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The determinants of private sector credit in industrialised countries: do property prices matter?

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Abstract

Episodes of boom and bust in credit markets have often coincided with cycles in economic activity and property markets. The coincidence of these cycles has already been widely documented in the literature, but few studies address the issue in a formal way. In this study we analyse the determinants of credit to the private non-bank sector in 16 industrialised countries since 1980 based on a cointegrating VAR. Cointegration tests suggest that the long-run development of credit cannot be explained by standard credit demand factors. But once real property prices, measured as a weighted average of real residential and real commercial property prices, are added to the system, we are able to identify long-run relationships linking real credit positively to real GDP and real property prices and negatively to the real interest rate. These long-run relationships may be interpreted as long-run extended credit demand relationships, but we may also capture effects on credit supply. Impulse response analysis based on a standard Cholesky decomposition reveals that there is significant two-way dynamic interaction between bank credit and property prices. We also find that innovations to the short-term real interest rate have a strong and significant negative effect on bank credit, GDP and property prices.

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1. Introduction[1]

Over the last two decades most industrial countries have experienced episodes of boom and bust in credit markets. These credit cycles have often coincided with cycles in economic activity and property markets. The coincidence of these cycles has already been widely documented in the policy-oriented literature (eg IMF (2000), BIS, (2001a)), but few studies assess the relationship between credit aggregates, economic activity and property prices in a formal way. In particular, the role of property prices has not been explored in any great detail. This paper attempts to partially fill this gap, by modelling the determinants of credit to the private non-bank sector as a function of economic activity, interest rates and property prices for a sample of 16 industrialised countries.[2]

Economic activity, interest rates and property prices may affect credit via both credit demand and supply channels. Economic conditions and prospects determine consumption and investment demand, and thus the demand for credit. On the other hand, changes in economic activity are reflected in firms' cash flow position and households' income. Cash flow and income determine the ability of firms and households to repay their debts, so that changes in economic activity may also affect the willingness of banks to extend credit. The state of economic activity may therefore also determine the supply of credit.

Financing costs, represented by market interest rates, have a negative effect on credit demand. When interest rates go up, loans become more expensive and loan demand is reduced. A monetary tightening, reflected by an increase in interest rates, may also induce banks to cut back credit supply. A reduction in credit supply may also arise from reduced creditworthiness of firms and households due to a deterioration in their financial positions following a monetary tightening (balance sheet channel of monetary transmission). A tightening of monetary policy, operated via open market sales by the central bank, may also drain reserves and thus loanable funds from the banking sector, which may also cause a reduction of loan supply (bank lending channel of monetary transmission).

Property prices may also affect both credit demand and credit supply. Property accounts for a substantial share of household assets, so that changes in property prices may have a significant wealth effect on credit demand. Since loans are often secured with real estate collateral, property prices may also have a significant effect on the borrowing capacity of the private sector. An increase in property prices increases the value of collateralisable assets and thus the creditworthiness of firms and households. As a result, banks are more willing to extend loans, so that the supply of credit to the private sector increases.

Thus, economic activity, interest rates and property prices may affect both credit demand and credit supply. The problem of identifying demand and supply effects in the analysis of credit aggregates is well known and is most likely one of the reasons why there are so few studies analysing the determinants of credit aggregates. Nevertheless, we still think that it is important to understand which factors drive the development of credit aggregates, even if it is not possible to clearly identify the demand and supply effects.[3]

Based on Johansen's (1988, 1991, 1995) approach to cointegration analysis we show that the long-run development of credit cannot be explained by standard credit demand factors, ie real GDP and the real interest rate. But once real property prices, measured as a weighted average of real residential and real commercial property prices, are added to the system, we are able to identify long-run relationships linking real credit positively to real GDP and real property prices and negatively to the real interest rate. Credit is found to adjust significantly to the cointegrating relationship, implying that there is a long-run relationship linking credit to GDP, property prices and interest rates.

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2 In the following we refer to credit to the private non-bank sector as private sector credit.

3 The identification problem could possibly be at least partly overcome if we were to model credit demand and credit supply simultaneously. We do not, however, attempt to explicitly model a credit supply function, since time series data on important credit supply factors, such as banking sector profitability or the degree of liberalisation and competition in banking markets, are not readily available.

The estimated error-correction models are then used to analyse dynamic interactions by computing orthogonalised impulse responses. The impulse responses are generally in line with our prior expectations. A rise in real GDP has a positive effect on lending and property prices, and increases in credit and increases in property prices trigger increases in output. The impulse responses also reveal that there is significant two-way dynamic interaction between bank credit and property prices. Increases in property prices boost lending and vice versa. We also find that innovations to the real interest rate have a strong and significant negative effect on credit, GDP and property prices. This finding raises the possibility that monetary authorities may be able to smooth financial cycles by timely and decisive action on interest rates in response to booms in property and credit markets. However, evidence of significant interest rate effects on credit, output and property prices only implies that central banks may have an instrument to control credit conditions. It does not guarantee that the instrument could be used to smooth financial cycles or that it is desirable to do so. Thus, the question of how central banks should respond to developments in credit and property markets remains an important open issue.[4]

The plan of the paper is as follows: in Section 2 we briefly review some stylised facts and the theoretical and empirical literature on the relationship between credit, economic activity and property prices. Section 3 describes the data. In Section 4 we outline the modelling strategy for the empirical analysis and present the results of the cointegration tests. Section 5 presents the results of the impulse response analysis, which is based on the models estimated in Section 4. Section 6 concludes.

2. Credit, economic activity and property prices

Credit markets in industrialised countries have gone through a process of profound liberalisation since the early 1980s.[5] Figure 1 shows that over the period 1980-98, private sector credit was characterised by on average rapid growth, reflected by upward trending credit-GDP ratios. Another remarkable feature of the development of credit markets over this period, which is also revealed by Figure 1, is the occurrence of pronounced financial cycles. Most industrial countries experienced sometimes violent boom and bust cycles in credit markets in the late 1980s and early 1990s. A comparison of the figures suggests that the severity of financial cycles was quite different across countries. In particular, the Nordic countries appear to have experienced especially large credit cycles. Cross-country comparisons are, however, complicated by the lack of standardised data for credit aggregates. Of particular importance are the coverage of credit aggregates and the treatment of non-performing loans (NPLs) in national credit aggregates. This second factor can be particularly important for countries that have experienced banking crises. One example of this can be seen in a comparison of the credit aggregates in the Nordic countries and Japan following the bursting of the late 1980s property boom. In the Nordic countries, credit aggregates fell significantly after the boom, while in Japan the decline was much more moderate (see Figure 1). One reason for this is that it took much longer to remove problem loans from banks' balance sheets in Japan than in the Nordic countries.[6]

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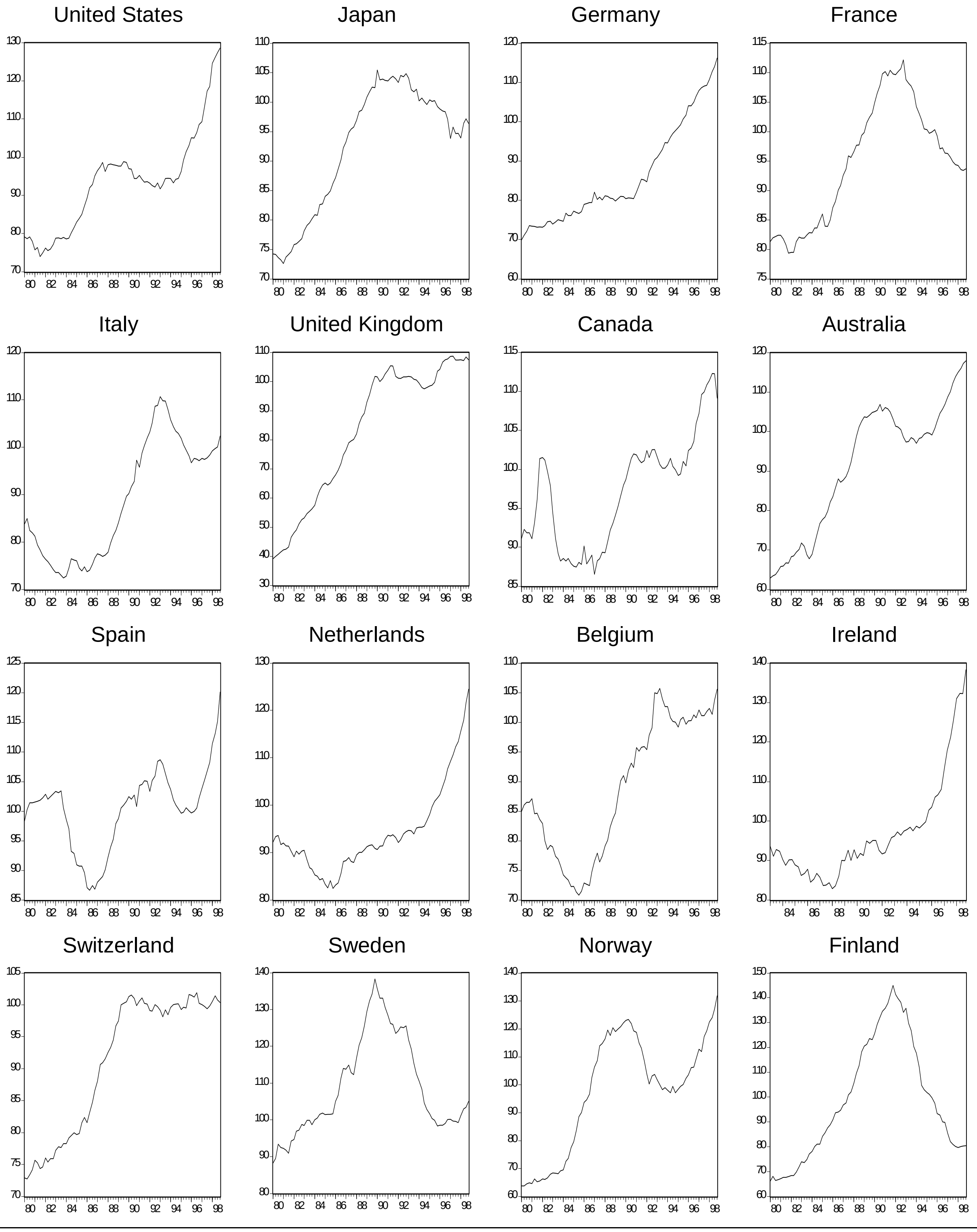
[4] Goodhart (1995) argues that the financial cycles of the late 1980s and early 1990s could have been avoided had central banks paid more attention to the development of property prices. He suggests that monetary policy should respond directly to movements in property prices. Cecchetti et al (2000) also come to the conclusion that a direct response of monetary policy to asset prices may help stabilising the economy. For a more sceptical view see Bernanke and Gertler (1999). A compilation of articles on the role of asset prices in the formulation of monetary policy in industrialised countries can be found in BIS (1998).

[5] See BIS (1999) for a compilation of articles reviewing the development of financial sectors in industrialised countries since the 1980s. A thorough description of the characteristics of credit markets in developed countries is provided by Borio (1996).

[6] For a more detailed discussion of this issue see BIS (2001b).

Figure 1

Credit-GDP ratios in industrialised countries 1980-98 (1995=100)



In many countries, financial cycles coincided with cycles in economic activity (BIS (2001a)). A comparison of the annual growth rates of real credit (DRDC, right-hand scale) and real GDP (DGDP, left-hand scale), shown in Figure 2, reveals that financial developments are procyclical. Episodes of strong credit expansion coincide with robust GDP growth, while slowdowns in credit growth are accompanied by downswings in economic activity. The coincidence of cycles in credit and economic activity may reflect adjustments of credit demand to changes in economic activity. Favourable economic conditions and prospects stimulate consumption and investment demand, thus increasing the demand for credit (Kashyap et al (1993)).[7]

A positive correlation between credit aggregates and economic activity may, however, also be explained from a credit supply perspective. Recent theoretical insights about the implications of asymmetric information in credit markets have motivated the development of business cycle models where credit plays an important role in shaping business cycles by propagating and amplifying productivity and monetary policy shocks.[8] In the standard real business cycle model and the standard Keynesian textbook IS-LM model, credit market conditions do not have any effect on macroeconomic outcomes. This result hinges on the assumption of frictionless credit markets. Following Brunner and Meltzer (1972), Bernanke and Blinder (1988) show that relaxing the assumption of perfect substitutability of loans and other debt instruments, such as bonds, gives rise to a separate macroeconomic role of credit in an otherwise standard textbook IS-LM model. Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) develop modified real business cycle models with informational asymmetries in credit markets. Because of these information asymmetries, firms and households are borrowing constrained and can only borrow when they offer collateral, so that their borrowing capacity depends upon their net worth. Since borrowers' net worth is procyclical,[9] the borrowing capacity of households and firms increases in economic upswings and decreases in downswings. An increase/decrease in credit availability stimulates/depresses economic activity, which in turn feeds back into borrowers' net worth, so that a self-reinforcing process evolves. This implies that credit is procyclical and amplifies business cycle fluctuations. The mutually reinforcing interaction between credit and economic activity is referred to in the literature as the ''financial accelerator''.[10]

The positive correlation between credit and economic activity may thus arise from the effect of changes in economic activity on credit demand and credit supply, but also from the effect of changes in the availability of credit on economic activity. Many economists argue that reduced credit supply played an important role in the propagation of the economic downswings of the early 1990s.[11] Financial factors are also held responsible for the particularly severe economic downturns in Japan and the Nordic countries. In these countries, the unwinding of the imbalances built up in the upswing of the financial cycle caused severe banking crises in the early 1990s. While the Nordic countries recovered during the 1990s, Japan continuous to labour under the heavy weight of a troubled financial sector.[12]

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[7] There are also arguments for a *negative* effect of economic activity on credit demand. If an economic expansion is expected to be transitory, households and firms may rather increase saving in order to smooth consumption. Also, in times of an economic upswing the cashflow position of firms is likely to improve, so that firms may switch from external to internal finance and thus reduce their borrowing (Bernanke and Gertler (1995)). The empirical evidence rather supports the view that economic activity has a positive effect on credit demand (Bernanke and Blinder (1988), Fase (1995), Calza et al (2001)).

[8] Early works focusing on the macroeconomic role of credit are Fisher (1933), Kindleberger (1973, 1978), Minsky (1964) and Brunner and Meltzer (1972). For a survey of this early literature see Gertler (1988).

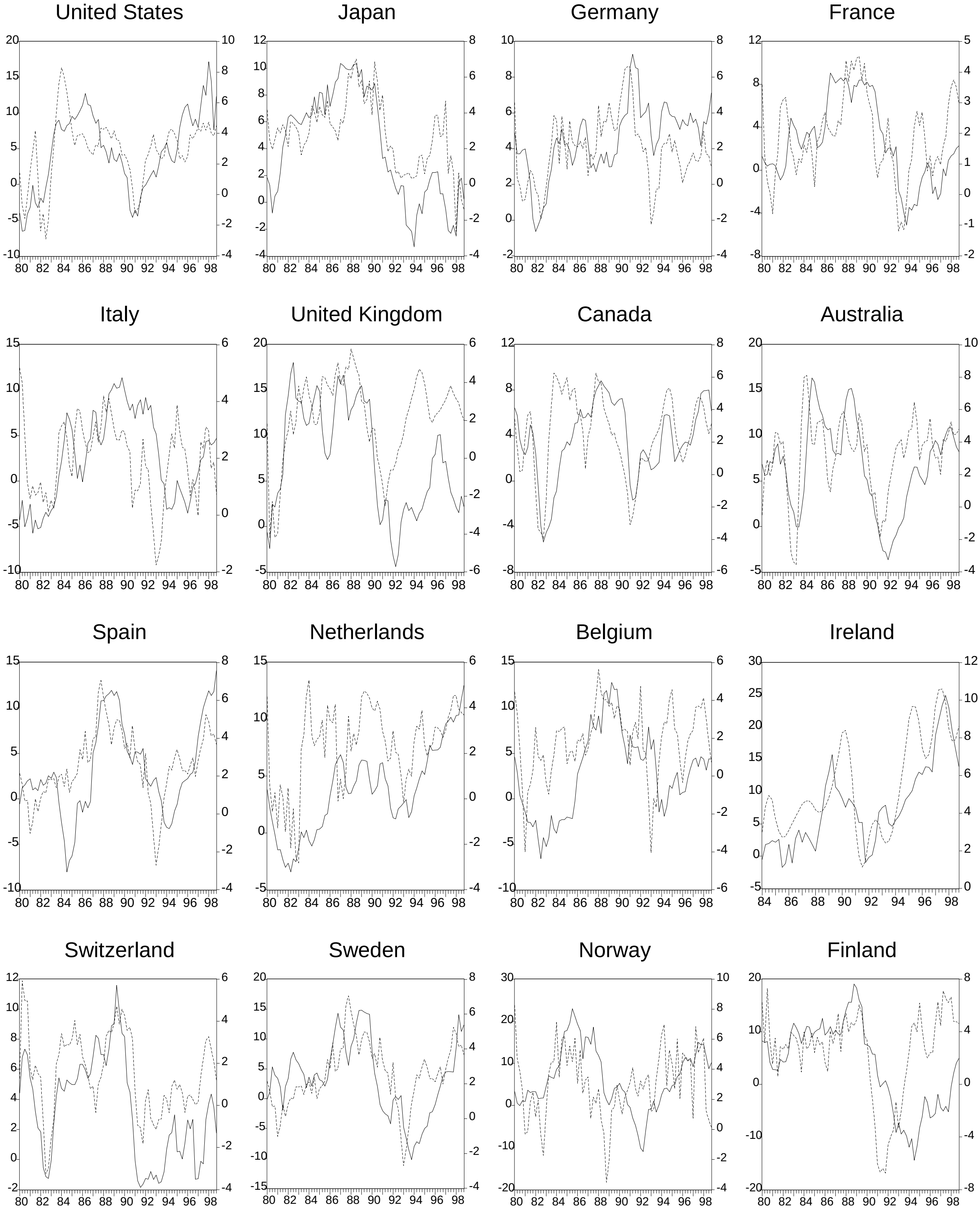
[9] Borrowers' net worth is procyclical because firms' cashflow positions and household income, and the value of collateralisable assets, are positive functions of real output.

[10] For a survey of the literature on the ''financial accelerator'' mechanism see Bernanke et al (1998).

[11] See eg Bernanke (1993) and Friedman and Kuttner (1993).

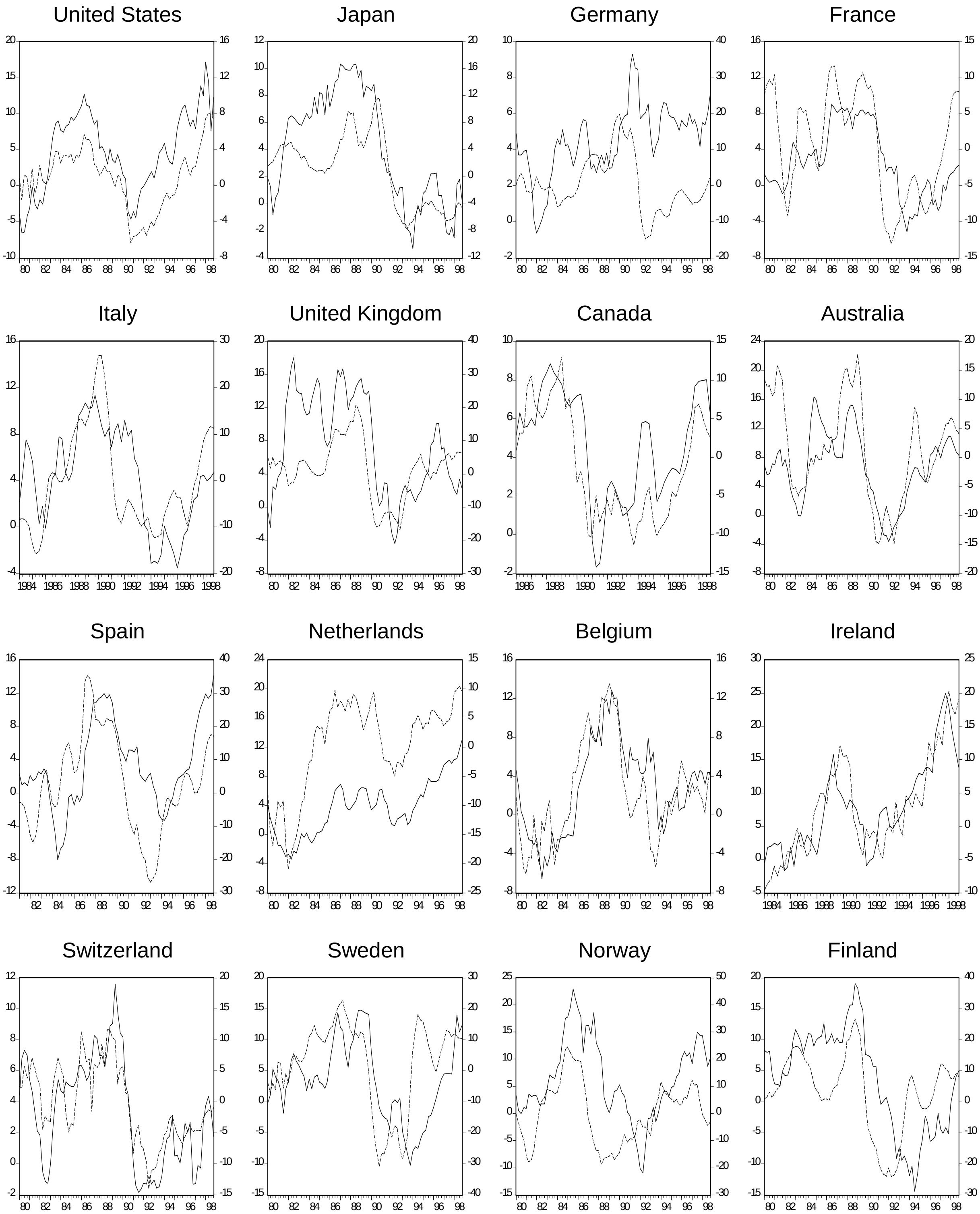
[12] Drees and Pazarbasioglu (1998) provide a survey on the causes and consequences of the banking crises in the Nordic countries. The literature on the Japanese crisis is of course enormous. See Hoshi and Kashyap (1999) for a recent survey and the references therein.

Figure 2
Credit and economic activity



Note: The figures show the annual rate of change of real credit (solid line, right-hand scale) and of real GDP (dotted line, left-hand scale).

Figure 3
Credit and property prices



Note: The figures show the annual rate of change of real credit (solid line, right-hand scale) and of real property prices (dotted line, left-hand scale).

Several studies (Borio et al (1994), IMF (2000), BIS (2001a)) have pointed to the close correlation between developments in credit markets and property prices. A comparison of the annual growth rates of real lending (DRDC, right-hand scale) and the annual rate of change of real property prices[13] (DRP, left-hand scale), displayed in Figure 3, reveals that there is in fact a close positive correlation between credit conditions and property prices across countries. In many countries, the episodes of boom and bust in credit markets in the late 1980s and early 1990s coincided with boom and bust cycles in property markets.

The close correlation between the development of credit aggregates and that of property prices may again reflect adjustments of credit demand to changes in property prices. Property prices may affect credit demand indirectly by stimulating economic activity via wealth effects.[14] Wealth effects may also give rise to a direct effect of property prices on the credit demand of homeowners. Table 1 reports the composition of household assets in the G7 countries as of 1998. The figures reveal that housing assets account for a substantial share of total household assets, especially in European countries. Thus, changes in property prices have a considerable impact on private sector wealth. According to the lifecycle model of household consumption, homeowners react to an increase in property prices by increasing their spending and borrowing in order to smooth consumption over the life cycle.[15] On the other hand, an increase in property prices also tends to trigger increases in rents. Renters may react by lowering consumption and borrowing. The overall wealth effect of property prices on consumption and credit demand is therefore theoretically ambiguous. The international empirical evidence on the relationship between property wealth and household consumption is mixed. Kennedy and Andersen (1994) analyse the effect of property prices on household saving in 15 industrialised countries. They find a significantly negative effect of house price movements on household saving in eight countries. In the other seven countries the estimated effect is positive. In a recent paper, Case et al (2001) find a significant and large effect of changes in housing wealth on household consumption both for a panel of 14 industrialised countries and for a panel of US states.

Table 1
The composition of household assets (in percentages)

	Housing assets	Equity	Other financial assets	Other tangible assets
United States	21	20	50	8
Japan	10	3	44	43
Germany	32	3	35	30
France	40	3	47	9
Italy	31	17	39	13
United Kingdom	34	12	47	7
Canada	21	17	39	23

Note: Data refer to 1998 (1997 for France).
Source: *OECD Economic Outlook*, December 2000, Table VI.1.

Property prices may also have a positive effect on loan demand by stimulating construction activity. According to Tobin's q-theory of investment (Tobin (1969)), investment activity depends positively on

[13] Our measure of real property prices is a weighted average of residential and commercial property prices deflated by the consumer price index. For more details see Section 3.

[14] Goodhart and Hofmann (2000a,b, 2001a) show that property prices have a significantly positive effect on inflation and aggregate output in industrialised countries.

[15] The lifecycle model of household consumption was originally developed by Ando and Modigliani (1963). A formal exposition of the lifecycle model can be found in Deaton (1992) and Muellbauer (1994).

the ratio of the market value of capital to the costs of acquiring it (Tobin's q). For the construction sector this implies that construction activity depends positively on the ratio of property prices to construction costs. Ceteris paribus, an increase in property prices will therefore increase construction activity, leading to an increase in the demand for credit.

The ''financial accelerator'' mechanism provides an alternative explanation for the coincidence of lending and property price cycles. The physical stock of assets is fixed in the short run, so that the value of collateralisable assets of households and firms is driven mainly by movements in asset prices. An increase in asset prices, triggered either by an increase in aggregate output, or by a decrease in interest rates, or by "irrational exuberance", drives up firms' and households' net worth and thus the availability of credit. An increase in lending stimulates economic activity, driving up asset prices further, so that a self-reinforcing process may evolve. The same chain of events results from an autonomous increase in credit, eg in the wake of financial liberalisation. Since loans are often secured with property, the development of property prices will be more relevant for the borrowing capacity of the private sector than the price of other assets, such as shares. Thus, a close correlation between credit conditions and property prices is a direct implication of the ''financial accelerator'' mechanism.

The positive correlation between credit and property prices can therefore be explained from both a credit demand and a credit supply perspective. Also, property prices may be affected by changes in credit conditions. Real asset prices depend on the discounted future stream of real dividend payments. Higher liquidity may have an indirect effect on asset valuations by lowering interest rates and thus the discount factor or by indicating brighter economic conditions and prospects and thus higher expected dividend payments. But it may also be that additionally available liquidity simply increases the demand for a (temporarily) fixed supply of property, driving up real property prices.

In the empirical literature, credit aggregates are usually assumed to be mainly demand determined (Bernanke and Blinder (1988), Fase (1995), Calza et al (2001)), depending positively on economic activity and negatively on financing costs.[16] This modelling approach assumes that banks follow the loan demand of the private sector and that lending rates adjust to equilibrate loan demand with banks' desired portfolio of loans (Fase (1995)). There are, however, also arguments, partly already outlined, suggesting that economic activity and interest rates may also have an effect on the supply of credit. Changes in economic activity are reflected in firms' cash flow and households' income, which determine the ability of firms and households to repay their debts, so that changes in economic activity may affect the willingness of banks to extend credit. The stance of monetary policy, reflected by the level of interest rates, may also affect the supply of credit by banks. Such supply effects may arise from the effect of monetary policy on the creditworthiness of firms and households via its effect on their financial positions, or from a drain of reserves and thus loanable funds from the banking sector following changes in the stance of monetary policy operated via open market sales by the central bank.[17] Thus, the interpretation of estimated relationships between credit, economic activity and interest rates as credit demand relationships should be taken with caution.

Little formal empirical research has been conducted into the relationship between credit and asset prices. Goodhart (1995) investigates the determinants of credit growth in the United States and the United Kingdom over a long sample period (United States 1919-91, United Kingdom 1939-91). He finds that the change in house prices has a significantly positive effect on credit growth in the United Kingdom, but not in the United States. Rolling regression estimates suggest that in the United Kingdom the relationship between credit and house price has strengthened over the postwar period. Borio et al (1994) investigate the relationship between credit-GDP ratios and aggregate asset prices for a large sample of industrialised countries over the period 1970-92.[18] They find that the

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16 There is some disagreement on how to best proxy financing costs. Most studies use a lending rate (Fase, 1995) or money market and capital market rates (Calza et al (2001)). Friedman and Kuttner (1993) argue that the interest rate paid on loans should be adjusted for the cost of funds obtainable from alternative sources, such as securities markets or internal cashflow.

17 In the literature, the transmission of monetary policy via credit supply is referred to as the credit channel. The sub-channel working via balance sheets and financial positions is called the balance sheet channel, the sub-channel working via bank reserves and deposits is called the bank lending channel. Surveys of the theoretical and empirical credit channel literature can be found in Bernanke and Gertler (1995) and Kashyap and Stein (1997).

18 They construct aggregate asset price indices as a weighted average of residential property prices, commercial property prices and equity prices. The weights are based on the share of each asset in national balance sheets, with the shares being derived from national flow-of-funds data and UN standardised national accounts.

development of credit conditions as measured by the credit-GDP ratio is in many countries a major driving force of aggregate asset prices. Based on simulations of their estimated models they show that the boom-bust cycles in asset markets of the late 1980s-early 1990s would have been much less pronounced or would not have occurred at all had credit ratios remained constant. Goodhart and Hofmann (2001b) find cross-country evidence for a long-run relationship between bank credit, GDP and residential property prices. Based on impulse response analysis they also show that there is a two-way relationship between credit and residential property prices. All these studies are reduced form exercises, focusing on the existence of significant relationships and paying less attention to structural interpretation. But, as we have already outlined above, the identification of credit demand and credit supply effects of changes in property prices is problematic, since property prices may affect both credit demand and credit supply.

In the following sections we model credit aggregates as a function of economic activity, interest rates and property prices. The discussion of this section has two main implications for the following empirical analysis. First, estimated relationships between credit, economic activity, interest rates and property prices may represent behavioural demand relationships, but they may also capture supply effects, so that the estimated relationships should be interpreted with caution. A simultaneous modelling of credit demand and credit supply could help to overcome at least part of this identification problem. We do not, however, attempt to explicitly model a credit supply function, since time series data on important credit supply factors, such as banking sector profitability or the degree of liberalisation and competition in banking markets, are not readily available. Second, the discussion above suggests that there may exist two-way relationships between credit, economic activity, interest rates and property prices. This implies that all variables should be treated as endogenous in the empirical analysis.

3. Data issues

In the following sections we analyse the relationship between aggregate private credit, aggregate economic activity, interest rates and aggregate property prices[19] in 16 industrialised countries since 1980 using quarterly data. All data are taken from the BIS database and are, with the exception of nominal interest rates, seasonally adjusted. Standardised data for aggregate credit to the private sector are not available, so that the comparability of the credit aggregates is restricted by differences in the national definition of credit. Nominal credit aggregates were transformed into real terms by using the consumer price index. We use real GDP as the broadest aggregate measure of real activity. As a proxy for aggregate real financing costs we use an ex post short-term real interest rate, measured as the three-month interbank money market rate[20] less annual CPI inflation.[21,22] With the exception of the real interest rate, all data were transformed into natural logs.

Following the approach of Borio et al (1994), we construct aggregate property price indices as a weighted average of residential and commercial property prices. Data on private sector balance

[19] A sectoral breakdown of aggregate credit was not available for most countries, so that an analysis of the determinants of sectoral credit aggregates was not possible.

[20] A more accurate measure of aggregate financing costs would of course be an aggregate lending rate. Representative lending rates are, however, not available for all countries. Empirical evidence suggests that short-term and long-term lending rates are in the long run tied to money market rates or policy rates (see Borio and Fritz (1995) for a large sample of industrialised countries, Hofmann (2001) for euro area countries and Hofmann and Mizen (2001) for the United Kingdom), so that money market rates appear to be a useful approximation of the financing costs of credit.

[21] Using quarterly instead of annual inflation rates introduces substantial variability in the real interest rate, giving rise to heteroskedasticity in the residuals of the estimated systems in Section 3.

[22] Investment and saving decisions are determined by the ex ante real interest rate, which is given by the nominal interest rate less inflation expectations over a corresponding time horizon. Data on inflation expectations are not available for a sufficient number of countries over a sufficiently long period of time, so that we use an ex post real interest rate as a proxy. For short-term real interest rates this is a valid approach, since inflation is highly persistent, and the inflation rate of the current year will be a useful approximation of inflation expectations for the coming year. For inflation expectations over longer horizons the current inflation rate may not be such a good proxy, so that ex post long-term real interest rates can be misleading guides for ex ante long-term real rates. For this reason we do not consider long-term real interest rates in the analysis.

sheets from national wealth statistics are available on a quarterly basis for the United States and Australia and on an annual basis for Japan, Germany, Canada and the United Kingdom. For Sweden and Norway annual data on the stocks of residential and commercial buildings are obtained from UN Standardised National Accounts (SNA). The annual wealth data were interpolated to obtain a quarterly series of weights. For all other countries, neither national flow-of-funds data nor data from the UN SNA were available. Thus, following Borio et al (1994) we assume that the relative share of residential and commercial property in private sector balance sheets in France, Italy, Spain, Switzerland, Belgium and the Netherlands is the same as in Germany, that in Ireland the share is the same as in the United Kingdom, and that in Norway it is the same as in Sweden.

The balance sheet weights were then applied to residential and commercial property price series to obtain a series of aggregate property prices. A detailed description of the property price data can be found in Appendix Table 1. We use residential property price indices representing country-wide developments. The exception is Germany, for which we use an average of residential property prices in Berlin, Frankfurt, Hamburg and Munich. Country-wide measures for commercial property prices were only available for the United States, Japan, Switzerland and Ireland. For the other countries we had to use commercial property price indices for single cities. Residential property prices were only available on an annual basis for Germany and on a semiannual basis for Italy and Japan. Except for the United States, Canada, Australia and Switzerland, commercial property price indices were only available in annual frequency (Japan semiannual). In these cases quarterly indices were constructed by linear interpolation.

Nominal property prices were deflated by the consumer price index in order to obtain a measure of real property prices. Figure 4 shows the real residential and commercial property price indices and the real aggregate property price indices for the period 1980-98. Commercial property price data for Italy, Canada and Ireland were only available from 1983, 1985 and 1983 respectively, reducing the sample for the aggregate property price index accordingly. The figures show that commercial property prices are substantially more volatile than residential property prices. This may indicate that there is more speculative activity in commercial property markets. But the validity of this conclusion is certainly limited by the fact that for most countries commercial property price indices represent price movements in only one or a few large cities and not the country as a whole.

4. Long-run relationhips

Standard augmented Dickey-Fuller (Dickey and Fuller (1981)) unit root tests reported in Appendix Table 2 suggest that all variables are integrated of order one over the sample period. In the following we therefore analyse the relationship between real lending, real GDP, the real interest rate and real property prices based on the multivariate approach to cointegration analysis proposed by Johansen (1988, 1991, 1995). We prefer the Johansen approach to alternative single equation estimators because we cannot rule out the existence of multiple long-run relationships, nor do we have any a priori reason to assume that any set of variables is weakly exogenous.[23]

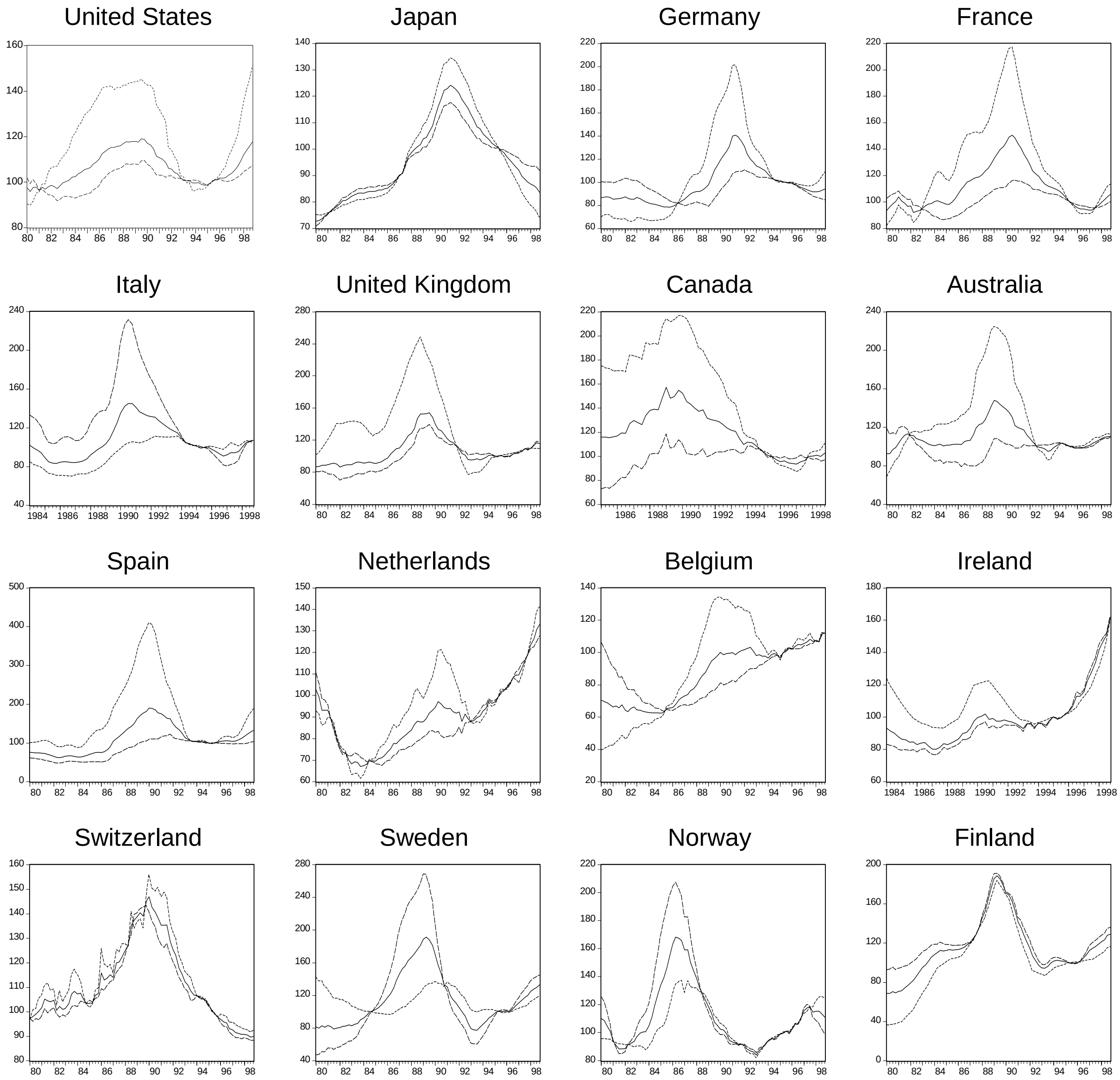
The cointegration analysis is based on the VAR model:

(1) $$x_t = B_1 x_{t-1} + ... + B_k x_{t-k} + \mu + \varepsilon_t ,$$

where x is a vector of endogenous variables, μ is a vector of constants, and ε is a vector of error terms, which are assumed to be whitenoise. In order to assess whether property prices play a role in explaining the development of credit we estimate two econometric models, a minimal system comprising only the log of real credit, the log of real GDP and the real interest rate, and an extended system also comprising the log of real property prices. The sample period for the analysis is the first quarter of 1980 till the fourth quarter of 1998. Due to data availability the sample is somewhat shorter for Canada, Italy, Ireland and Spain, starting in 1986:2, 1984:1, 1983:3 and 1981:1 respectively.

[23] Estimating a long-run relationship based on single equation estimation techniques if there exist multiple long-run relationships and if the explanatory variables are not weakly exogenous yields inefficient coefficient estimates.

Figure 4
The development of property prices in industrialised countries (1995=100)



Note: The figures show the real residential property price index (broken line), the real commercial property price index (dotted line) and the real aggregate property price index (solid line), constructed as a weighted average of the residential and the commercial property price index. The weights are based on the respective share of residential and commercial property in private sector wealth. A detailed description of the data can be found in Appendix Table 1.

The Johansen methodology is based on maximum likelihood estimation, so that Gaussian error terms are required. The lag-order of the VARs was therefore chosen in order to obtain well behaved VAR residuals. Centred impulse dummies[24] had to be added to the VARs for Australia (81:4 and 82:3), Italy (92:3) and Switzerland (82:2) in order to eliminate a few large outliers in the real interest rate equation, which gave rise to heteroskedasticity in the whole system. In Appendix Tables 3 and 4 we report for the minimal and the extended system respectively the chosen lag-order and some diagnostics for the whole system. The diagnostics suggest that there is no evidence of serial correlation or heteroskedasticity, but in some cases there is evidence of non-normality of the VAR residuals. Lütkepohl (1993) shows that the Johansen approach does not strictly depend on the normality assumption, so that the violation of the normality assumption might not be too severe a caveat to our analysis.

Another important precondition for valid statistical inference is subsample stability of the estimated systems. Since we do not have a clear prior for the timing of a possible structural break, we consider every possible breakpoint in the sample. In Appendix Figure 1 we display for each country the recursive Chow breakpoint test statistic for the extended systems, ie for the VARs comprising the log of real credit, the log of real GDP, the real interest rate and the log of real property prices, together with the respective 5% critical value. There is little evidence of instability of the estimated systems. Only for Japan, Germany, Italy and Finland is the test statistic slightly above the 5% critical value in the late 1980s and in Japan again in the late 1990s. However, the standard critical values for the Chow breakpoint test are actually not appropriate when testing for unknown breakpoint. Andrews (1993) derives critical values for recursive Chow breakpoint tests for single equations. These critical values are substantially higher than the standard critical values. Critical values for system breakpoint tests are not available, but the appropriate critical values will presumably also be higher than the standard critical values plotted in Appendix Figure 1. Taking this into account, we may conclude that the estimated systems are sufficiently stable.

The VAR model can be reformulated in vector error-correction form:

$$\Delta x_t = C_1 \Delta x_{t-1} + ... + C_{k-1} \Delta x_{t-k+1} + C_0 x_{t-1} + \mu + \varepsilon_t \tag{2}$$

The constant is left unrestricted, allowing for deterministic time trends in the levels of the data. The cointegration test is based on the rank of the matrix C_0, which indicates the number of long-run relationships between the endogenous variables in the VAR. Johansen proposed two tests for the cointegration rank, the Trace test and the Maximum-Eigenvalue test.[25] The following cointegration analysis is based solely on the Trace test, since the Maximum-Eigenvalue test does not provide a coherent testing strategy (Johansen (1994)). Based on the number of long-run relationships indicated by the cointegration test, the matrix C_0 can be factorised as $C_0 = \alpha\beta'$. α is a (*nxr*) matrix of loading or adjustment coefficients and β is a (*nxr*) matrix of cointegrating vectors, with *n* equal to the number of endogenous variables and *r* equal to the number of long-run relationships in the system. The cointegrating vectors forming the matrix β describe the relationships linking the endogenous variables in the long run. The loading coefficients forming the matrix α describe the dynamic adjustment of the endogenous variables to deviations from long-run equilibrium given by $\beta' x$.

Table 2 shows the estimation results for the minimal system not comprising property prices. The Trace test suggests the existence of a single long-run relationship for the United States, Germany, Canada, Spain, the Netherlands and Belgium and of no long-run relationship for all other countries. For Germany, Canada, Spain, the Netherlands and Belgium the cointegrating vector is identified by normalising on the credit coefficient. We therefore hypothesise that the long run relationship represents a relationship linking credit to GDP and interest rates. In Table 3 we show the identified long-run relationships with asymptotic standard errors in parentheses. Real credit (C) is in the long run positively related to real GDP (Y) and negatively to the real interest rate (R). The long-run income elasticity of credit is in all five cases significantly larger than one. This finding could reflect either a

[24] The use of centred as opposed to uncentred dummy variables ensures that the standard critical values for the cointegration test are still valid (Johansen (1995)).

[25] For a more detailed technical exposition of the Johansen approach see eg Johansen (1988, 1991, 1995), Lütkepohl (1993) and Hamilton (1994).

process of financial deepening as a result of financial liberalisation since 1980, or the effect of omitted variables, such as property prices, which are captured by GDP. The semi-elasticity of credit demand with respect to the real interest rate is negative and also significant except for Belgium.

The adjustment coefficient in the credit equation, which is shown in the last column of Table 2, is in all cases negative and also, with the exception of Germany, significant at least at the 5% level. This means that credit adjusts to the identified long-run relationship, lending support the view that it represents a relationship explaining the long-run development of credit. In the literature long-run relationships between credit, real GDP and interest rates are usually interpreted as long-run credit demand relationships. The discussion in Section 2 suggests, however, that such long-run relationships may equally capture long-run effects on credit supply.

Table 2
Cointegration analysis for the minimal system

	Trace test for cointegration			Long-run relationship	α
	r=0	r=1	r=2		
United States	20.16	4.25	0.23	no cointegration	
Japan	24.46	10.36	2.02	no cointegration	
Germany	36.70**	12.16	0.91	C=**1.411**·Y-**0.096**·R (0.195) (0.018)	0.005 (0.008)
France	16.61	4.35	0.39	no cointegration	
Italy	19.59	7.85	0.79	no cointegration	
United Kingdom	27.07	10.25	1.04	no cointegration	
Canada	36.40**	9.68	0.01	C=**1.559**·Y-**0.030**·R (0.097) (0.006)	**-0.077** (0.045)
Australia	19.55	8.77	0.82	no cointegration	
Spain	33.52*	8.97	1.26	C=**1.269**·Y-**0.022**·R (0.068) (0.005)	**-0.112** (0.023)
Netherlands	37.48**	11.87	0.01	C=**1.689** Y-**0.035**·R (0.126) (0.007	**-0.047** (0.012)
Belgium	38.00**	12.57	0.14	C=**2.169**·Y-0.011·R (0.136) (0.009)	**-0.059** (0.018)
Ireland	25.42	7.64	0.75	no cointegration	
Switzerland	25.27	6.65	2.80	no cointegration	
Sweden	21.59	7.26	0.06	no cointegration	
Norway	18.93	3.165	0.025	no cointegration	
Finland	23.35	7.51	0.18	no cointegration	

Note: The table displays the test statistics of the Johansen Trace test for cointegration, the identified long-run relationship (if any) and the loading coefficient (a) in the VECM equation for lending (if any); the 5% (1%) critical values for the cointegration test are 29.68 (35.65), 15.41 (20.04) and 3.76 (6.65) for r=0, r=1 and r=2 respectively (Osterwald-Lenum (1992)). * and ** indicate significance of the cointegration test statistic at the 5% and 1% level respectively. C represents the log of real credit, Y the log of real GDP and R the real interest rate. Long-run and loading coefficients which are significant at least at the 10% level are in bold.

Table 3
Cointegration analysis for the extended system

	Trace test for cointegration				Long-run relationship	α
	r=0	r=1	r=2	r=3		
United States	72.80**	28.03	8.57	0.32	C=**1.845**·Y-**0.010**·R+**0.493**·P (0.033) (0.003) (0.068)	**-0.157** (0.086)
Japan	51.46**	21.69	3.62	0.03	C=**1.040**·Y-**0.043**·R+**0.736**·P (0.147) (0.010) (0.131)	**0.068** (0.024)
Germany	69.10**	36.03**	13.06	0.17	C= **2.185**·Y-**0.046**·R (0.067) (0.009)	**-0.072** (0.020)
					Y= **1.249**·P-**0.144**·R (0.142) (0.022)	**-0.034** (0.014)
France	50.19*	29.43	12.23	0.36	C= **1.332**·Y-**0.014**·R+**0.778**·P (0.097) (0.004) (0.058)	**-0.053** (0.030)
Italy	48.75**	25.87	12.14	2.40	C=**1.379**·Y-**0.034**·R+**0.636**·P (0.203) (0.016) (0.111)	**-0.049** (0.020)
United Kingdom	54.45*	27.40	10.1	5.25	C=**2.036**·Y-**0.057**·R+**1.04**·P (0.324) (0.024) (0.285)	**-0.015** (0.008)
Canada	49.51**	21.25	10.99	2.40	C= **1.834**·Y-**0.036**·R+**0.227**·P (0.121) (0.006) (0.077)	**-0.076** (0.032)
Australia	55.93**	28.51	9.35	0.10	C= **1.729**·Y-**0.015**·R+**0.738**·P (0.083) (0.009) (0.156)	**-0.025** (0.015)
Spain	56.93**	25.11	8.14	0.177	C= **1.178**·Y-**0.023**·R+0.036 P (0.104) (0.006) (0.062)	**-0.079** (0.019)
Netherlands	49.59**	29.21	11.50	1.34	C= **1.326**·Y-**0.050**·R+**0.736**·P (0.295) (0.011) (0.210)	**-0.024** (0.008)
Belgium	57.58**	25.32	11.33	0.02	C= **1.269**·Y-**0.011**·R+**0.459**·P (0.265) (0.005) (0.152)	**-0.062** (0.026)
Ireland	52.98*	27.96	7.67	0.12	C= **1.172**·Y-**0.030**·R+**0.361**·P (0.110) (0.006) (0.171)	**-0.082** (0.036)
Switzerland	59.11**	24.10	6.57	0.66	C= **2.487**·Y-**0.077**·R+**0.438**·P (0.147) (0.011) (0.100)	**-0.026** (0.015)
Sweden	53.11*	25.96	9.14	0.24	C= **1.147**·Y+0.003·R+**0.748**·P (0.351) (0.007) (0.132)	**-0.056** (0.011)
Norway	54.43**	24.82	2.79	0.00	C= **2.263**·Y+0.003·R+**1.457**·P (0.194) (0.011) (0.224)	**-0.038** (0.011)
Finland	76.98**	27.69	10.16	1.41	C= -0.494·Y+0.009·R+**1.681**·P (0.389) (0.011) (0.200)	**-0.058** (0.013)

Note: The table displays the test statistics of the Johansen Trace test for cointegration, the identified long-run relationship and the loading coefficient (a) in the VECM equation of the dependent variable of the long-run relationship; the 5% (1%) critical values for the cointegration test are 47.21 (54.46), 29.68 (35.65), 15.41 (20.04) and 3.76 (6.65) for r=0, r=1, r=2 and r=3 respectively (Osterwald-Lenum (1992)). * and ** indicate significance of the cointegration test statistic at the 5% and 1% level respectively. C represents the log of real credit, Y the log of real GDP, R the real interest rate and P the log of real property prices. Long-run and loading coefficients which are significant at least at the 10% level are in bold.

Based on the minimal system we are therefore not able to explain the long-run development of real credit for the large majority of countries. Table 3 reports the results of the cointegration analysis for the extended system, also comprising the log of real property prices in addition to the log of real credit, the log of real GDP and the real interest rate. With the exception of Germany, the Trace test indicates the existence of a single long-run relationship for all countries. We hypothesise that the indicated long-run relationship is a long-run relationship linking credit (C) to real GDP (Y), real property prices (P) and the real interest rate (R). The cointegrating vector is therefore again identified by normalising on the credit coefficient.

On the whole, we obtain plausible estimates of the long-run coefficients. With very few exceptions, we find a significant positive long-run correlation between credit (C), real GDP (Y) and real property prices (P) and a significant negative long-run correlation between credit and the real interest rate (R). In the Nordic countries, we are unable to detect any significant long-run effect of the real interest rate on real credit. In Finland, real credit appears to be exclusively tied to real property prices in the long-run, since the long-run coefficient of real GDP is also insignificant. The long-run elasticity of credit with respect to real GDP is not significantly different from one at the 5% level in Japan, Italy, Spain, the Netherlands, Belgium, Ireland and Sweden. In the other countries, except for Finland, the long-run coefficient of real GDP is significantly larger than one. This finding could again reflect a process of financial deepening since the early 1980s, or wealth effects captured by GDP, such as the effect of rising equity prices. With the exception of the Nordic countries, the long-run semi-elasticity of credit with respect to the real interest rate is significantly negative. The point estimates suggest that a one percentage point increase in the short-term real interest rate triggers a long-run reduction in real lending of between 0.01 and 0.08 percent. Thus, interest rate effects are small, but statistically significant. The elasticity of credit with respect to real property prices is significantly positive. The only exception is Spain, where property prices do not significantly affect credit in the long-run. For the other countries we find a wide variation in the estimated long-run property price coefficient, ranging between 0.23 (Canada) and 1.68 (Finland).

The adjustment coefficient in the equation for real lending, which is again shown in the last column of Table 3, is, with the exception of Japan, negative and significant at least at the 10% level. Credit adjusts significantly to the identified long-run relationship, supporting the view that it represents a long-run relationship linking real credit to real GDP, the real interest rate and real property prices. In Japan the adjustment coefficient is also significant, but positive. This means that credit moves away from its long-run equilibrium. The reason for this may be that aggregate credit has not fallen as much in the 1990s as might have been expected according to our empirical model, partly because many impaired loans have remained on the banks' balance-sheets. The identified long-run relationships may be interpreted as long-run extended credit demand relationships. But again such an interpretation is qualified by the potential effects of real GDP, real interest rates and real property prices on credit supply via the channels outlined in Section 2.

The case of Germany is different from the other countries, since the Trace test indicates the existence of two long-run relationships. It appears that the most plausible interpretation of the two long-run relationships is that of a long-run relationship linking credit to real GDP and the real interest rate and a long-run relationship linking output to real property prices and the real interest rate. This interpretation is supported by the estimated adjustment coefficients, which indicate that credit adjusts significantly to the long-run relationship for credit and real GDP adjusts significantly to the long-run relationship for output.

5. Dynamic interaction

In this section we analyse, based on the vector error-correction models estimated in the previous section, the dynamic interaction of credit, real GDP, real interest rates and real property prices by computing orthogonalised impulse responses. The multivariate framework enables us not only to analyse the dynamic effect of changes in GDP, interest rates and property prices on credit, but also other interesting dynamics, such as the effect of credit innovations on output and property prices.

In order to recover the structural shocks from the reduced form system in (2) we use a standard Cholesky decomposition, proposed by Sims (1980). A Cholesky decomposition involves a recursive ordering of the variables. The ordering adopted here is the following: real GDP, real credit, real property prices and the real interest rate. This ordering is based on the assumption that real GDP does not respond contemporaneously to innovations to any of the other variables, but may affect all other variables within the quarter. This assumption is fairly standard in the monetary policy transmission literature. We further assume that real interest rates may react contemporaneously to all innovations, but do in turn not have a contemporaneous effect on any of the other variables. This reflects the common assumption that interest rate moves are transmitted to the economy with a lag, but that all other variables may appear in the reaction function of monetary policymakers as indicators of current or future aggregate demand and inflation. Furthermore, we assume that credit may have a contemporaneous impact on property prices, but not vice versa. A change in credit may have an immediate liquidity effect on property prices, but we assume that it takes time for the wealth or balance sheet effects of a change in property prices to have an impact on lending. This ordering of the variables has, in our view, the most intuitive appeal and also yields plausible impulse responses. A reordering of the variables did not have a considerable effect on the impulse responses. The exception is the ordering of property prices and the interest rate. If we change the ordering of these two variables we obtain many insignificant impulse responses to an interest rate innovation.

Figures 5 to 13 display the impulse responses together with 5% confidence bounds. Figures 5 and 6 show respectively the responses of lending and property prices to a one standard deviation shock to real GDP. Figures 7 and 8 show respectively the response of credit and real GDP to a standardised property price shock. The responses of property prices and GDP to a standardised innovation to real lending are displayed respectively in Figures 9 and 10. Finally, Figures 11, 12 and 13 show respectively the response of credit, property prices and GDP to a one standard deviation shock to the real interest rate.

An increase in real output is predicted to trigger increases in real lending and real property prices. Real lending is predicted to rise because of increases in both credit demand and credit supply in the wake of a positive output shock. Credit demand may go up because an unexpected change in real GDP may trigger increases in consumption and investment demand, subsequently leading to higher credit demand. Higher output indicates higher real incomes, which may in turn increase the willingness of banks to extend loans. We find that, with few exceptions, the response of real credit to a real GDP innovation is significantly positive. Insignificant impulse responses are obtained for the United States, Japan, the United Kingdom and Sweden. Increases in real output therefore trigger increases in real lending. Whether this effect reflects changes in credit demand or credit supply cannot be determined.

Real property prices are also predicted to increase following a positive change in real GDP, since output may be assumed to be a proxy for returns on housing. An increase in real GDP may therefore lead to an increase in the valuation of property.[26] Our results show that the response of real property prices to a change in real GDP is in fact positive in the large majority of countries, but insignificant in almost half of the countries. This finding may indicate that in many countries output is only a rather noisy proxy for the returns on housing, or that property prices do not fully obey standard asset pricing rules.[27]

Changes in property prices are expected to have a positive effect on credit and GDP via their effect on private sector wealth and balance sheets. Higher property prices may increase the perceived lifetime wealth of households, leading to a rise in output demand. As a result, credit demand may rise, too. Since a large share of loans is secured with property, higher property prices also imply an increase in the value of collateralisable assets and thus of the creditworthiness of firms and households. The impulse responses reveal that an innovation to real property prices leads to a significant increase in both real lending and real GDP. Real lending responds insignificantly only in Spain. Thus, Spain is the only country where property prices have no significant effect on credit in both the long and the short run. An insignificant GDP response is obtained only for Canada, the Netherlands and Belgium.

An innovation to real lending is predicted to trigger a rise in output demand and thus real GDP. Property prices are also expected to increase either because of an indirect effect of credit on asset valuations via higher output, or because of a direct liquidity effect. With the exception of France, Canada, Spain and Sweden, we find a significantly positive response of real GDP to a credit shock. For the large majority of countries we also find a significant increase in property prices. Insignificant impulse responses are obtained for Germany, the United Kingdom (almost significant), Canada and Spain.

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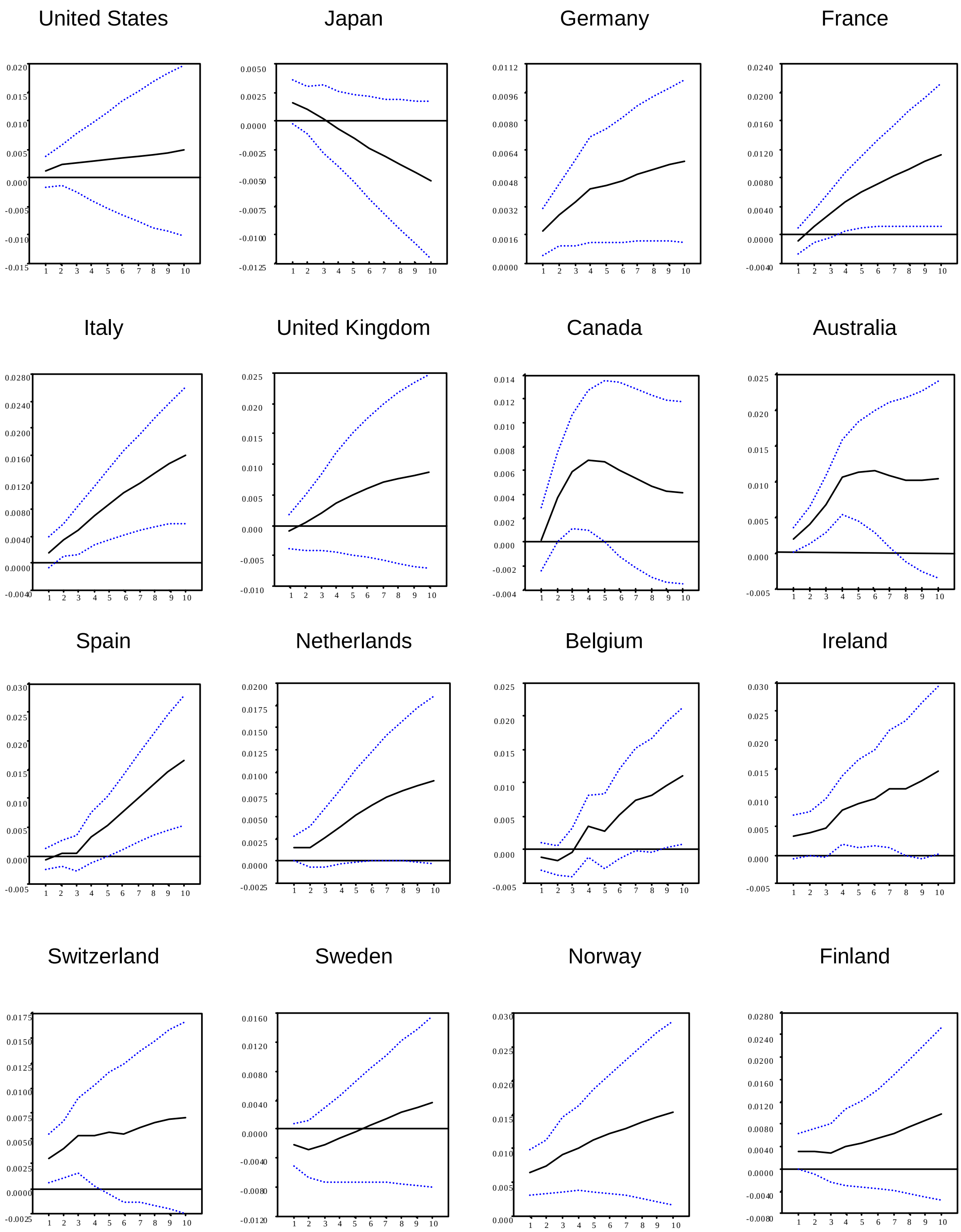
[26] Englund and Ioannides (1997) report a significantly positive effect of GDP on house prices in a panel of 15 industrialised countries.

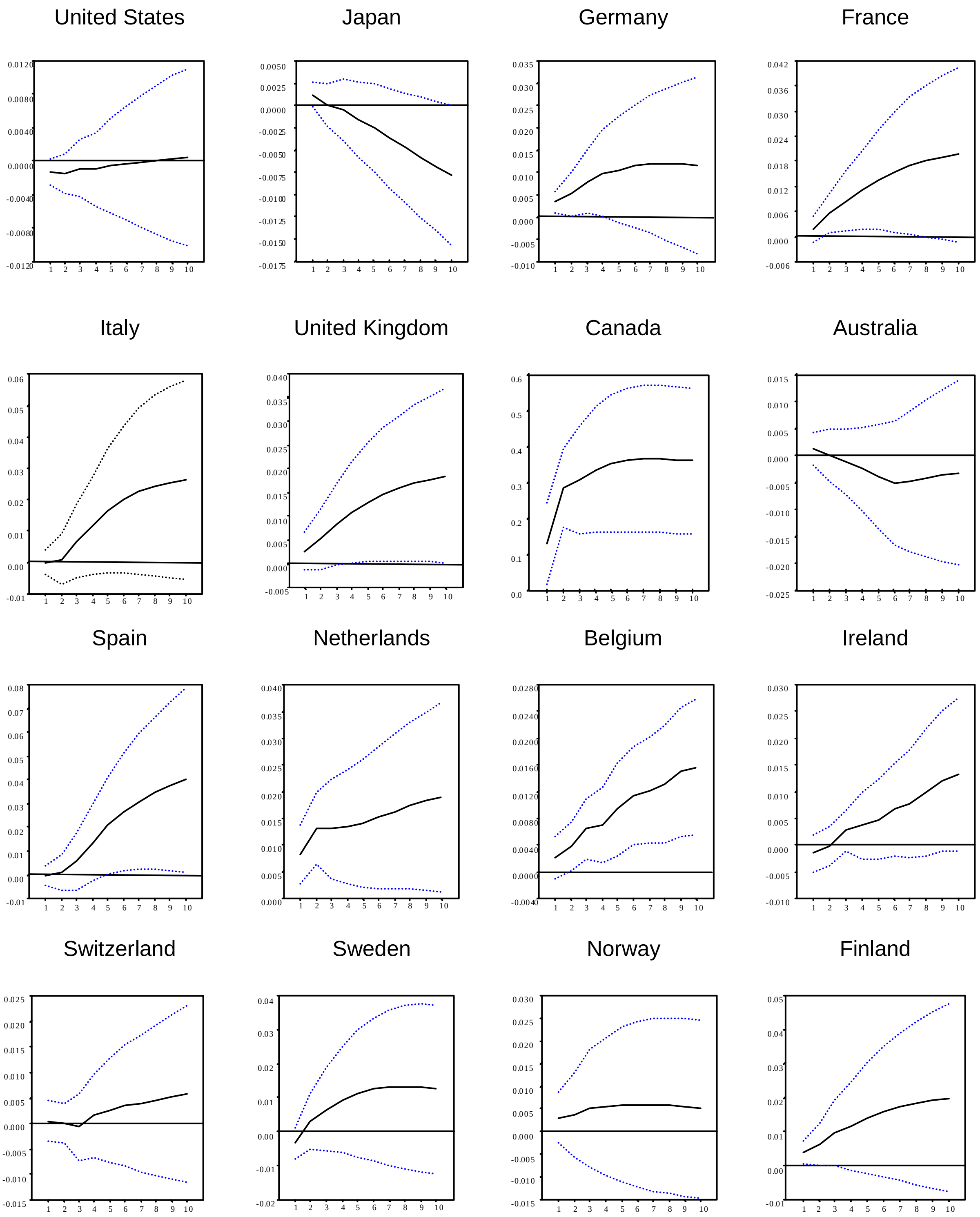
[27] Kennedy and Andersen (1994) find, based on a sample of 15 industrialised countries, that the presence of speculative activity in residential property markets cannot be ruled out.

Figure 5
Response of real credit to a real GDP shock



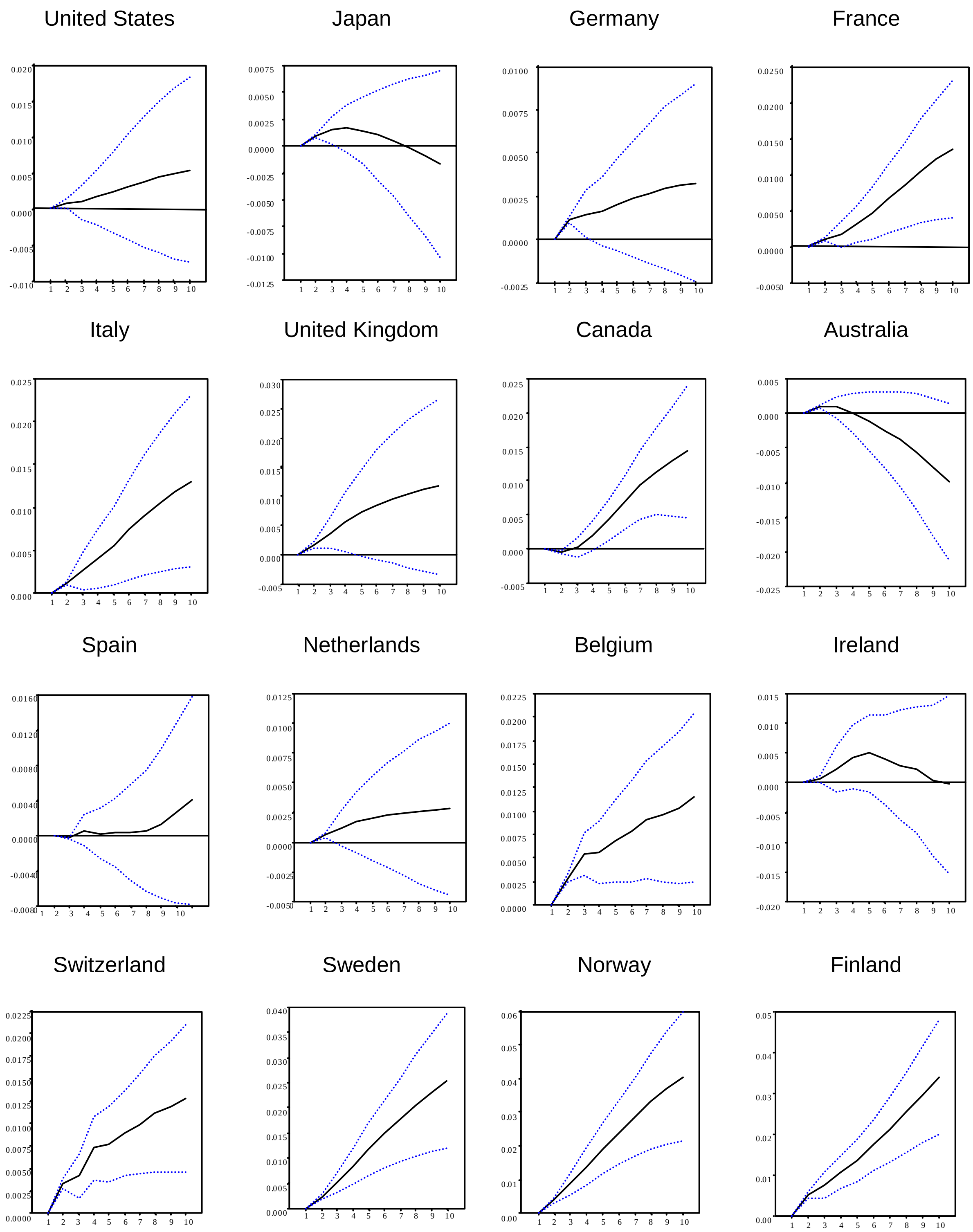
Note: The figures display impulse responses in a ± 2 standard error band.

Figure 6
Response to real property prices to a real GDP shock



Note: The figures display impulse responses in a ± 2 standard error band.

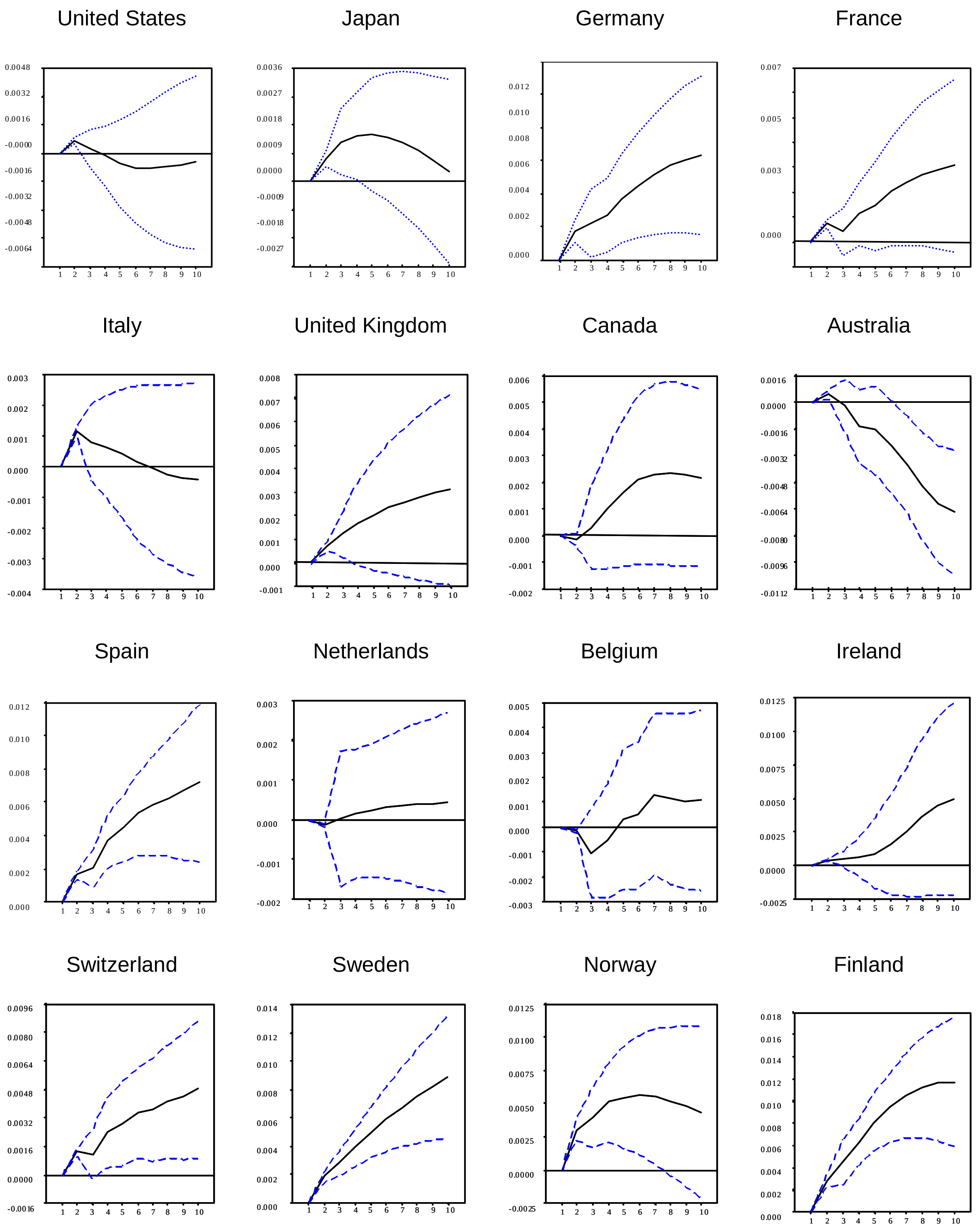
Figure 7
Response of real credit to a real property price shock



Note: The figures display impulse responses in a ± 2 standard error band.

Figure 8

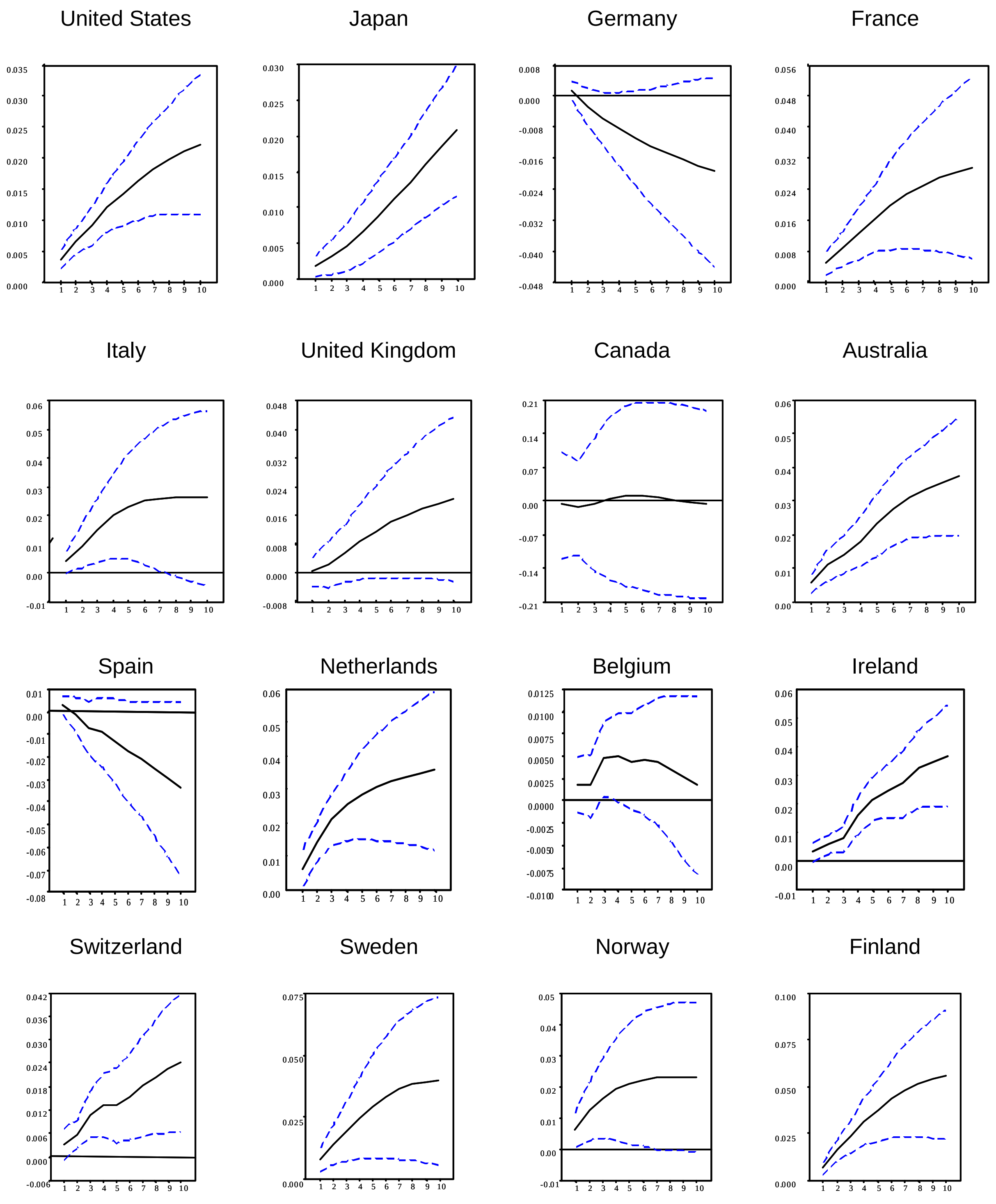
Resonse of real GDP to a real property price shock



Note: The figures display impulse responses in a ± 2 standard error band.

Figure 9

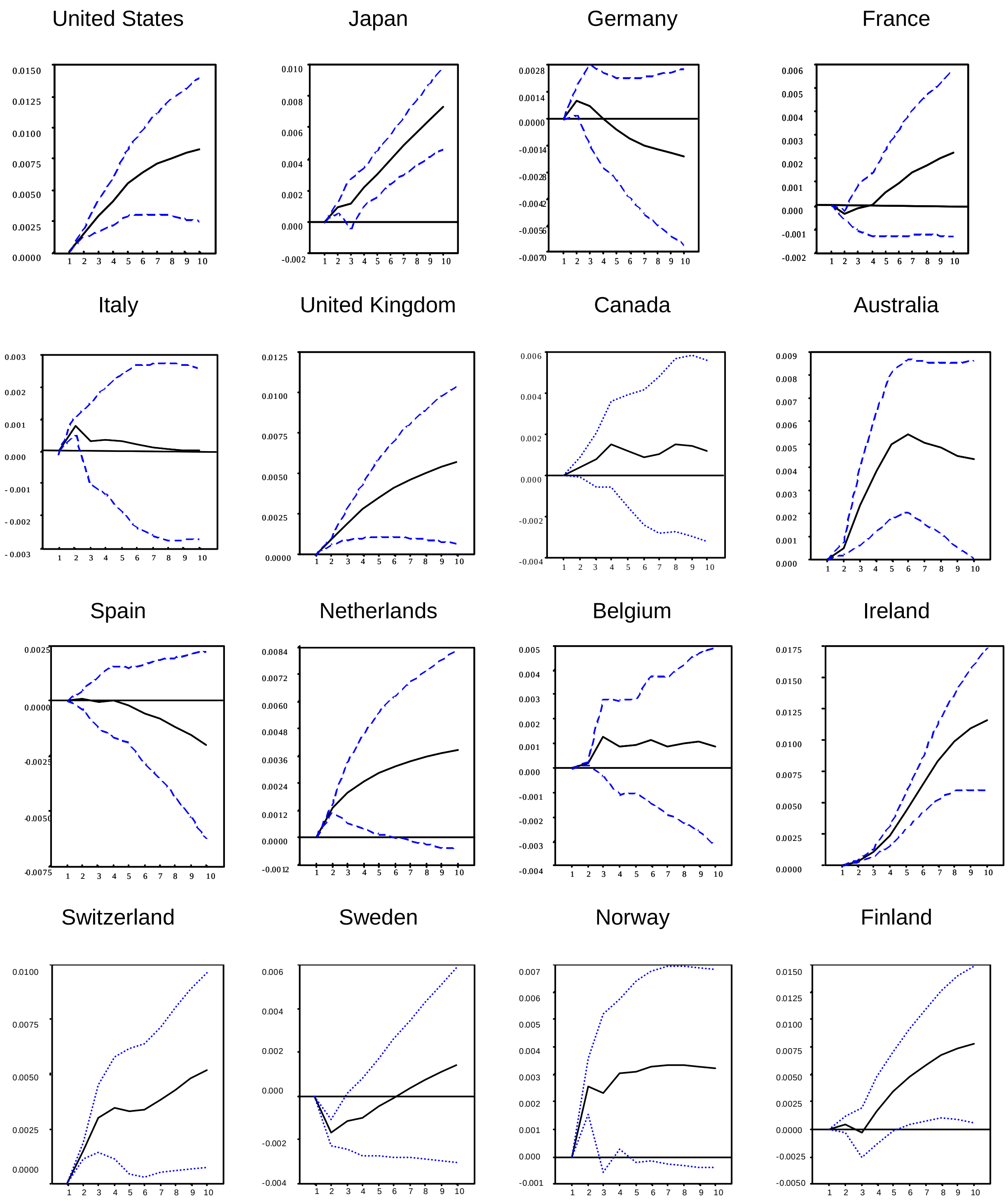
Response of real property prices to a real credit shock



Note: The figures display impulse responses in a ± 2 standard error band.

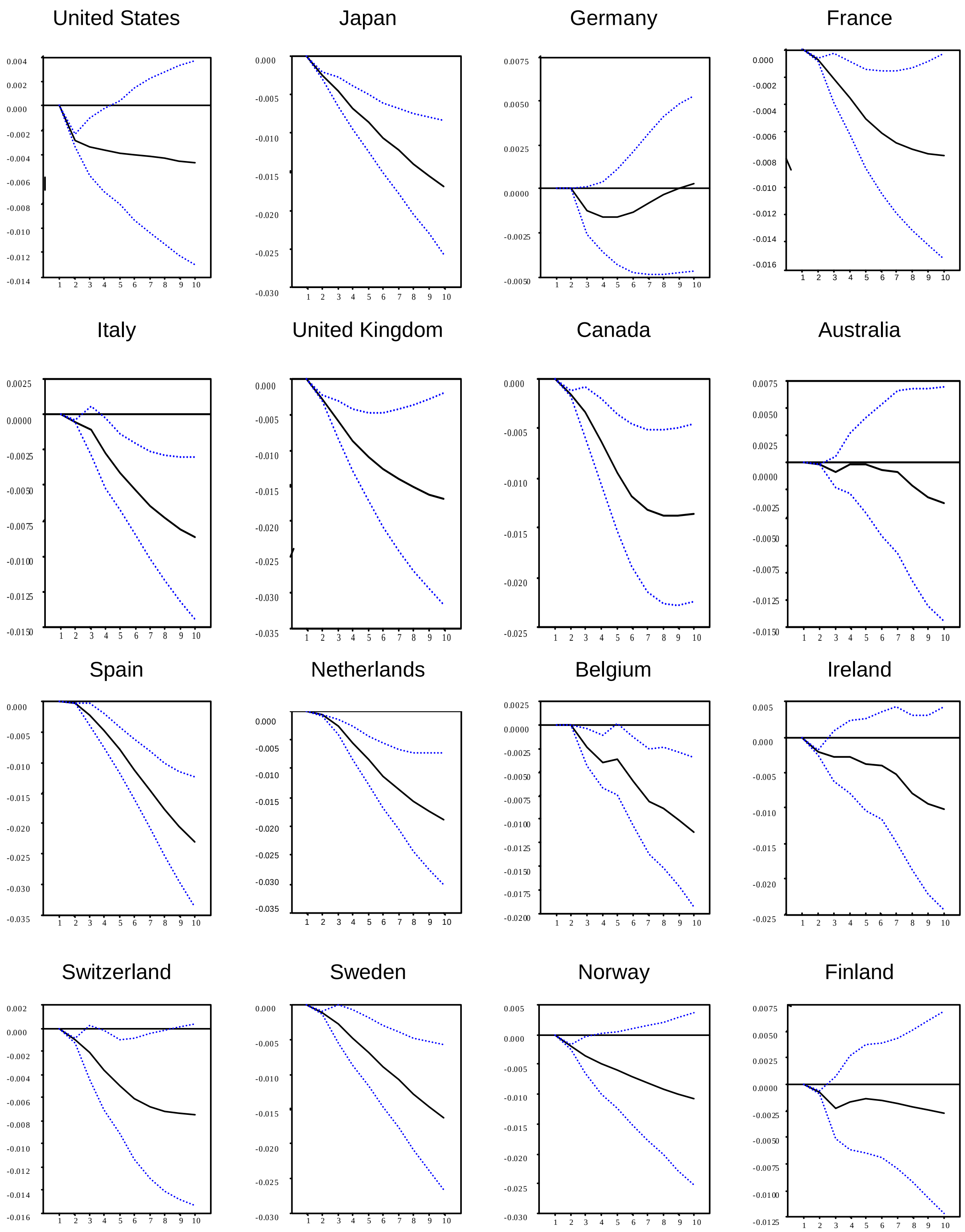
Figure 10

Response of real GDP to a real credit shock



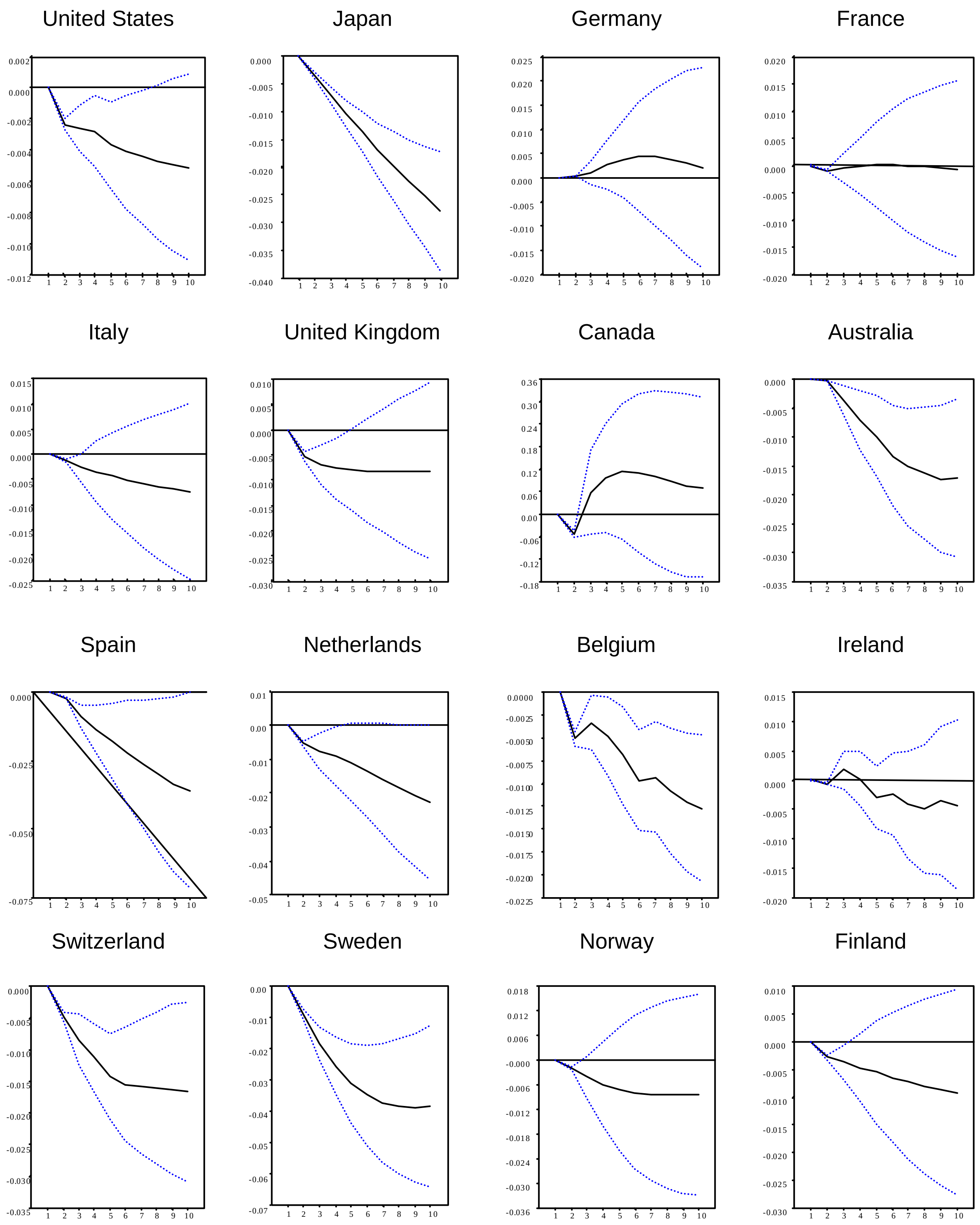
Note: The figures display impulse responses in a ± 2 standard error band.

Figure 11
Response of real credit to a real interest rate shock



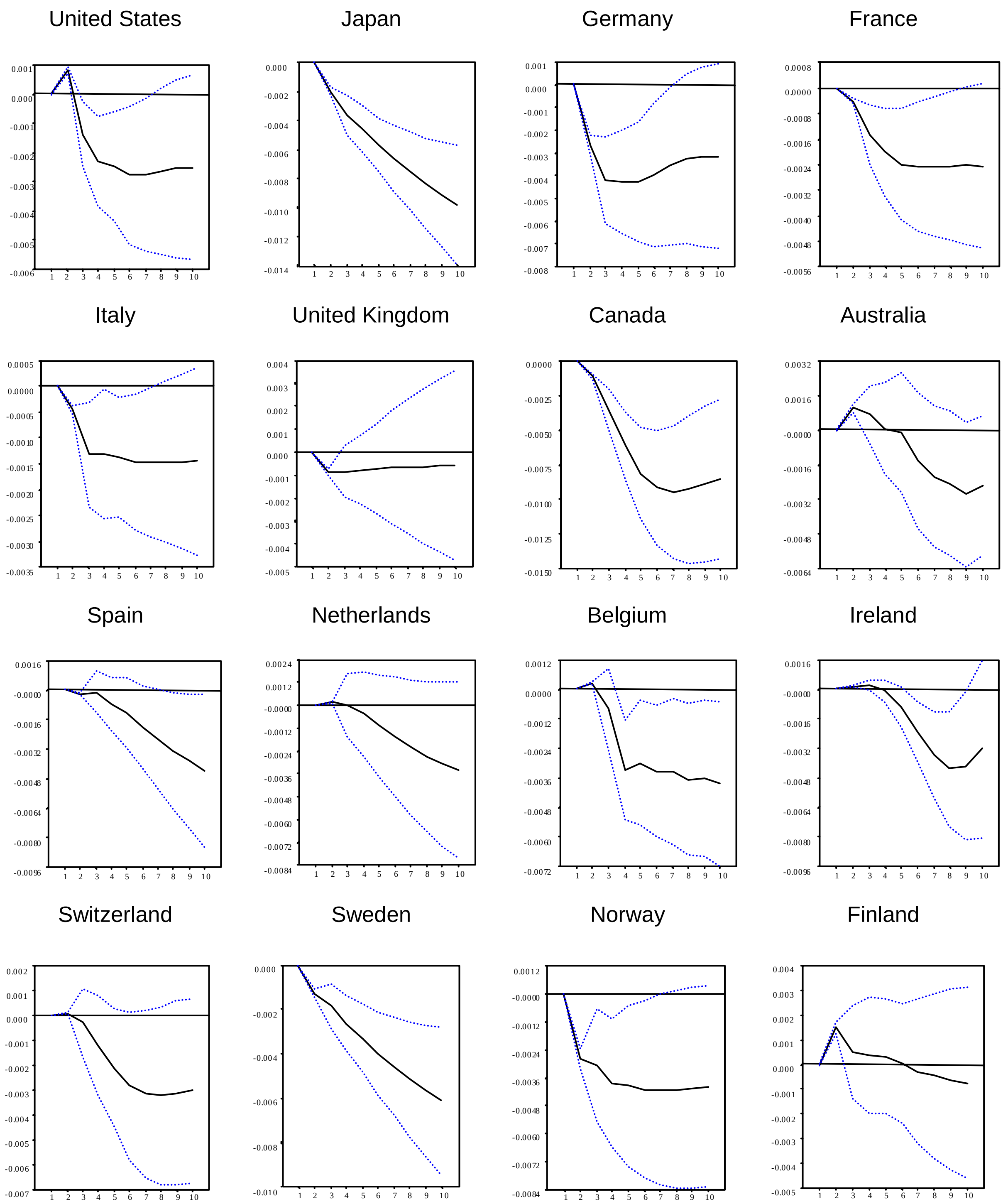
Note: The figures display impulse responses in a ± 2 standard error band.

Figure 12
Response of real property prices to a real interest rate shock



Note: The figures display impulse responses in a ± 2 standard error band.

Figure 13
Responses of real GDP to a real interest rate shock



Note: The figures display impulse responses in a ± 2 standard error band.

In Canada and Spain, autonomous changes in credit therefore do not appear to be an independent source of fluctuations in real GDP and property prices. In most countries the effect of a credit shock on real property prices is substantially stronger than the effect on output (eg in the United States and Japan about twice as large). This finding indicates the presence of strong direct liquidity effects of credit on property prices.

An autonomous increase in the real interest rate is expected to trigger negative responses of real GDP, credit and property prices. Output is expected to drop because of the negative demand effects of higher real interest rates. A negative effect on lending may arise because credit demand decreases when financing costs increase. Lending may also fall because of a decrease in credit supply in the wake of a monetary tightening, motivated either by a deterioration of the financial position and thus the creditworthiness of firms and households, or by a drain of loanable funds from the banking sector via open market sales by the central bank. Property prices may fall because higher real interest rates imply a stronger discounting of current and future returns on property. Except for Australia, the Netherlands and Switzerland (almost significant), a shock to the real interest rate triggers a significant drop in real GDP. We also find that real lending is significantly reduced in the wake of a real interest rate shock. The exceptions are Germany and Australia, where the responses are also almost significantly negative. Property prices also fall significantly in all countries except for Germany.

6. Conclusions

Over the last two decades most industrialised countries have experienced pronounced boom and bust cycles in credit markets, often ending in economic distress and financial crises. These credit cycles have often coincided with cycles in economic activity and property markets. The coincidence of these cycles has already been widely documented in the literature, but few studies address the issue in a formal way. In particular, the role of property prices has not been explored to any significant degree. This paper attempts to partially fill this gap. Based on a cointegrating VAR we analyse the determinants of credit to the private non-bank sector in 16 industrialised countries over the period 1980-98 using quarterly data. Cointegration tests suggest that the long-run development of credit cannot be explained by standard credit demand factors, ie real GDP and the real interest rate. But once real property prices, measured as a weighted average of real residential and real commercial property prices, are added to the system, we are able to identify long-run relationships linking real credit positively to real GDP and real property prices and negatively to the real interest rate. The long-run relationships may be interpreted as long-run extended credit demand relationships, but we may capture effects on credit supply as well. A clear identification of the effects on credit demand and credit supply cannot be achieved. This is a well-known problem which will have to be addressed in future research.

The adopted multivariate approach enables us to analyse the dynamic interaction between real credit, real GDP, the real interest rate and real property prices. Based on the estimated vector error-correction models we use a standard Cholesky decomposition to compute orthogonalised impulse responses. The identified shocks represent isolated, autonomous changes in each of the endogenous variables. The impulse responses are in line with prior expectations. A rise in real GDP has a positive effect on lending and property prices. Increases in credit and increases in property prices trigger increases in output. We also find strong evidence of a significant two-way relationship between credit and property prices. Increases in property prices boost lending and vice versa.

Innovations to the real interest rate have significantly negative effects on real lending, real GDP and real property prices. Together with the significant negative long-run effect of real interest rates on credit, this finding could be interpreted as supporting the view that monetary authorities may, via their leverage over short-term interest rates, be able to smooth or even limit the occurrence of financial cycles. However, the finding that central banks have an instrument to influence credit conditions and asset prices does not guarantee that the instrument can be used to smooth financial cycles. Whether and how central banks should respond to changes in credit conditions and property prices therefore remains an important open issue for future research.

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Appendix

Appendix-Table 1
Property prices in industrialised countries

	Residential property prices	Commercial property prices
Australia	Established house price index Source: central bank	Sydney commercial property price index (CPPI) Source: central bank
Belgium	Index of house prices Source: Stadim, Antwerp	Brussels CPPI Source: Jones Lang LaSalle, London (JLL)
Canada	Average house price index Source: central bank	Ontario CPPI Source: Frank Russell Canada
Finland	National house price index Source: central bank	Helsinki CPPI Source: central bank
France:	Residential house price index Source: central bank	Paris CPPI Source: JLL
Germany	Average sales price of owner occupied dwellings in Frankfurt, Munich, Hamburg and Berlin Source: Ring Deutscher Makler	Frankfurt CPPI Source: JLL
Ireland	Average prices of new houses for which loans were approved by all lending agencies Source: Department of the Environment	National CPPI Source: Investment Property Databank, London
Italy	National house price index Source: central bank	Milan CPPI Source: JLL
Japan	Nationwide residential land price index Source: Japan Real Estate Institute	Nationwide commercial land price index Source: Japan Real Estate Institute
Netherlands	Price index for existing dwellings Source: central bank	Amsterdam CPPI Source: JLL
Norway	Sales price index for one family houses Source: central bank	Oslo CPPI Source: JLL
Sweden	Single-family house price index Source: central bank	Stockholm CPPI Source: JLL
Switzerland	National residential property price index Source: central bank	National CPPI Source: central bank
Spain	National house price index Source: central bank	Madrid CPPI Source: JLL
United Kingdom	All dwellings price index Source: Department of the Environment	London CPPI Source: JLL
United States	Single-family house price index Source: OFHEO and National Association of Realtors	National CPPI Source: NCREIF

Appendix-Table 2
Augmented Dickey-Fuller unit root test results

	Real credit		Real GDP		Real interest rate		Real property prices	
	Level	Change	Level	Change	Level	Change	Level	Change
United States	-3.03(T)	-3.27(C)	-2.47(T)	-5.80(C)	-2.78(C)	-8.14(N)	-2.15(C)	-2.67(N)
Japan	-2.16(C)	-3.45(N)	0.96(T)	-5.02(C)	-1.27(C)	-9.62(N)	-1.94(C)	-2.03(N)
Germany	-1.94(T)	-5.74(C)	-2.58(T)	-4.65(C)	-2.77(C)	-6.49(C)	-1.95(C)	-2.70(N)
France	-1.98(T)	-4.42(C)	-1.94(T)	-4.27(C)	-1.94(C)	-7.16(N)	-2.1(C)	-2.50(N)
Italy	-1.45(T)	-4.34(C)	-1.44(T)	-4.06(C)	-2.13(C)	-7.62(N)	-2.56(C)	-2.53(N)
United Kingdom	-2.27(C)	-2.45(N)	-2.54(T)	-3.77(C)	-2.79(C)	-10.75(N)	-1.46(C)	-4.39(N)
Canada	-2.60(T)	-3.35(C)	-1.54(T)	-3.60(C)	-2.58(C)	-3.36(N)	-3.12(T)	-2.61(C)
Australia	-1.95(T)	-3.20(C)	-2.59(T)	-6.61(C)	-2.41(C)	-3.78(N)	-2.34(C)	-3.69(N)
Spain	-3.17(T)	-2.91(C)	-7.86(T)	-3.52(C)	-2.10(C)	-6.18(N)	-2.12(C)	-2.38(N)
Netherlands	0.91(T)	-3.06(C)	-1.65(T)	-6.87((C)	-0.92(C)	-5.41(N)	-2.08(T)	-3.51(C)
Belgium	-2.19(T)	-3.07(C)	-2.54(T)	-4.15(C)	-2.11(C)	-7.15(N)	-3.43(T)	-6.39(C)
Ireland	-2.27(C)	-2.56(N)	-1.47(T)	-2.92(C)	-2.26(C)	-8.08(N)	-0.91(C)	-2.49(N)
Switzerland	-1.76(C)	-3.13(N)	-1.31(C)	-3.88(N)	-2.65(C)	-7.64(N)	-1.04(T)	-3.65(C)
Sweden	-1.29(C)	-2.81(N)	-2.15(T)	-3.71(C)	-2.36(C)	-5.76(N)	-2.47(C)	-2.17(N)
Norway	-1.80(T)	-2.91(C)	-1.68(T)	-7.40(C)	-1.51(C)	-6.14(N)	-2.62(C)	-2.43(N)
Finland	-1.74(C)	-2.34(N)	-2.15(T)	-4.23(C)	-1.61(C)	-8.08(N)	-1.64(C)	-4.13(N)

Note: T, C and N indicate whether the test regression includes a time trend and a constant (T), only a constant (C), or neither a trend nor a constant (N). The 5% critical values depend on the choice of the deterministic components of the model and are given by –3.49, –2.91, and –1.95 respectively (MacKinnon (1991)). Lag orders (not reported) were chosen by eliminating all lags up to the first significant lag, starting with a maximum lag order of eight. The specification of the deterministic terms was chosen based on the critical values reported in Dickey and Fuller (1981).

Appendix-Table 3
Specification and diagnostics for the minimal system

	Lag order	AC	H	N
United States	2	8.49	121.52	41.52*
Japan	5	1.90	168.05	33.71**
Germany	3	10.24	129.05	48.24**
France	6	14.47	83.36	17.95**
Italy	4	4.61	137.80	9.28
United Kingdom	3	6.23	105.71	7.55
Canada	5	14.92	183.52	16.92**
Australia	5	5.42	208.94	14.89*
Spain	8	12.73	315.75	19.00**
Netherlands	2	8.45	105.87	5.30
Belgium	4	9.95	172.64	11.14
Ireland	6	7.07	201.75	13.09*
Switzerland	3	9.62	202.94	6.14
Sweden	2	13.43	85.91	24.48**
Norway	3	4.08	110.85	10.98
Finland	3	7.98	199.42	15.26*

*Note: AC is a Lagrange Multiplier test for autocorrelation up to order 5, H is White's test for heteroskedasticity and N is a Jarque-Berra test for normality. All tests refer to the system as a whole. * and ** indicate significance of a test statistic at the 5% and 1% level respectively.*

Appendix-Table 4
Specification and diagnostics for the extended system

	Lag order	AC	H	N
United States	5	18.29	430.04	21.47**
Japan	2	10.75	183.32	48.16**
Germany	2	5.51	180.84	84.97**
France	6	13.60	520.37	31.11**
Italy	4	9.00	330.06	24.27**
United Kingdom	2	17.46	175.36	5.08
Canada	2	19.39	165.27	8.36
Australia	3	10.05	274.33	15.16
Spain	4	15.65	342.08	16.70*
Netherlands	2	16.04	203.04	12.17
Belgium	4	16.37	371.86	20.78**
Ireland	2	18.75	157.73	75.17**
Switzerland	3	14.28	251.01	7.88
Sweden	2	19.95	175.57	16.22*
Norway	2	11.45	179.14	8.72
Finland	3	24.68	254.52	10.66

*Note: AC is a Lagrange Multiplier test for autocorrelation up to order 5, H is White's test for heteroskedasticity and N is a Jarque-Berra test for normality. All tests refer to the system as a whole. * and ** indicate significance of a test statistic at the 5% and 1% level respectively.*

Appendix-Figure 1
Recursive Chow breakpoint for the extended system

Note: The figures display the recursive Chow breakpoint test statistic relative to the 5% critical value.

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