity

Table A.6: Sign and zero restrictions imposed to identify mortgage supply shock.

A5. Further robustness exercises

A5.1. Allowing fewer contemporaneous effects of the mortgage shock

To document the sensitivity of the results to the recursive ordering, we set up an alternative specification, reordered so that the mortgage spread is not allowed to affect the policy rate contemporaneously.[26]

[26]Note that there are strong economic arguments to let the mortgage spread shock affect the policy rate contemporanously, i.e. in favor of our baseline identification. It is instead the identification of the

Variable \ Horizon in quarters	2	4	8	12	16
Consumption	12	13	13	11	10
Residential investment	7	7	6	6	6
GDP	7	12	14	12	11
Mortgage spread	9	11	13	13	13
Policy rate	7	7	9	9	9
House prices	13	12	7	6	6

Table A.7: Variance decomposition - fraction of variance, in percent, explained by mortgage spread shock, sign restriction specification. US 1983q1-2011q4. Median.

The impulse responses for a mortgage spread shock for this specification are documented in Figure A.6. All aggregate quantities respond more strongly than in our baseline specification while the federal funds rate offsets the mortgage spread shock substantially less. For detailed quantification, see the elasticities in the second column of Table A.8. Compared to our baseline specification, we note the largest increase in elasticity for residential investment and house prices. For GDP, the elasticity is only marginally increased. The policy rate elasticity is half as large as for the baseline specification.

We also note that the monetary policy shock IRFs for aggregate quantities (not plotted) have a lower amplitude and are statistically weaker when this shock is allowed to affect the spread contemporaneously. Finally, the monetary policy shock effect on the mortgage spread is initially negative but of negligible size.

Finally, we note a tendency for increased importance of the mortgage spread shock in this specification also in terms of variance decomposition, as documented in Table A.9. This is closely related to the decreased responsiveness of the policy rate to the mortgage spread shock.

We also computed the IRF of a mortgage spread shock using an identification scheme where the mortgage spread shock is not allowed to affect any other variable contemporaneously (not plotted), i.e. not even house prices. Effects on all variables except house prices are approximately unchanged compared to the results documented in this subsection. Effects on house prices are substantially smaller, approximately zero. But it is hard to justify this ordering as mortgage rates are publicly observed and theoretically relevant within the quarter for house prices.

A5.2. Subsample excluding ZLB period

In this robustness exercise, we end the sample in 2008q2 to avoid dynamics what may be specific to the financial crisis as well as any potential econometric problems induced by the ZLB binding from the end of 2008 onwards.[27] An additional reason to exclude the crisis period is that one might think that it is characterized by non-linear relationships not well captured by a (linear) VAR, although we have established using simple diagnostics (not

monetary policy shock that is debatable as the assumption of no contemporanous effect on mortgage spread is questionable.

[27] We also excluded the entire financial crisis period, i.e. 2007q1 onwards, and obtained very similar results.

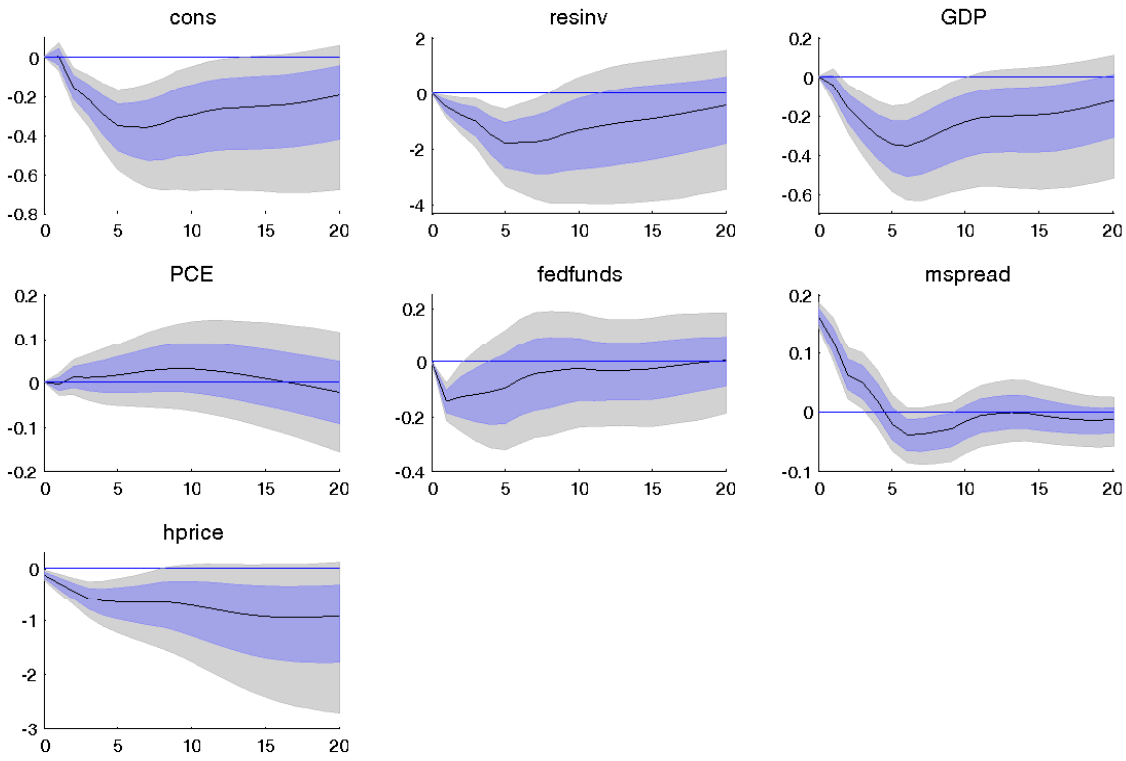

Figure A.6: IRF to mortgage spread shock. VAR specification where the federal funds rate is ordered before the mortgage spread. US 1983q1-2011q4. See Figure 3 for units etc.

reported here) that effects of mortgage spread shocks do not appear non-linear in the size of the shock. In a general sense, unconventional monetary policy such as the LSAP programs can be considered endogenous. One might therefore question our assumption of exogenous mortgage spread innovations. Yet, this problem is limited by our identification strategy as only mortgage spread movements that are orthogonal to current and lagged aggregate quantities are identified as mortgage spread innovations. Accordingly, we do not think that the financial crisis period should be excluded because of endogeneity issues affecting the identification, nor because of concerns related to non-linear dynamics.

The impulse responses for the subsample are documented in Figure A.7. The standard deviation of the mortgage spread shock is marginally lower than for the full sample; 17 bps instead of 18 bps. The most striking difference is the decreased precision in the estimates represented by the widening of the probability bands. Importantly, the mortgage spread itself overshoots more in the subsample estimation. The responses of residential investment and house prices are noticeably reduced. Elasticities are documented in the third column of Table A.8. Compared to the full sample results, these elasticities are generally lower. Only the policy rate elasticity remain unchanged. The elasticity of GDP and consumption is reduced by one half.

Variable	Baseline	FFR before mspread	Subsample	Subsample w. corp. spread
Consumption	-1.6	-2.2	-0.8	-2.3
Residential investm.	-6.2	-11	-3.5	-8.2
GDP	-1.9	-2.2	-0.9	-2.2
Policy rate	-1.8	-0.9	-1.8	-1.3
House prices	-2.6	-4.3	-0.8	-4.1

Table A.8: Elasticity of variables to mortgage spread shocks. Various VAR specifications. Computed as max (response of variable)/standard deviation of shock. US 1983q1-2011q4, except subsample that ends 2008q2. Median.

Variable \ Horizon in quarters	2	4	8	12	16
Consumption	4	10	16	14	13
Residential investment	3	6	9	7	6
GDP	3	10	16	14	13
Mortgage spread	54	46	36	29	26
Policy rate	4	4	5	5	5
House prices	10	13	10	8	8

Table A.9: Variance decomposition - fraction of variance, in percent, explained by mortgage spread shock. VAR specification with the federal funds rate ordered before the mortgage spread. US 1983q1-2011q4. Median.

We also analyzed robustness in terms of lag length for the subsample. We find that for lag lengths longer than 4, the affected variables have more persistent declines and higher elasticities (not reported).[28]

Subsample and corporate spread combined We also present results for the subsample in a specification where we include a corporate spread, i.e. combining two of the above robustness exercises. The IRFs are reported in Figure A.8 and elasticities in the last column of Table A.8. In terms of elasticity point estimates, results are similar to our baseline specification and the full sample specification with a corporate spread. The key difference is that this specification has less precise estimates in that only for consumption and the federal funds rate are the 90 percent probability bands entirely below zero. The propagation is also slower than in the baseline specification. If we instead compare this specification to the subsample estimation without a corporate spread, we note that adding a corporate spread to the VAR yields much larger mortgage shock effects, with the exception of the policy rate response.

[28] Shorter lag lengths than 4 appear unsuitable as we then obtain large coefficients on the third lag and oscillating dynamics.

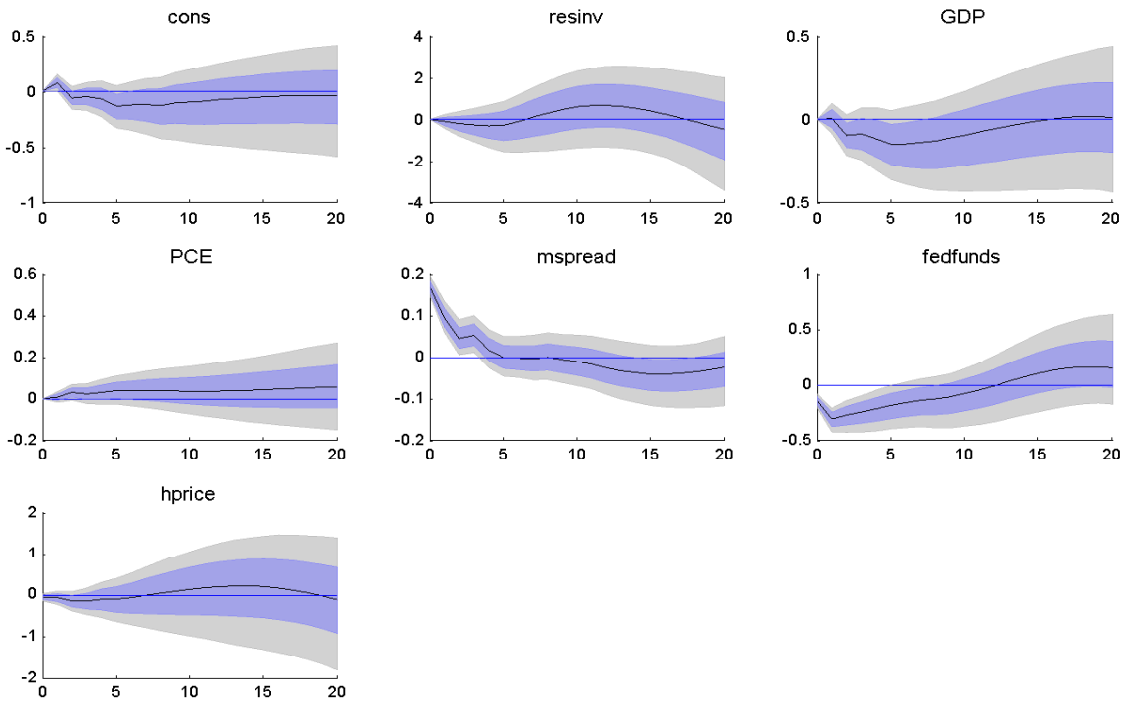

Figure A.7: IRF to mortgage spread shock. US subsample 1983q1-2008q2. See Figure 3 for units etc.

A5.3. Number of lags

As mentioned previously, the appropriate lag length is unclear. It is therefore important to demonstrate the robustness of the results to the number of lags.

The results are virtually unchanged using 5 lags. Impulse responses (not plotted) are visually identical, except that i) the GDP trough is reached after 6 quarters instead of 5 and ii) the precision in the IRF for residential investment is slightly reduced such that the decrease is only clear for the 68 percent probability band. We provide the elasticities for the 5-lag specification in the third column of Table A.10 to document how minor the differences are. Compared to our baseline 4-lag specification, elasticities are generally marginally larger in this specification.

For the 6-lag specification the impulse responses (not plotted) are visually identical to the baseline specification except that the precision of estimates is slightly reduced. The 6-lag elasticities shown in the fourth column of Table A.10 confirm that the differences are small.

The variance decomposition for the 5-lag specification in Table A.11 provides essentially the same picture. According to this specification, mortgage shocks are slightly more important than in our baseline specification. On the other hand, the 6-lag specification implies a slightly lower variance contribution (not reported) of the mortgage shock than in our baseline.

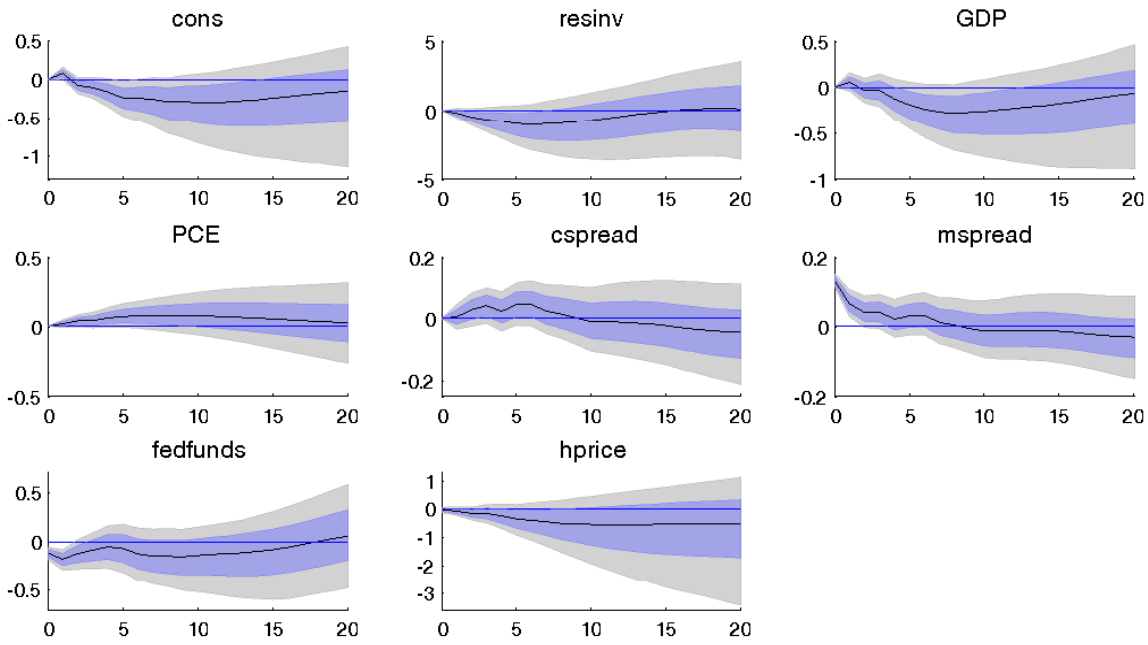

Figure A.8: IRF to mortgage spread shock. US subsample 1983q1-2008q2 with corporate spread. See Figure 3 for units etc.

B Data appendix

B1. Data definitions and sources

The macroeconomic data is taken from standard sources. The CPI price level is measured using core inflation indices where available: core PCE for US, CPIF for Sweden. For the US, the house price index is from Freddie Mac, FMHPI. For variables recorded at higher frequency than quarterly we use the end-of-period values for house prices and mortgage debt outstanding, and averages for interest rates.

B2. Detailed cross-correlations between mortgage spread and GDP

B3. Mortgage maturities and mortgage defaults in countries studied

The US is the country with the highest average fixed period of mortgage rates according to Campbell (2012). In an international comparison, it is also in the high end of mortgage defaults.

Towards the low end in Campbell's (2012) ranking of duration of mortgage contracts we find the UK and Sweden. UK mortgage maturities are approximately an equal fraction of i) variable rate and ii) between 1 and 5 years maturity, and a negligible fraction (<4 percent)

Variable	Baseline	5 lags	6 lags
Consumption	-1.6	-1.8	-1.8
Residential investment	-6.2	-6.1	-5.0
GDP	-1.9	-2.2	-2.1
Policy rate	-1.8	-2.0	-1.8
House prices	-2.6	-3.0	-3.1

Table A.10: Elasticity of variables to mortgage spread shocks. Computed as max (response of variable)/standard deviation of shock. Alternative specification with more lags. US 1983q1-2011q4. Median.

Variable \ Horizon in quarters	2	4	8	12	16
Consumption	3	7	12	10	8
Residential investment	1	2	3	3	4
GDP	2	8	16	12	10
Mortgage spread	62	53	38	32	29
Policy rate	25	21	18	16	14
House prices	10	11	6	4	4

Table A.11: Variance decomposition - fraction of variance, in percent, explained by mortgage spread shock. Alternative specification with 5 lags. US 1983q1-2011q4. Median.

of mortgages with longer maturities.[29] For Sweden, half of the mortgages are variable rate, a third are fixed up to 5 years and the remaining fraction are fixed at longer horizons (although a negligible fraction with above 8 years duration).[30] These maturity fractions are averages, but there is some time variation during the sample period.

An additional reason for including Swedish data is the low level of Swedish mortgage credit losses, which in turn is due to the legal framework with full recourse loans, strict personal bankruptcy rules and strong legal enforcement. Average residential credit losses during our sample period, 1995-2011, is less than 0.05 percent of the residential loan volume. In the 'Great Recession', Swedish residential mortgage credit losses peaked at 0.06 percent.

A similar tendency is present in the UK where mortgage holders have a personal responsibility for mortgage repayment, in addition to the lender's right to repossess the collateral. Accordingly, repossessions are unusual: they average approximately 0.1 percent of outstanding mortgages in quarterly rates and have not increased much in the recent crisis (UK Ministry of Justice, 2012, covering England and Wales). On the other hand, claims for repossessions are more frequent (average of roughly 0.25 percent) and vary more.

[29] Source: Bank of England, 'UK MFIs' (excluding central bank) distribution of balances within effective interest rates', Table G1.5. Sample period 2006q2-2011q4 due to data availability.

[30] Source: Sveriges Riksbank. Sample period 1996-2011.

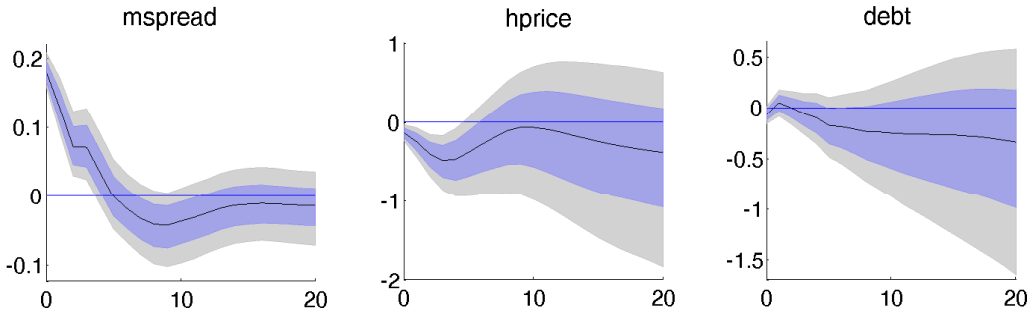

Figure A.9: IRF to mortgage spread shock of key variables for VAR specification with 8 variables: baseline plus the quantity of real mortgage debt outstanding. US 1983q1-2011q4. See Figure 3 for units etc.

	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6
HP-filter	-0.25	-0.34	-0.38	-0.41	-0.40	-0.32	-0.21	-0.06	0.08	0.17	0.21	0.24	0.19
CBO	-0.33	-0.38	-0.41	-0.42	-0.41	-0.38	-0.34	-0.22	-0.11	-0.04	0.02	0.05	0.01

Table B.1: Correlation between mortgage spread and GDP-gap, Corr(GDP(t), mspread(t+i)). GDP are in terms of deviation from HP-trend (first row) or Congressional Budget Office potential GDP (second row). Quarterly frequency. US 1983q1-2011q4.

B4. References specific to the Data appendix

Campbell, John, 2012, "Mortgage Market Design," mimeo based on keynote address to European Finance Association annual meeting 2011.

UK Ministry of Justice, 2012, "Mortgage and landlord possession statistics," www.justice.gov.uk/statistics/civil-justice/mortgage-possession.

C Statistical appendix

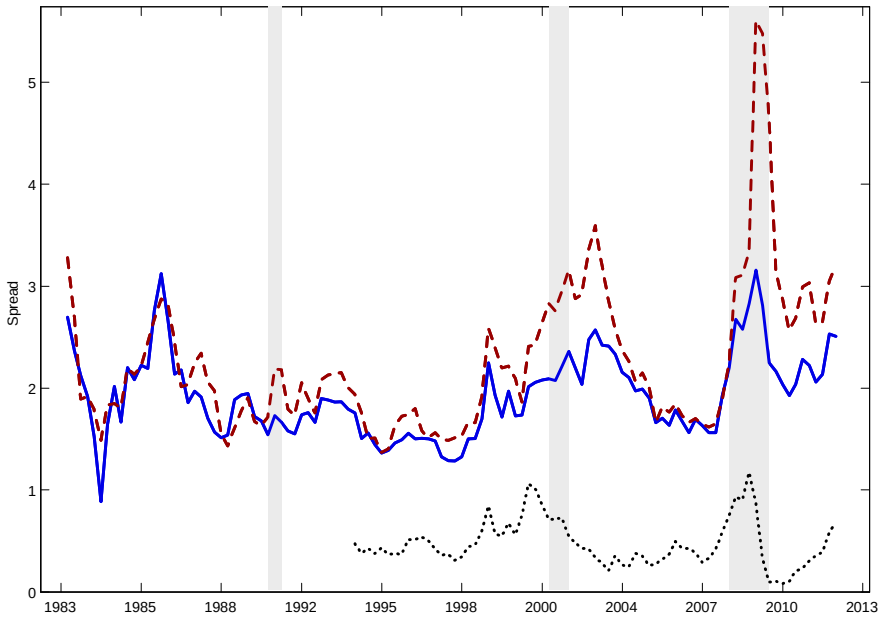

Figure C.1: Mortgage spread (solid line), corporate bond spread (dashed line), option-adjusted mortgage spread, "OAS" (dotted line) and NBER recession dates (shaded bars) The corporate spread is defined as the difference in the interest rates on Moody's Baa-rated seasoned corporate bonds and the 10-year Treasury bond. The OAS is Barclays' estimate of the current coupon 30-year agency MBS yield over the corresponding Treasury yield. US 1983q1-2011q4.

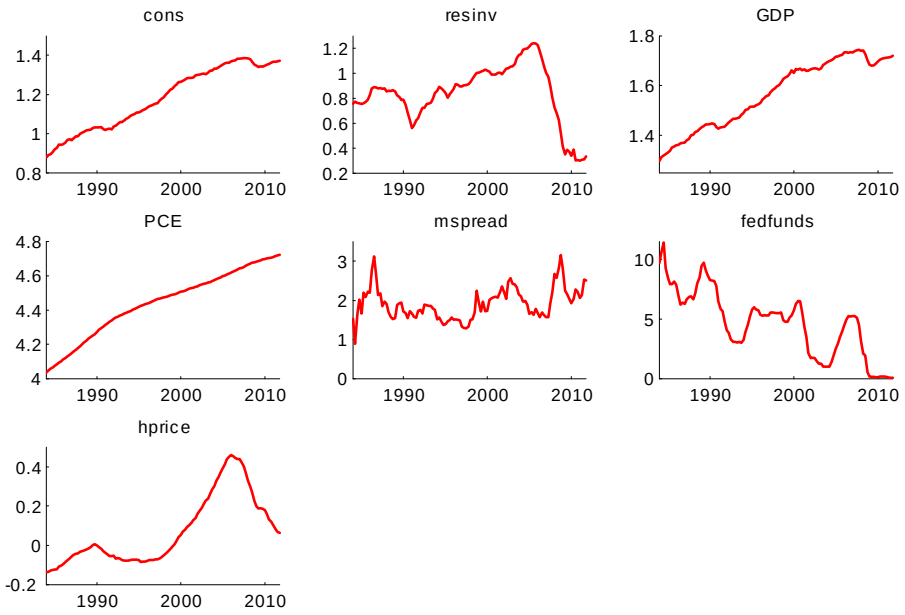

Figure C.2: US 1983q1-2011q4. Time series used in VAR.

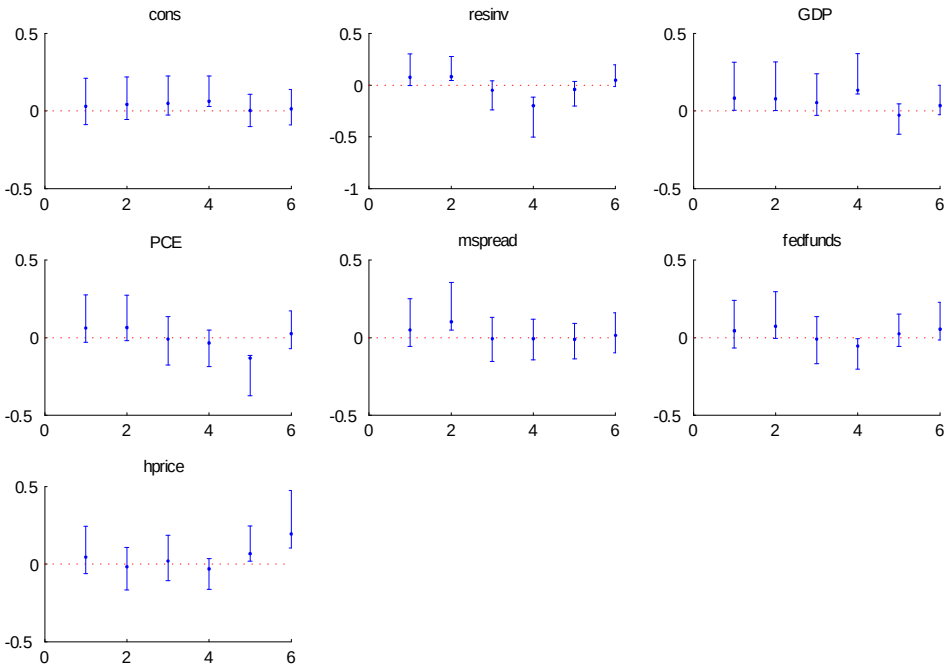

Figure C.3: US 1983q1-2011q4. Residual autocorrelation. Median and 90% probability band.

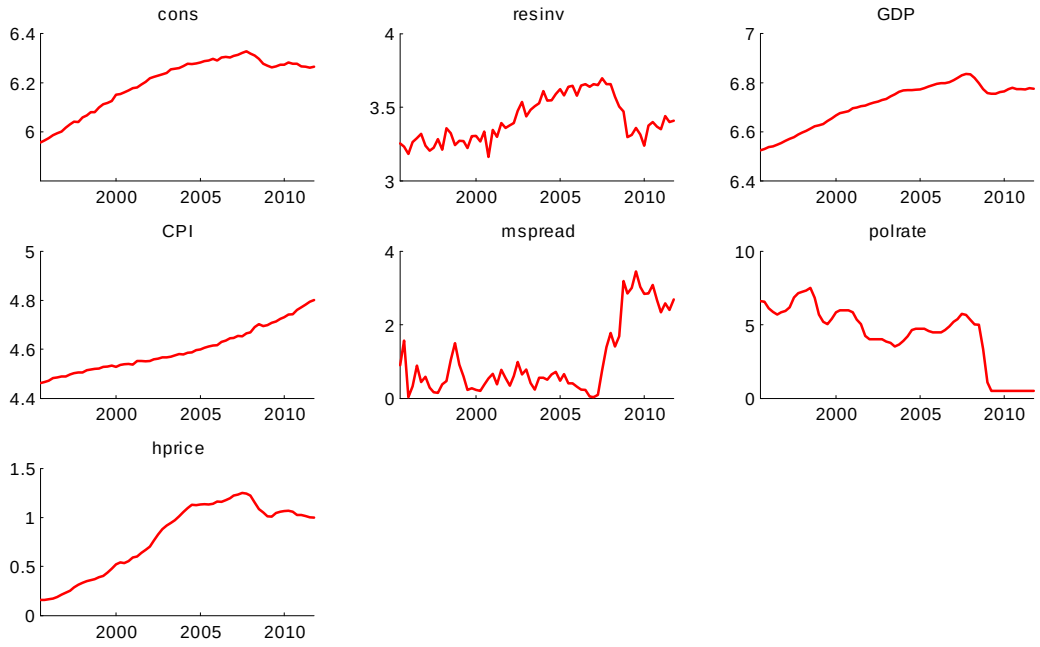

Figure C.4: UK 1995q1-2011q4. Time series used in VAR.

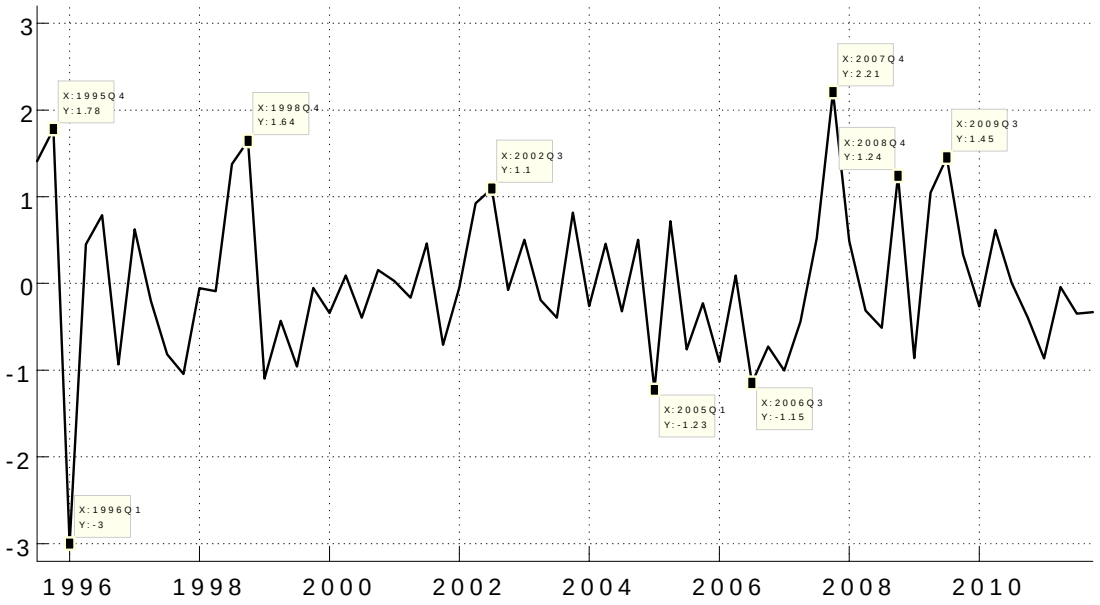

Figure C.5: UK 1995q1-2011q4. Mortgage spread innovations. Y-axis units are in terms of standard deviations. The standard deviation is 36 basis points.

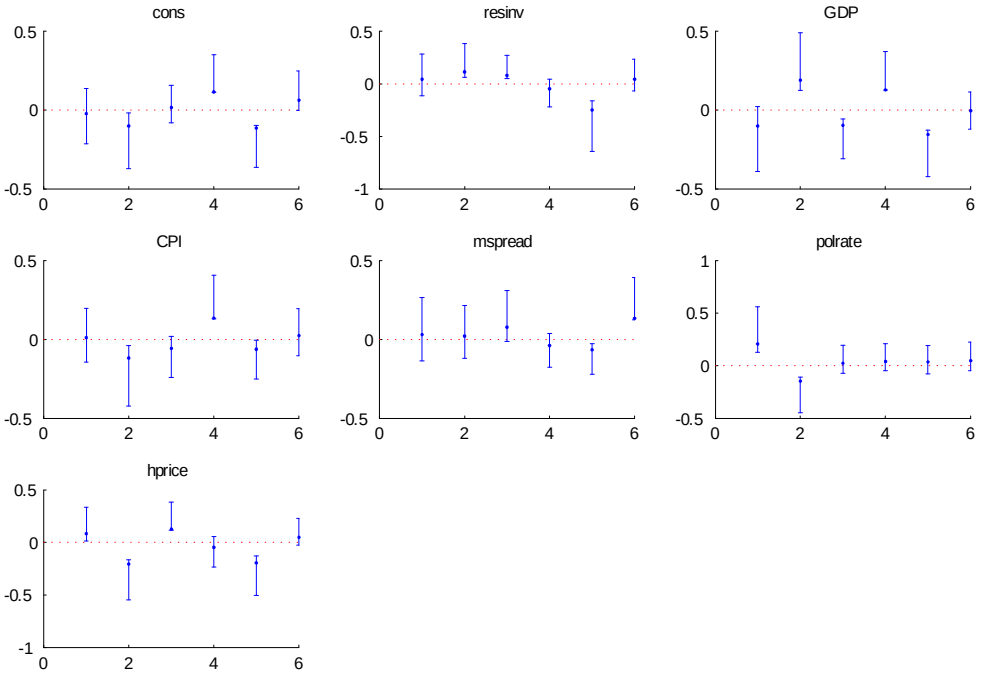

Figure C.6: UK 1995q1-2011q4. Residual autocorrelation. Median and 90% probability band.

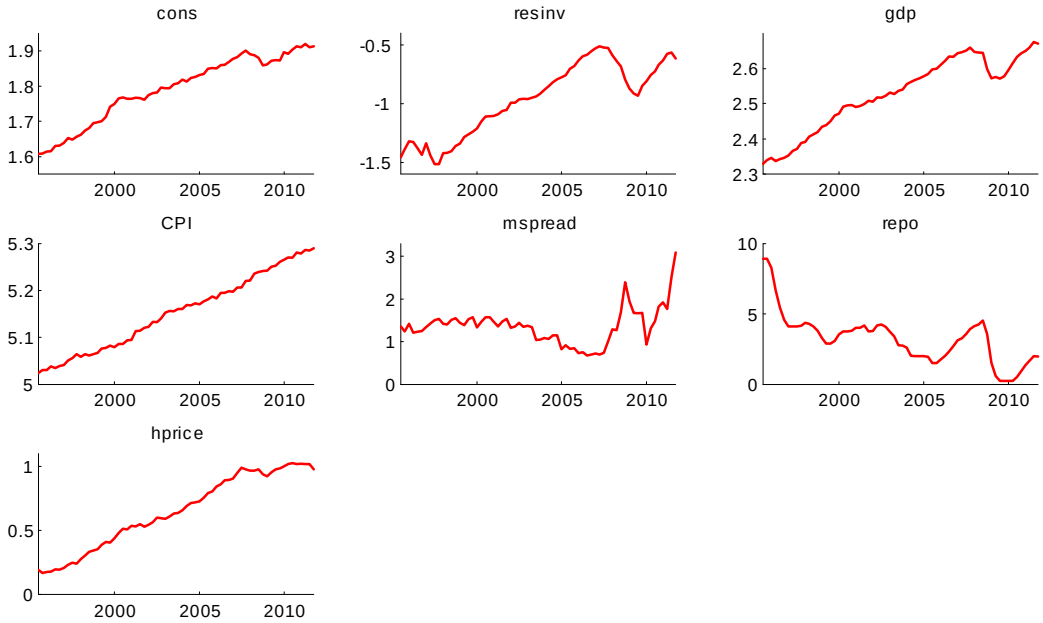

Figure C.7: Sweden 1995q1-2011q4. Time series used in VAR.

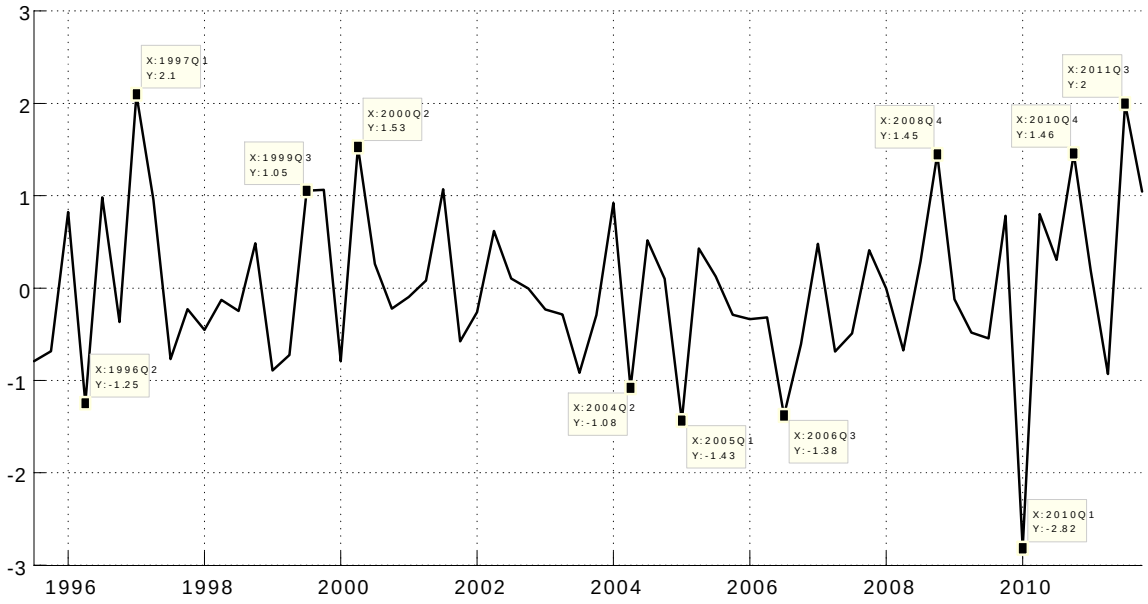

Figure C.8: Sweden 1995q1-2011q4. Mortgage spread innovations. Y-axis units are in terms of standard deviations. The standard deviation is 19 basis points.

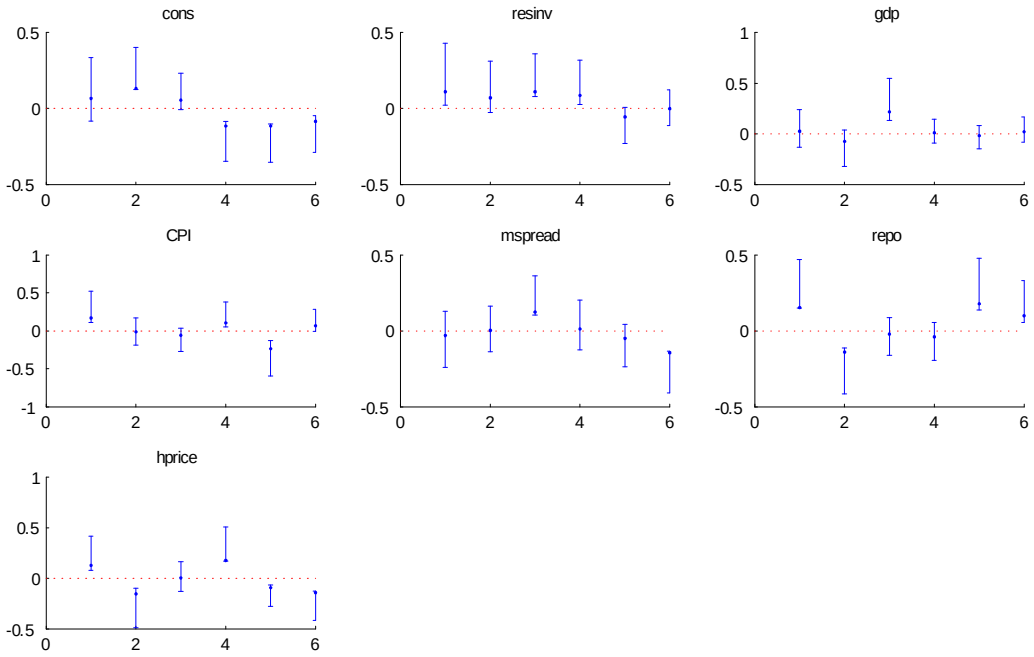

Figure C.9: Sweden 1995q1-2011q4. Residual autocorrelation. Median and 90% probability band.