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Bank lending and commercial property cycles: some cross-country evidence

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Abstract

Motivated by the frequently observed link between commercial property price volatility and banking crises, this paper investigates at a macroeconomic level the determination of commercial property prices and the interaction between commercial property prices and bank lending. We develop a reduced-form theoretical model which suggests bank lending is closely related to commercial property prices and that commercial property can develop cycles given plausible assumptions, where the cycles are largely driven by the dynamic linkage between the commercial property sector, bank credit and the macroeconomy. Cross-country empirical analysis based on a sample of 17 developed economies, using a unique dataset collected by the BIS, confirms the model's predictions. An investigation of determinants of commercial property prices shows particularly strong links of credit to commercial property in the countries that experienced banking crises linked to property losses in 1985-95. Further studies of dynamic interaction suggest that commercial property prices are rather "autonomous", in that they tend to cause credit expansion, rather than excessive bank lending boosting property prices. In addition, GDP has an important influence on both commercial property prices and bank credit. The work has implications for risk management and prudential supervision.

Keywords: commercial property prices, bank credit, time series analysis

JEL classification: G12, G21

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I. Introduction[1]

Over the past decade there has been growing interest in and ongoing research into commercial property cycles and their interaction with financial stability. Unlike residential property, which can provide accommodation to its owners and has an intrinsic reservation value, the value of commercial property is determined by the value of future rents. The demand for commercial property is more likely to be affected by the business environment and economic confidence. In addition, some unique characteristics of the commercial property market (such as longer construction lags, longer leases and different funding methods) may cause the commercial and residential property cycles to show distinctive dynamic behaviour and to interact with the financial system and the real economy in different ways (Green (1997), ECB (2000)). Tsolacos (1999) furthermore points out that commercial property cycles may be asynchronous across regions and sectors, while Wheaton (1999) notes that different types of commercial property may themselves have varying dynamics, depending on the elasticity of supply, development lags and the durability of the real estate assets.

Banks play a crucial role in the financing of commercial real estate. They lend for the purchase of land for development and existing buildings; they finance construction projects; they lend to non-banks and finance companies that may finance real estate; and they lend to non-financial firms based on real estate collateral. The lending attitude of bankers therefore has a major impact on the behaviour of property investments and transactions. On the other hand, the state of the commercial property sector affects the performance of the banking sector (Allen et al (1995)). Declining property prices increase the proportion of non-performing loans, lead to a deterioration in banks' balance sheets and weaken banks' capital bases. Not surprisingly, most existing theories highlight a close connection between these two sectors. As Herring and Wachter (1999) pointed out, property cycles may occur without banking crises, and banking crises may occur without real estate cycles. But these two phenomena have been correlated in a remarkable number of instances in a wide range of countries.

However, empirical evidence at a macroeconomic level on the interaction between commercial property cycles and credit cycles has been sparse and limited, mainly due to a lack of historical data on the commercial property sector. Much of the research on this matter to date has been focused on the residential property sector or on a single regional office market. To our knowledge, this paper is the first to explore the cross-country evidence on the determination of commercial property prices, as well as the dynamic relationship between bank lending and commercial property prices. We employ annual data for 17 countries. We utilise standard single equation techniques (namely error correction modelling in the tradition of Hendry and GARCH modelling of variance) to assess determinants of commercial property prices, while we also employ Granger causality, VECM and VAR approaches to address interactions between credit and commercial property price series.

The remainder of this paper is organised as follows. In Section II we review the theoretical and empirical literature on real estate cycles and the relationship between credit and commercial property prices. In Section III we develop a model of real estate cycles, which is tested in our empirical work. In Section IV we examine econometrically the determination of commercial property prices, and in Section V we test for dynamic interactions between lending, prices and GDP. Section VI concludes.

II. Literature review

Reflecting the aim of the study, to obtain a comprehensive view of the behaviour of commercial property prices at a macroeconomic level, this section is divided into two parts. First in Section II.1 we examine the literature on the determination of commercial property prices per se. Then in Section II.2

[1] The authors thank Steve Arthur and Philippe Hainaut for data support, and Claudio Borio, Joseph Bisignano, Patrick McGuire, Kostas Tsatsaronis and participants in seminars at the Bank for International Settlements and Brunel University for comments.

we look at extant theoretical and empirical work on the interaction between commercial property prices and bank lending.

II.1 Explanations of real estate cycles

II.1.1 Theory

The economic determination of commercial property prices is in many ways similar to that of other assets, with the key determining factors being (i) the discounted present value of future rents (composed of the current level of rents and their expected growth over the expected life of the building), and (ii) the real long-term interest rate as augmented by the risk premium as a discount factor. Equally, real estate investment, as for other capital goods, may be seen as determined by a form of valuation ratio as suggested in Tobin (1969). The theory implies that investment should be an increasing function of the ratio of the capitalised financial value of the investment project relative to the replacement (purchase) cost of the unit of capital. Whereas the standard application uses equity prices, it is natural to use commercial property prices in the numerator for real estate developments. In this context, cyclicality can naturally arise from the economic cycle, changes in interest rates and the risk premium.

Nevertheless, the commercial property market also has a number of distinctive features relative to other asset markets. As noted by Hilbers et al (2001), these include heterogeneous supply; the absence of a central trading market; infrequent trades; high transactions costs; the lack of price transparency owing to the role of bilateral negotiations; rigid and constrained supply; and the use of real estate as collateral for lending. There are also long-term rental contracts and a twofold reliance on external finance: short-term to cover construction and longer-term mortgage finance for the occupancy period. Although equity financing is feasible, historically there has generally been a reliance on debt financing with high loan-to-value ratios.[2]

These features can give rise to cyclical behaviour, with for example investor optimism about future rents generating excess demand and driving up prices (Carey (1990)) while supply response is slow. But over time, because of lags combined with imperfect foresight, supply may ultimately become excessive relative to demand. Traditionally, the cyclical movements in property prices have been explained as results of sticky supply and rents in combination with certain irrationalities in the market. Hendershott (1994) and MacFarlane (1998) propose that "myopia" or the so-called "rule of thumb" expectation causes overvaluation of properties. When real estate prices rise above the replacement costs, constructors and developers will initiate new construction based on current property prices. However, as new construction may take several years to be completed, the adjustment process is slow. By the time the construction is delivered, the market demand may have fallen and the resulting oversupply situation forces property prices to decline.[3] Following the same line, Herring and Wachter (1999) posit "disaster myopia" in property lending explaining systematic overlending, which may interact with the effect of rising real estate prices on banks' own fixed assets and capital. Banks may simply disregard the impact of low-frequency shocks in good times, and the disaster myopia may easily turn into disaster magnification once a shock occurs.

These hypotheses are subject to the rational expectations critique, that investors should learn from experience and avoid systematic errors. According to this view, market participants should be able to forecast demand and supply accurately, with the market equilibrium only being disturbed by unanticipated and unforecastable shocks. For example, Hendershott and Kane (1992) highlight the US tax reform of 1981 as well as poor regulation of depository institutions as causes of overbuilding in the 1980s. Whereas such random shocks might only be expected to cause a temporary deviation from

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2 Some important distinctions between real estate and other large investment projects such as steel plants include the lack of ongoing cash flow to back up new investment, the pervasiveness of real estate investment across regions or countries, and the imperfection of information (eg about competing office blocks being planned contiguous to one another) that may cause herding in new construction activities.

3 Later, Wheaton (1999) showed in a formal model that an endogenous property cycle is much more likely to arise in a "myopic expectations" environment (although, as discussed below, it is neither a sufficient nor a necessary condition).

equilibrium, other researchers have shown that rational expectations need not be inconsistent with real estate cycles.

At a basic level, Collyns and Senhadji (2002) point out that some features necessary for rational expectations to operate, such as sophisticated investors selling short when the price rises above fundamentals, are absent for real estate. There are no futures or options markets for land.

In the real estate literature, Grenadier (1995) showed that if there is “anticipated uncertainty”, overbuilding could occur because there is an option value of holding vacant space due to adjustment costs. Arguably price volatility could have similar effects. Or such anticipated uncertainty can give rise to game-theoretic strategic behaviour among developers, where information externalities lead them to all construct or wait together (Grenadier (1996)). Wheaton (1999) showed that cycles could also occur in real estate when all actors behave rationally and there is no anticipated uncertainty, given certain institutional features (such as long leases or the use of credit that give rise to “historic” dependence of investment on current market prices). In the former case, prices incorporate past as well as future rents, since leases have varying lengths and start dates. In the case of credit, moral hazard and asymmetric information give rise to a risk of default even before the project is complete, implying that the liquidation value of the real estate as indicated by the current price has a key influence.

Cyclical movements in commercial property prices often exhibit strong linkages with credit cycles due to the predominant reliance on debt financing in most countries. In the finance literature, the interaction between the two cycles has been extensively explored in the “financial accelerator” framework, represented by Kiyotaki and Moore (1997), Bernanke et al (1994) and Aoki et al (2002). They consider the situation where the credit market is imperfect due to asymmetric information between borrowers and lenders. In their models, borrowing conditions are determined by the net value of real estate assets (as collateral). Increases in land prices lower the external finance premium[4] and improve credit availability for borrowers, hence boosting the demand for real estate assets and driving property prices even higher. By contrast, falling property prices tend to generate downward-spiral movements of the value of real estate assets and the volume of bank loans as credit rationing intensifies.

Another model in which bubbles and crises are shown to arise in a rational world is developed by Allen and Gale (2000). They propose that important driving forces behind upturns in the lending and property cycles include risk-shifting behaviour by banks (related to agency problems) and their expectations of continued credit growth, which may in turn be influenced by its volatility.

II.1.2 Empirical work

On the empirical side, there has been quite extensive work on the determinants of investment, rents and prices within the commercial real estate sector. For example, McGough and Tsolacos (1999) examine office development in the United Kingdom, finding in the context of an unrestricted vector autoregression (VAR) that rents and service sector output are the key determinants of investment, rather than employment and interest rates. They find a three-year lag from the price/rent signal to office opening. Wheaton et al (1997), also focusing on the United Kingdom, highlight a role of employment in services but also highlight the effect of changes in building restrictions. More generally, the hypothesis of gradual adjustments of supply and rents has been supported by extensive empirical evidence, including Wheaton (1987), Baum (1999), Wheaton and Torto (1994) and Hendershott (1996).

In addition to the above studies on national real estate markets, there has also been financial-economics work on the international correlation of commercial real estate returns. Whereas hitherto most studies, such as Eichholz (1996), have found real estate relatively uncorrelated, and hence a good source of diversification, Case et al (1999) find that real estate returns are “surprisingly high” despite the economic segmentation and lack until recently of securitisation of real estate property companies. Using data for the 1990s, they suggest that correlations across markets link strongly to effects of changes in global GDP.

[4] That is, the excess of the cost to a company of external bank or market finance over the cost of financing from retained earnings.

As regards bubbles in property prices, Higgins and Osler (1997), focusing solely on house prices rather than credit, suggest there is evidence of bubbles in the asset markets of the late 1980s, with price declines driven by previous rises in OECD countries rather than changes in fundamentals. Peng (2002) tests bubble terms in the Hong Kong housing market.

II.2 Property prices, bank lending and financial instability

II.2.1 Theory

Some research effort has been devoted to examining the linkages between financial instability and downturns in commercial property markets. One major observation is that commercial property market booms and busts have preceded banking crises, not only in industrial countries (ECB (2000), Davis (1995)) but in emerging market economies as well (Collyns and Senhadji (2002), Davis (1999a), Renaud (1999)). Based on the above hypotheses of commercial property cycles, there are at least three dimensions of interaction between commercial property prices and bank lending.

First, property prices may affect the volume of bank credit for various reasons. From the borrowers' point of view, changes in property prices will have a large effect on their perceived wealth and borrowing capacity, inducing them to change their borrowing plans and credit demand (given positive costs of bankruptcy when net worth becomes negative). The low liquidity and price volatility of property should induce caution among borrowers in taking full account of property price rises, however.

From the banks' point of view, banks have been involved in real estate markets not only directly by owning properties and extending real estate loans, but also by providing loans that are collateralised by real estate assets. Lending to property and construction companies alone is one of the most procyclical and volatile elements of banks' provisioning (Davis (1993)). Accordingly, adding these mechanisms together, changes in property prices will have major impacts on banks' asset quality and the value of bank capital, and therefore affect banks' lending capacity. Banks are willing to provide more property-related loans at cheaper terms when property prices are higher, generating a propagation mechanism though which property and credit cycles are strongly linked with each other. Such a cycle may be exacerbated by capital inflows intermediated by domestic banks, as in East Asia in the mid-1990s, as well as poor regulation (Collyns and Senhadji (2002)).

A further complementary effect may operate via the above-mentioned financial accelerator mechanism, whereby lenders become less concerned about moral hazard and adverse selection when net worth is high, as borrowers have more to lose from default. This implies that changes in asset prices over the cycle give rise to procyclical feedback effects of agency costs on the cost of external finance and hence on real corporate expenditures. This channel might be more powerful if banks tend to underestimate the default risk of property-related loans in a real estate boom - and the moral hazard to which borrowers financing real estate are subject. In practice, this tendency can be the result of various factors, including poor risk management practice, inadequate data or pervasive incentives of banks, including moral hazard linked to the safety net (Herring and Wachter (2002)).

Second, bank lending may affect property prices via various liquidity effects. Changes in credit availability and lending attitudes have a sizeable impact on the demand for real estate and investment decisions on new construction, which will ultimately lead to changes in property prices.[5] It has been widely documented[6] that floods of capital seeking investment opportunities and the "industrial" competition among financial institutions after financial deregulation helped to stimulate the building frenzy phenomenon in a number of countries in the 1980s and 1990s. Following the same line,

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5 An imponderable factor at the time of writing is whether changing sources of finance will affect the nature and dynamics of the commercial property cycle and its link to bank lending. Zhu (2002) highlights the fact that the late 1990s were not characterised by strong commercial property cycles, and attributes this partly to shifts towards equity and securitised debt financing of commercial property projects, which even out the flow of credit, improve information transparency and enable risk to be spread. But he also notes that the overhang of the 1980s boom may still be being absorbed, while closer integration with capital markets could make commercial property more vulnerable to external shocks such as those arising from the Russia/LTCM crisis (Davis (1999b)).

6 See Davis (1995), Demirguc-Kunt and Detragiache (1998), G10 (2002), Hendershott and Kane (1992), Kummerow (1998) and Renaud (1994) for detailed descriptions.

Krugman (1998) and Renaud (1998) emphasise that the moral hazard problem caused by the safety net is the key to understanding the asset price bubbles and subsequent banking crises in East Asian countries. Hargraves et al (1993) note in addition that liberalisation tends to drive the higher-quality corporate borrowers to the bond market and depositors to money funds, thus leading banks to take excessive risks to re-establish margins.

Finally, credit and property cycles can be driven by common economic factors. On the one hand, credit cycle behaviour is largely determined by economic conditions and prospects (notably GDP and interest rates). On the other hand, the state of economic activity also exerts important forces on the commercial property market. Changes in the business environment will cause demand and supply imbalances in commercial property and generate variations in real estate investments and prices. These external shocks can arise from the demand side, such as changes in income, interest rates and demographic factors; or they can arise from the supply side, such as labour and construction costs as well as changes in restrictions enhancing the availability of credit or land for development (Dokko et al (1999), Chen and Patel (1998)).

II.2.2 Empirical work

Most empirical research in this area focuses on the residential property sector for reasons of data availability. Country-specific studies reveal strong evidence of dynamic interactions between house prices and bank lending in Hong Kong (Gerlach and Peng (2002)), the Netherlands (de Greef et al (2000), Rouwendal and Alessie (2002)) and the United States (Quigley (1999)). Gerlach and Peng, for example, find both short-term and long-term causality running from property prices to lending but not the opposite. They also highlight the effect of regulatory changes on credit expansion. Quigley shows that the "history" of house prices plays an important role in their determination and not merely fundamentals. He also suggests that moral hazard and overlending drive property price bubbles, for example in East Asia in the 1990s. Hofmann (2001a) looks into a panel of 16 countries and finds evidence that bank lending and house prices have a significant two-way interaction in the short run but that long-run causality is from property prices to bank lending. Goodhart (1995) investigates the role of house prices in determining credit growth in the United Kingdom and the United States. He finds that changes in house prices significantly affected credit growth in the United Kingdom but not in the United States.

There are also a few studies based on asset prices that include a mix of residential and commercial property prices (generally with a much higher weight on residential property). Goodhart (1995) explains credit conditions with asset prices, while Borio et al (1994) explain asset prices with credit conditions (debt/GDP ratio), and both find significant results. Hofmann (2001b) includes a mixture of residential and commercial property prices in a vector error correction model (VECM) structure and again finds a strong dynamic interdependence between bank credit and property prices with the latter being the causal element. He also finds that fluctuations in bank credit and property prices are jointly determined by changes in real short-term interest rates. He notes that a difficulty with most macro level work - including his own - is to distinguish between credit demand and credit supply effects of real estate prices, both of which may be operative. Recently, Borio and Lowe (2002) have shown that credit growth and property prices have predictive power over financial instability using the Kaminsky and Reinhart (1999) framework. Pugh and Dehesh (2001) argue that financial liberalisation has contributed to a closer interdependence between property and financial sector developments in a number of countries since the 1980s.[7]

The conclusion of this review is that, in contrast to the extensive work on real estate per se, and despite its importance in banking crises and the extent of theoretical work, no major academic research project has yet looked at links to bank lending from the commercial property sector on a

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[7] In addition, some recent studies have looked into the real effects of house price fluctuations. Work by Higgins and Osler (1997) and Helbling and Terrones (2003) find that house price busts cause reductions in output, especially in bank-based financial systems. Hendershott and Kane (1992) note that the early 1990s credit crunch in the United States could be partly attributed to capital rebuilding by financial institutions that had made large real estate losses. Moreover, on the demand side the recession itself may have linked to a collapse in investment reflecting excessive capital formation in terms of real estate. Ludwig and Slok (2002) suggest that, in market-based economies, housing prices tend to have a significant effect on consumption; similar evidence is provided by Boone et al (2001) and Barrell and Davis (2004).

systematic, empirical, cross-country basis. This is an important motivation for our own work set out below.

III. A model of real estate cycles

Following on from the literature survey, in this section we develop a theoretical model of real estate cycles based on the work of Carey (1990) and Wheaton (1999). The supply of commercial property is fixed in the short run. In the long run, the supply adjusts gradually because of lags in the delivery of new construction, including new licences for development. The new construction is funded by the banking industry, whose lending decisions are mainly based on the value of property-based collateral. In common with other asset prices, commercial property prices are linked to expectations of future returns and can adjust relatively rapidly to reflect changes in market conditions. Thus property prices react rather quickly to economic shocks, while the volume of physical assets responds in a sticky way.

We explain commercial property cycles as the results of two possible mechanisms. On the one hand, exogenous business cycle shocks – such as ups and downs in output, inflation rates and interest rates – exert a cyclical influence on commercial property prices. On the other hand, there are intrinsic characteristics of the real estate market that tend to amplify these exogenous shocks, causing overproduction of properties and generating endogenous cycles. The two types of property cycles may coexist and their relative importance may differ across sectors and regions.

III.1 The economic environment

The model setup is as follows. There are N potential investors in the economy. All investors are identical except that they have different reservation prices of properties, either because they have private information or they have different valuation methods. In aggregate, these individual reservation prices follow a cumulative distribution function of $F(P)$ where P is the commercial property price.

The banking industry is the single most important funding source for the real estate sector. An optimistic investor, whose reservation price is higher than the market price, will borrow from the banks to finance his purchase of properties. The amount an investor can borrow from the banks (L represents bank lending for property purchase) increases in his endowment (Y_t, which may be proxied by real GDP or personal disposable income) and decreases in interest rates (i_t). It also depends on the banks' lending attitude (w_t). Importantly, credit availability for property purchasers also depends on the level of commercial property prices. Higher property prices increase bank lending for two reasons. First, as properties are usually used as collateral assets, higher property prices indicate a higher collateral value and a smaller probability of default (including via moral hazard and adverse selection). Second, the banks may invest in commercial properties. A booming property market strengthens the capital base of the banking industry and therefore the banks are able to lend more.

On the supply side, the supply of commercial property is fixed in the short run but can adjust gradually to changes in market conditions. When property prices rise above their replacement cost (analogous to a Tobin's Q above 1), builders will start new construction. However, it will take several years before the new construction is completed. Compared with residential properties, commercial properties (especially the office market or shopping centres) may take even longer because of restrictions in getting planning permission. For simplicity, in this model we assume that there is a one-period lag between the new construction and its delivery date.

Another key assumption is the historical dependence of investment decisions, ie the amount of investment in new construction is determined by *current* property prices rather than being based on a rational expectation of future property prices when the new construction will be completed. We believe this assumption is reasonable for the following reasons. First, irrational market expectations, such as adaptive expectation or "myopia" forecasting, induce the investors and bankers to extrapolate the current property price (or recent growth rate of property prices) forward.[8] As a result, the expected

[8] Case and Shiller (1989) look into the US single-family home market and find strong evidence that some form of irrationality exists in the property market.

future property price is determined by its current level. Second, banks themselves invest in the property sector. Higher property prices strengthen the capital base of the banking industry and therefore increase their lending capacity. Third, modern financial economics shows that this historical dependence is likely to exist even when all investors are rational. In particular, Kiyotaki and Moore (1997) and Bernanke and Gertler (1989) suggest that this could be attributed to credit market imperfection, notably moral hazard and adverse selection in lending given the presence of asymmetric information. Existence of a borrowing constraint (in the KM model) or state verification costs (in the BG model) generates a historical dependence of the credit availability cycle, which interplays with asset (real estate) price cycle to cause booms and busts.

To summarise, the dynamics of the property market is determined by:

$$D_t \equiv \frac{N[1-F(P_t)]L(Y_t, i_t, P_t, w_t)}{P_t}, \qquad L_Y > 0, \quad L_i < 0, \quad L_P > 0 \tag{1}$$

$$K_t = (1-\delta)K_{t-1} + I_{t-1} \tag{2}$$

$$I_{t-1} = \alpha \cdot B_{t-1}(Y_{t-1}, i_{t-1}, P_{t-1}, w_{t-1}), \qquad B_Y > 0, \quad B_i < 0, \quad B_P > 0 \tag{3}$$

$$D_t = K_t \tag{4}$$

Equation (1) is the market demand function, which depends on the number of optimistic buyers who are willing to purchase commercial property at the current market price and the borrowing capacity for each of them. Here the lending attitude variable (w_t) is included to reflect a potential impact from structural changes in the banking industry, such as financial liberalisation and introduction of government guarantees. Equation (2) is the adjustment function of the stock of market supply of buildings *K*, in which δ is the depreciation rate and I_{t-1} is the completed new construction (which was started one period earlier). Equation (3) specifies that new construction put in place at time t-1 is a linear function of new construction financing (*B*) during the same period. Note that *B* is distinct from *L*, which is bank loan finance to purchase existing buildings. The amount of bank lending to developers and constructors for new buildings increases in the level of income or economic activity, decreases in the interest rate and also changes with the prevalent lending attitude. Most importantly, it again increases in *current* property prices for the reasons mentioned above. Equation (4) is the market-clearing condition at each period.[9]

The above four-unknown (*D, K, I* and *P*), four-equation system can be simplified by plugging equation (3) into (2) and by using equation (4) in (1). The two new equations (5) and (6), one determining the current-period market price and the other reflecting the gradual adjustment of market supply, lie at the heart of the dynamics of the property market.

$$K_t = \frac{N[1-F(P_t)]L(Y_t, i_t, P_t, w_t)}{P_t} \tag{5}$$

$$K_t = (1-\delta) \cdot K_{t-1} + \alpha \cdot B_{t-1}(Y_{t-1}, i_{t-1}, P_{t-1}, w_{t-1}) \tag{6}$$

In the equilibrium, the amount of commercial property (K^*) and its market price (P^*) (for given *Y* and *i*) are constant.[10] Straightforwardly, they are jointly determined by:

$$K^* = \frac{N[1-F(P^*)]L(Y, i, P^*, w)}{P^*} \tag{7}$$

$$\delta \cdot K^* = \alpha \cdot B^*(Y, i, P^*, w) \tag{8}$$

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[9] Vacancy is ignored in this model.

[10] It can be easily extended to incorporate a balanced-growth equilibrium if these variables are normalised.

III.2 Dynamics of property prices

The above dynamic system (equations (1) to (4)) incorporates the three-dimensional connections between bank lending and property prices. First, higher property prices improve the borrowers' balance sheets and increase the value of collateral assets. The property loans are perceived to be less likely to default, therefore banks are induced to increase their lending to the property sector and property-related industries. Second, bank lending is important in determining property prices. If banks lend more to finance the purchase of properties, it will boost the market demand and increase property prices. If banks instead extend credit to finance the construction of new buildings, property prices will eventually adjust downwards due to increases in supply. Due to the existence of lags in supply, the latter effect usually takes longer to be incorporated into property prices than the former one. Therefore, even though it is difficult to distinguish the credit for purchasing (*L*) from that for new construction (*B*) in the data, a reasonable prediction is that bank credit tends to drive up property prices in the short run (due to the immediate demand effect) but depress property prices in the long run (due to the lagged supply effect). Finally, both bank lending and commercial property prices are driven by common economic factors, such as productivity shocks, fiscal policy shifts, interest rate shocks and shifts in market perception. Overall economic conditions affect the banks' profitability, change the market perception on the value of property assets, and influence the investment decisions. These common factors, together with the interactive impact between the two sectors, generate a linked property and credit cycle.

In the remaining part of this section, we will illustrate how a macroeconomic or structural shock could generate oscillations in property operations before they finally reach the new steady state. Suppose that a permanent income shock occurs at time 0, ie, $\Delta Y_0>0$, $\Delta Y_t=0$ for $t>0$. By totally differentiating equations (5) and (6), the dynamics of K_t and P_t after the shock is determined by:[11]

$$\begin{bmatrix} 1 & -\dfrac{dD_t}{dP_t} \\ 1 & 0 \end{bmatrix} \cdot \begin{bmatrix} dK_t \\ dP_t \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 1-\delta & \alpha \cdot \dfrac{dB_{t-1}}{dP_{t-1}} \end{bmatrix} \cdot \begin{bmatrix} dK_{t-1} \\ dP_{t-1} \end{bmatrix} + \begin{bmatrix} \dfrac{dD_t}{dY_y} \Delta Y_t \\ \alpha \dfrac{dB_{t-1}}{dY_{t-1}} \Delta Y_{t-1} \end{bmatrix}$$

After some rearrangements, the dynamic equations can be rewritten as:

$$\begin{bmatrix} dK_t \\ dP_t \end{bmatrix} = \begin{bmatrix} 1-\delta & \alpha \cdot dB_{t-1}/dP_{t-1} \\ \dfrac{1-\delta}{dD_t/dP_t} & \alpha \cdot \dfrac{dB_{t-1}/dP_{t-1}}{dD_t/dP_t} \end{bmatrix} \cdot \begin{bmatrix} dK_{t-1} \\ dP_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha \dfrac{dB_{t-1}}{dY_{t-1}} \Delta Y_{t-1} \\ -\dfrac{dD_t/dY_t}{dD_t/dP_t} \Delta Y_t + \alpha \dfrac{dB_{t-1}/dY_{t-1}}{dD_t/dP_t} \Delta Y_{t-1} \end{bmatrix} \quad (9)$$

If the market is initially in a steady state and suddenly an unanticipated income shock occurs, the property prices and new construction activities will increase, and then move to the new steady state equilibrium in the long run. However, whether the process turns out to be a monotonic convergence or an oscillation around the new steady state depends on the structural characteristics of the property market.

Remark: the responses of property prices to macroeconomic shocks depend on the relative magnitude of the elasticity of supply versus the elasticity of demand. Define $\lambda \equiv 1-\delta+\alpha \cdot (dB/dP)/(dD/dP)$: (1) when the supply is more elastic than the demand ($-1<\lambda<0$),[12] the market reacts to a permanent demand shock in the form of an oscillation around the new steady state; (2) when $0<\lambda<1$, property prices "overshoot" and then gradually converge to the new steady state.

Proof: from equation (9), it is straightforward that

[11] Note that *L* (lending to purchase properties) drops out – it is determined by changes in *Y* and *P* – while lending attitude (*w*) and interest rate (*i*) are assumed to be fixed.

[12] Notice that this condition is equivalent to $(dB/dP)/(|dD/dP|)>(1-\alpha)/\delta$.

$$\begin{bmatrix} dK_0 \\ dP_0 \end{bmatrix} = \begin{bmatrix} 0 \\ -\dfrac{dD_0 / dY_0}{dD_0 / dP_0} \end{bmatrix} \cdot \Delta Y_0 = \begin{bmatrix} 0 \\ + \end{bmatrix}$$

$$\begin{bmatrix} dK_1 \\ dP_1 \end{bmatrix} = \begin{bmatrix} 1-\delta & \alpha \cdot dB_0 / dP_0 \\ \dfrac{1-\delta}{dD_1 / dP_1} & \alpha \cdot \dfrac{dB_0 / dP_0}{dD_1 / dP_1} \end{bmatrix} \cdot \begin{bmatrix} dK_0 \\ dP_0 \end{bmatrix} + \begin{bmatrix} \alpha \dfrac{dB_0}{dY_0} \\ \alpha \dfrac{dB_0 / dY_0}{dD_1 / dP_1} \end{bmatrix} \cdot \Delta Y_0 = \begin{bmatrix} + \\ - \end{bmatrix} \quad (10)$$

$$\begin{bmatrix} dK_t \\ dP_t \end{bmatrix} = \begin{bmatrix} 1-\delta & \alpha \cdot dB_{t-1} / dP_{t-1} \\ \dfrac{1-\delta}{dD_t / dP_t} & \alpha \cdot \dfrac{dB_{t-1} / dP_{t-1}}{dD_t / dP_t} \end{bmatrix} \cdot \begin{bmatrix} dK_{t-1} \\ dP_{t-1} \end{bmatrix} \qquad for \quad t \geq 2$$

That is, when a positive income shock occurs, the demand for property increases immediately. But the supply stays fixed. Therefore the property price suddenly jumps up at period 0. At period 1, the new construction that started in period 1 is completed, yet demand remains the same as in period 0. The oversupply drags down the market price until the market clears at the new price level. After period 1, the dynamics of property prices and construction activities are less clear. Notice that the quantity of property supply and property prices move in opposite directions ($dK_t/dP_t=dD_t/dP_t<0$ from the dynamic equations). Because the property price is determined by equalising the supply and demand at each period, P_t and K_t are actually moving along the same downward-sloping demand curve across time. Moreover, another important observation from equation (10) is:

$$\begin{aligned} dK_t &= (1-\delta) dK_{t-1} + \alpha \frac{dB_{t-1}}{dP_{t-1}} dP_{t-1} \\ &= (1-\delta) dK_{t-1} + \alpha \frac{dB_{t-1} / dP_{t-1}}{dD_{t-1} / dP_{t-1}} dK_{t-1} \\ &= [1-\delta + \frac{\alpha \cdot dB_{t-1} / dP_{t-1}}{dD_{t-1} / dP_{t-1}}] dK_{t-1} \end{aligned}$$

When the elasticity of supply is larger than the elasticity of demand, property supply and price exhibit oscillation (over- and under-building) before moving to the new equilibrium. Only when the elasticity of supply is smaller will the supply and price gradually converge to the new equilibrium level without exhibiting oscillations.[13] In other words, the responses of property prices to economic shocks depend on the characteristics of demand and supply factors in a particular market.

Following the same line, the model can also be developed to explain the formation of bubbles in the real estate market. One possible channel is through changes in the banks' lending attitude (*w*), which are often connected with financial liberalisation or structural changes in the banking industry.[14] In many situations financial liberalisation introduces intensive competition among lenders and leads to an expansion of credit. As the amount of credit available for lending to investors increases, real estate prices climb. Such a credit-driven expansion can cause property prices to be much higher than in the old situation. The boom period could be prolonged if increases in property prices encourage inflows of foreign capital. However, when the impact of the building frenzy starts to kick in and the supply of new construction cannot be absorbed by the market, property prices are forced to move downwards. When bank credit is very sensitive to the value of property assets, such a cyclical movement tends to be amplified and appears as a boom and a subsequent bust.

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13 The effect of interest rate shocks (*i*) can be analysed in the same way.

14 An alternative channel for real estate bubbles is when investors update their perception on property values using the adaptive expectation method, ie they tend to be more optimistic when property prices move up. During an upturn phase market participants are willing to pay more for a property. The rising demand in turn drives the price even higher. Such a spiral interaction causes the property price to be much higher than if market perceptions are relatively stable.

In summary, our simplified framework is able to incorporate some key elements in the determination of the commercial property cycle and its interaction with the credit cycle, even though the partial-equilibrium setting ignores other aspects of the linkages (such as the feedback effect from property prices to the macroeconomy). First, the model predicts a common set of macroeconomic and structural factors that drive property price movements, and meanwhile suggests that the direction and the size of responses could vary across countries. Depending on the responsiveness of market supply, property prices may react to macroeconomic shocks in the form of either a hump-shaped or a cyclic movement. Second, the model suggests strong interlinkages between the property sector and bank credit. Higher property prices encourage the expansion of bank lending to the property sector. In reverse, increases in bank credit tend to boost the property market in the short term, but the impact will turn negative in the long run due to excessive supply of new construction. Moreover, our analysis also shows that structural changes in the market, such as financial liberalisation, fiscal changes relating to real estate and land policy reform, will substantially change market behaviour and therefore warrant special attention.

IV. Empirical analysis: determination of commercial property prices

We now go on to assess the determinants of commercial property prices and (in Section V) their interrelation with bank lending. Our empirical work covers 17 countries, namely Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States. Data were from the BIS macroeconomic database and its database of commercial property prices. Note that in a number of cases the data cover the largest cities rather than the country as a whole. Data for commercial property prices are available from 1970 onwards except for Canada (starting in 1985), Germany (1971), Spain (1980), Finland (1971), Ireland, (1982), Italy (1983) and the United States (1977). Shorter data periods for some countries may obviously affect the econometric estimates.

Following the analytical model and the literature review, our empirical work focuses mainly on five key variables, namely real commercial property prices per se (deflated by the CPI), real credit to the private sector, real GDP, the real short interest rate (nominal short rate less the CED inflation rate) and real private investment. Note that the credit and investment variables are "wider" than is fully desirable, in that we would ideally have credit to the corporate sector and business sector investment in buildings, but these are the narrowest definitions which are consistently available for our 17 countries. The real short rate is chosen in preference to the long rate as it indicates impulses generated by monetary policy action, the long rate being more part of the transmission process. The credit variable does not distinguish between loans from domestic and foreign banks, where the latter can be influenced by macroeconomic and financial conditions abroad.[15]

Although all data are available quarterly, the frequency of commercial property source data is actually quarterly only for Australia, Canada, Ireland, Switzerland and the United States. It is half-yearly for Japan; elsewhere, annual data have been interpolated. This affects the usefulness of some of the desirable analysis; in particular, it makes the use of GARCH estimation less meaningful for the remaining countries' commercial property prices, namely those of Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden and the United Kingdom. It also means that work on the dynamics of property prices will be poorly determined. With these arguments in mind, we have employed annual data for our main regressions, with the exception of some experiments with GARCH for the countries where there are genuine higher-frequency data.

A first test to undertake before choosing a specification is to assess stationarity. As shown in Table 1 (ADF tests without a trend), we find that logs of real commercial property prices, real credit, real GDP and real investment all need to be differenced for stationarity. Meanwhile, the levels of real short rates are close to borderline stationary in many countries, where theory acknowledges that they have to be

[15] In practice, most OECD countries' lending is domestically sourced. Hence this factor may have been more important in East Asia in the 1990s, for example.

stationary in the long run. We generally treat real short rates as stationary and the other variables as having a unit root.

We estimated an error correction model on panel data (an unbalanced panel using all available data), simplified to the significant variables. This allows short-run as well as long-run influences on commercial property prices to be discerned. Such a model was originally popularised for the consumption function by Davidson et al (1978). Pesaran and Shin (1995) argue that such an autoregressive-distributed-lag approach can give a helpful approach to cointegration analysis. We can also enter real short rates in levels as implicit I(0) variables. Results are shown in Table 2. Of course, this approach will average out country-specific effects, which are investigated in detail below.

We first comment on our panel estimate for all countries together – 439 observations. The methodology was GLS,[16] with fixed effects and cross section weights which allow for cross section heteroskedasticity. Standard errors are White heteroskedasticity consistent. There is shown to be a close positive short-run relation between growth in credit and commercial property prices, as well as with GDP growth, all of which are consistent with the theoretical model. Note that the elasticity with respect to GDP is well over one, suggesting high volatility with respect to the cycle. It is interesting to note that similar coefficients – 1.8 on GDP growth and 0.8 on credit growth – were found for the five Asian crisis countries over 1979-2001 by Collyns and Senhadji (2002).

These results have implications for credit risk and hence should influence loan pricing and capital adequacy. This is because they show a high cyclical "beta" on commercial property with an additional influence of aggregate lending per se, where falls in prices during recessions and credit contractions are correlated in turn with bankruptcies of property companies and loan losses for banks (see Davis (1993)).

There are also long-run relations, fed through a significant lagged dependent variable which gives an indication that cointegration is present. Levels coefficients suggest a positive long-term link to GDP (proxying profit expectations) and a negative one to credit. The results are plausible in terms of the theoretical model, whereby GDP proxies rents which boost commercial property prices in the short and long run, while the availability of credit boosts demand in the short term with fixed supply but leads to higher capacity in the longer term by financing investment, which chokes off excess demand, lowering prices.

There is a positive lagged relation to real short-term interest rates, contrary to the model and normal economic intuition. One aspect of this may be that financial liberalisation promoted higher real interest rates and also free availability of credit to finance commercial property. Hendershott and Kane (1992) also noted that the 1980s commercial property boom in the United States occurred during periods of high real interest rates.

We ran a number of regressions for subgroups within the total, which provide interesting variations from the basic results. First we estimated separately for the G7 and the remaining small open economies. The main results hold with a positive short-term effect from credit and GDP growth, and a significant lagged dependent variable, showing effects on prices take time to reach their long-run level. On the other hand, it is in the larger G7 economies that the negative long-run effect from credit comes through, as well as a positive effect from investment. In the SOEs a short-run positive effect arises from investment while there is a long-run positive effect from real interest rates (which may again proxy financial liberalisation).

We then divided between market-oriented and bank-dominated countries, where the former are the United Kingdom, the United States, Canada, Australia and Ireland and the latter are the remainder. In the market-oriented countries effects arise largely from credit, which again has a positive short-run effect and a negative long-run one. The other effect apart from the lagged dependent variable is a positive lagged investment effect. In the bank-dominated countries, there are wider macroeconomic effects from GDP growth, investment growth (both positively) in the short run and from GDP growth in the long run (also positively). Credit is only significant in the short run, with a lower elasticity than for the market-oriented countries. This is a little surprising, because bank credit is more important in bank-

[16] The alterative of SUR (which would have allowed for contemporaneous correlations as well as cross-sectional heteroskedasticity) would have been inappropriate owing to lack of degrees of freedom, given the calculation in SUR of cross-equation residual covariances.

dominated countries and should be expected to have a more significant effect on commercial property prices – it may reflect a greater prevalence of credit controls in the bank-dominated countries on average over the sample.

Finally we estimated for the crisis countries of the late 1980s and early 1990s, namely the United Kingdom, United States, Japan, Sweden, Norway, Finland, France and Australia (defined as countries witnessing both collapses in real property prices and banking crises during this period). Over the full sample the results are virtually identical to the full pool, except for there being no real interest rate effect. It is only when we restrict the data period to 1985-95, the period of the property boom and bust in these countries, that results differ markedly. Then we have a very high short-run elasticity in respect of credit growth of 2.4 and of GDP of 3.5 showing much greater sensitivity of property prices to activity and lending – in the boom and also the succeeding downturn. Also investment growth has a short-term negative effect, consistent with our model above (whereby investment increases supply, putting downward pressure on prices). This negative investment effect is also present in the long run.

Meanwhile, unlike the other estimates there is a positive long-run effect of credit on property prices. Many of these results carry through to the full sample of countries over the same period, except for the long-run credit effect. These results are consistent with different behaviour of commercial property markets from their “norm” at this time and are worthy of further investigation. The different result suggests that the mechanism during crisis periods might be different from normal periods. In particular, the different long-term effect implies a more persistent positive connection between bank lending and property prices, possibly reflecting a deviation of price from fundamentals.

We estimated for individual countries in the same error correction framework (Table 3). A number of the full panel results are also present. For example, in Australia, Finland, France, Ireland, Japan, Norway and the United Kingdom – all of which saw credit/asset price booms during the sample period, there is a positive short-run relation of growth in real credit to rises in commercial property prices. In Belgium, Finland, Germany, Spain, Sweden and the United Kingdom there is a short-run positive link to GDP. Growth in investment has a positive link to rises in real commercial property prices in Canada, Denmark, Ireland, Italy, the Netherlands, Switzerland and the United States. On the other hand, Ireland, Norway and the United States have significant negative short-term links to GDP – albeit in each case combined with a significant positive sign on credit and/or investment.

The lagged dependent variable comes in significantly for all countries except Denmark and Sweden (in the latter country, only GDP growth was significant of the variables selected). Interestingly, although GDP has a positive long-run effect in the panel, for individual countries the effect is zero or negative except in Belgium. Investment has a positive long-run effect everywhere where it was significant, including Canada, Denmark, Finland, Italy, Japan, the Netherlands, Switzerland, the United Kingdom and the United States. As in the panel, credit has a negative long-run effect in Belgium, Canada, Switzerland and the United Kingdom but a positive one in Ireland, Italy, Norway and the United States. Where GDP is significantly negative, it is always combined with a significant positive sign on credit (in Ireland) or on investment ((Canada, Denmark, Finland, Italy, Japan, the Netherlands and the United States). Finally, a positive real interest rate effect comes through in Australia, Belgium, Germany, Denmark, Italy, Japan, Switzerland and the United States, many of which have experienced financial liberalisation.

Note that these equations are generally well determined with only a minority of countries showing autocorrelation, heteroskedasticity, non-normality or structural instability. The RESET test is of particular interest, in that it implies that financial liberalisation and other structural changes have not induced structural breaks in the price relationship except for Australia, France and Japan. Also the Chow test (for a forecast from 1995 onwards) suggests that there is not a marked change in overall behaviour detectable at a macro level in the 1990s.

A number of variants on the above models were run in order to test robustness and also address further hypotheses:

(1) As in Peng (2002) we experimented with richer dynamics including a lagged difference term and a “frenzy” term of the change in lagged log of property price changes cubed. This variable, originally due to Hendry, assesses whether large price changes tend to have a disproportionate effect on future price changes, giving a priori evidence of bubble formation. We also tested for richer dynamics using a lagged dependent variable (ie the lagged first difference of real commercial property prices).

(2) Following Gerlach and Peng (2002) we sought to assess whether the effect of credit aggregates has changed between the 1970-85 period and 1986-2001. Did credit rationing in the earlier period

imply a larger effect of credit or was it financial liberalisation around 1985 that boosted the effect of credit? The method was to add a variable for a dummy over 1970-85 times credit levels and difference where they were significant and where sufficient pre-1985 data are available.

(3) We instrumented contemporaneous changes in credit (with lagged changes in credit) to assess whether results were affected by simultaneity.

Results are summarised in Table 4. Broadly speaking, the results for the richer dynamics do not favour explosive behaviour by the commercial property market, with the cube term being either negative (a high rate of growth leads to a lower one next period) or insignificant. Only Belgium and Canada have positive cube terms. On the other hand, there is some evidence of significant lagged difference terms suggesting further path-dependence of commercial property prices, which could entail forms of oscillation similar to that suggested by the model – and could also be consistent with a link from commercial property prices to credit as assessed in the following section.

As regards the test for different credit market effects in the 1970s and early 1980s, in the panel this tended to show a lower sensitivity of commercial property prices in the earlier period, notably for the difference term in the panels. For the individual countries, results are mostly absent owing to insignificance, lack of data for the earlier period or an insignificant difference or level of credit variable in the baseline equation. France and the United Kingdom are the main exception, showing a smaller effect of the difference of credit on commercial property prices in 1970-85 than since 1986, and also a stronger long-run effect. Finally, the results of instrumental variables estimation, where we instrumented credit growth with two lags of itself, show that the significance of credit is not solely due to simultaneity bias. It remains significant in all cases where this was the case in the original equations. But in most cases the estimated elasticity shown is lower.

The next two sections focus on the co-movements of commercial property prices, the first over time (ie volatility) and the second across space (ie cross-country correlations). These complement the main results on determination provided by the error correction equations above, offering as comprehensive a view as possible of the dynamics that lenders in this market may face.

We are interested in the determinants of the volatility of property prices owing to the potential link to default and option values, while bearing in mind that valuation smoothing means property prices are less volatile on a short-term basis than are other asset prices such as equities, bonds or foreign exchange. In the GARCH(p,q) model introduced by Bollerslev (1986) we consider the information set Y_{t-1}, which contains all information on the variable y_t until time t-1. Also we assume the time series y_t can be described as

$$y_t \mid Y_{t-1} = (h_t)^{\frac{1}{2}} \eta_t, \qquad \eta_t \sim NID(0,1) \tag{11}$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i y_{t-1}^2 + \sum_{i=1}^{p} \beta_i h_{t-1} \tag{12}$$

where h_t is the conditional variance. To ensure a well defined process, all the parameters in the infinite order AR representation must be non-negative, where it is assumed that the roots of the polynomial lie outside the unit circle. For a GARCH(1,1), where one is a sufficient lag length in most applications according to Bollerslev et al (1992), this amounts to ensuring that both α_1 and β_1 are non-negative. It follows also that y_t is covariance stationary if and only if $\alpha_1+\beta_1<1$. Given a coefficient on the lagged squared error α_1 greater than zero, volatility will tend to cluster, with large residuals following large ones and vice versa, but of unpredictable sign, while a random, normally distributed variation in the conditional distribution (error variance) gives the unconditional distribution (error distribution) fatter tails than the normal distribution. Using the coefficient β_1 on the lagged dependent variable and setting the conditional variance constant, GARCH enables a long-run response of the conditional variance to shocks to be calculated. α_0 shows the mean level of volatility. One may add other variables to the basic GARCH to assess their effect on volatility. Also we may allow there to be asymmetric effects using the exponential or leveraged EGARCH approach of Nelson (1991).

Most of the studies in the literature, for stock returns, the term structure or exchange rates, have found a significant degree of both short- and long-run shock persistence with high-frequency data, thus accounting for the clustering of volatility characteristic of such markets (Bollerslev et al (1992)). Studies of inflation have found similar results (Engle (1983)).

In Table 5 we show results of GARCH estimation of commercial property prices. Only in the United States, Japan and Switzerland are both the ARCH and GARCH terms significant, suggesting a weak effect of shocks on volatility elsewhere. This may link to the smoothed nature of property prices as compared to equity prices or other financial asset returns. We assessed lagged credit growth as an extra variable in the ARCH model, and found that rapid credit growth increases volatility in Ireland and Switzerland while it is credit contraction that promotes volatility in Australia and the United States. With an EGARCH (asymmetric) approach, it is positive shocks that generate higher conditional volatility in Ireland and Switzerland but negative shocks for the United States.

Before concluding this section, we also wish to assess international correlations of commercial property prices. Normally, it is assumed that such imperfect markets as those for commercial property, which are highly dependent on national circumstances, should be rather uncorrelated. It is thus often seen as a risk-reducing investment for institutional investors, as well as offering some risk reduction for international banks lending in a variety of national commercial property markets.

But work such as Case et al (1999) highlights relatively high correlations in the recent period. This is relevant for international investment and lending as well as for potential "omitted variables" in equations based purely on domestic influences. A high global correlation emphasises that the risk in lending is not reduced by lending in different national markets and again underlines the need for caution by lending officers. The full correlation matrices are available on request; here we summarise the results for average correlations (Table 6). It is evident that there was a decline in correlation during the turbulent period of the 1980s, with recovery in the 1990s to a higher level than in the 1970s. This is consistent with increased integration of global commercial property markets, although as suggested by Case et al it may rather link indirectly via a global GDP growth factor. We tested the latter by regressing the residuals from the country estimates on the growth of global GDP and found indeed a coefficient of 0.27 significant at 10%. If this is correct, and given close correlation of cycles in the 1990s, it implies equations based on domestic variables remain broadly appropriate (in fact, adding an international growth variable to the estimates in Table 3 proves insignificant in most countries).

Further insight can be gained by using rolling correlations of property prices, which are in the Figure 1 appended. Consistent with the table, they suggest that there could have been a regime shift in the late 1980s, as the average correlation jumped from about 0.10 to over 0.50. As above, the disappearance of a diversification effect may reflect the increased integration of global commercial property markets but also a common cycle. The degree of increase in correlation varies across countries. Unlike the rest of the world, commercial property markets in Finland, Japan and Norway (at least before the late 1990s) are less related to the other markets. Recently the average correlation seemed to show signs of decreasing, but still remained at high levels. Note that the RESET and Chow results in Table 3 do not suggest a breakdown of previous patterns, however.

V. Empirical analysis: interaction between bank lending and commercial property prices

The above investigation of commercial property price determination does not give any direct evidence as to the causality links between lending and prices. Is it commercial property price rises that lead to heightened lending via collateral and bank capital, or is there an autonomous increase in credit which generates higher commercial property prices? Or are both influenced by common shocks in fundamental variables?

We initially ran Granger causality tests on the relationship between the real commercial property prices and real credit. The Granger causality test assesses whether there is a consistent pattern of shifts in one variable preceding the other. Such tests do not give any proof on causality, but nevertheless where causal mechanisms based for example on supply and demand can be suggested, as outlined above, then a positive result gives grounds for further investigation.

Granger causality can only be a starting point in empirical investigation. Notably, there are a number of additional influences on real commercial property prices, as outlined above, so a multivariate regression approach needs to be adopted before reaching any conclusions. On the other hand VECM (vector error correction model) analysis as undertaken below has some disadvantages, such as the problem of recursive ordering etc, that are not present in the Granger analysis, and the latter is therefore an invaluable complement to the VECM analysis.

To run the Granger causality test, the following equations are estimated for each country:

$$X_t = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \varepsilon_t \quad (13)$$

where X is either the difference of the log of real commercial property prices or the difference of the log of real bank lending, and ε is a disturbance term. If there is Granger causality from *Y* to *X*, then some of the *ß* coefficients should be non-zero; if not then all of the *ß* coefficients should be zero. Testing whether the coefficients on the lagged indicator variables are zero can be readily performed using standard *F*- or *t*-tests. We began with tests for lag length. The tests are consistent with a range of lags, but with all covering the range 1-2, and the Schwarz criterion, which we consider most useful, generally favouring one. Accordingly, we selected one lag as appropriate in all cases except Italy, Spain and the United Kingdom (two lags).

According to the data in Table 8, we find that Granger causality operates from commercial property prices to bank lending in nine countries; Australia, Denmark, Finland, France, Ireland, Italy, the Netherlands, Sweden and the United Kingdom. This is broadly to be expected from the suggestion in the theoretical model that higher commercial property prices generate increased collateral for borrowing as well as capital for bank lending. On the other hand, there was also evidence of reverse causality from lending to prices in a number of countries. These included Belgium, Italy, Japan, Spain, Sweden, Switzerland and the United Kingdom. Note that in the United Kingdom, Sweden and Italy there is a two-way relationship, consistent with spirals between the two variables over protracted periods of time.

A key problem associated with the estimation of predictive links between variables is that they are almost always conditioned on the other variables incorporated in the related equation. A criticism of Granger causality tests is naturally that only two variables and their interrelations are assessed, while as shown above these should only be a subset of the set of variables which combine to determine real commercial property prices. Accordingly, to further investigate the relationship between commercial property prices and bank lending, as well as assessing the wider determinants of prices, we undertook VECM and VAR (vector autoregression) estimation.

In short, VARs focus on the dynamic short-run response of variables to one another while VECMs give information on short- and long-run responses, estimating the cointegrating vector by the Johansen technique. The latter are in principle of greater interest, notably in terms of impulse responses, so we focus largely on VECM results. However, VECMs could not be estimated for Canada, Finland and Italy, where there were insufficient observations, while in Denmark, Finland, Norway and Switzerland cointegration is not present at 5% according to the trace test in the variant where real interest rates are excluded. Accordingly, we also report VAR results for those countries.

The VECM estimates the properties of relationships between the I(1) variables in the dataset. In the light of the discussion of property price determination above, we sought to assess the relation between the logs of real property prices, real credit, real GDP and real investment and the level of the real short rate (treated in the VECM as an I(1) variable, and omitted in a variant). As noted, we expect investment and GDP to have different effects in that the former entails increased property supply whereas the latter is mainly a demand variable (although there may also be collinearity as investment is a component of GDP, and investment activity may take time to be translated into supply).

We first estimate the reduced-form VECM (VAR) model,[17] and then use the estimates to examine the dynamic linkages among these variables. To do this we need to orthogonalise the estimated VECM to identify the effect of shocks to the innovations of the variables in the system. The standard Cholesky decomposition is used to identify the responses in VECMs. Identification then uses the Sims's triangular ordering. A well known problem with the Sims triangular ordering is that it is arbitrary, and requires a justification for the ordering chosen. The presence of common shocks and co-movements among the variables makes the decision on ordering a crucial one. In our main results, we ordered the

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17 The lag order for the VECM was tested using the Schwarz Bayesian criterion and found generally to be one year, although in some cases it extended to two years. This is consistent with earlier work by McGough and Tsolacos (1999), who found the lag in their VAR on office building to be six quarters. The estimates were carried out using the Johansen procedure, after which the estimates were incorporated in VECM analysis.

variables with GDP first, followed by commercial property prices, credit, investment and real short rates, with the following justification:

Most of the monetary transmission literature would suggest putting GDP first and RSR last. It can be argued that GDP does not respond contemporaneously to other economic variables, but macroeconomic conditions (shown by GDP) affect the other economic variables. On the other hand, RSR and hence monetary policy can respond rapidly to changes in market conditions, but it takes a while for the policy to become effective. Investment comes after property prices and credit because of the lag between investment activity and the increase in market supply. Commercial property prices can come ahead of credit for two reasons. First, as argued in the model, banks' lending decisions are often based on the value of real estate collateral, which is often evaluated using current market prices. Hence fluctuations in property price tend to have a contemporaneous effect on bank credit. Second, commercial property prices are sticky and may not reflect changes in credit conditions immediately.[18]

The key outputs of a VECM for the purposes of our current exercise are the variance decomposition and impulse responses. There may be effects in the whole system that are hidden from individual equations. With a model of this sort, a large amount of output is generated by this exercise: five equations subject to five different shocks gives 25 solutions. Therefore, only a few key results are presented. Given the focus of the work on real commercial property prices and real bank lending, we report only the variance decompositions and impulse responses for these variables.

The variance decompositions show the degree to which the variance of the "independent variables" explains the forecast variance of the "target" variable in the VECM system. Table 8 shows that commercial property prices are rather autonomous even five years after shocks, with an average of 47% of the variance being self-determined. The proportion of variance accounted for by credit only exceeds 20% in Belgium, Sweden and Switzerland. These may link to financial repression during part of the sample, which means credit had an autonomous role, although we note also that these are "bank-dominated" countries, with a lower availability of securities market financing.

Using a similar benchmark of 20%, the variance of GDP helps largely to determine the variance of commercial property prices in Australia, Belgium, Denmark, France, Norway, Sweden and the United States. Investment has an effect in the Netherlands, Spain and the United States, while there are major effects of variance to short rates in Ireland. The lesser importance of credit as a determinant of commercial property as compared to the Granger causality regressions suggests that the latter suffered from omitted variables bias. Meanwhile, "fundamentals" such as investment, GDP and interest rates also have a relatively small effect on property prices even after five years, with GDP being most important (averaging 26% of the explanation of variance).

As regards private sector credit, the degree of autonomy is much less (an average of 33% of the variance is self-determined after five years). The main influence is GDP (33%) followed by commercial property prices (20%). The proportion of variance explained by GDP is above 20% except in Belgium, Germany, the Netherlands and Switzerland. Commercial property prices have a marked effect in the variance decomposition for credit in France, Germany, Ireland, Japan, the Netherlands, Norway and the United Kingdom – many of which are countries reputed to have witnessed a "credit bubble". Investment is nowhere in excess of 20%, and real short rate variance helps to determine credit variance in Germany, Ireland and Japan, ie including the major "relationship banking" countries.

In terms of the theoretical model, these results are consistent with a major effect of exogenous shocks to the credit/property price nexus (from GDP), but the predominant direction of causality between them is from commercial property prices to credit rather than vice versa, except where there have been bubbles. In a variant where we exclude the variable real short rates, results are similar (the last row in Table 8).

We examined the pattern of significant ECMs in the VECM, following Hofmann (2001a). Interestingly, long-run causality applies most strongly to commercial property prices and least to credit, with the other variables being intermediate (Table 9). This contrasts with Hofmann's result, which suggested

[18] There are also arguments that support ordering in the reverse direction. For example, the commercial property price is a forward-looking variable and should react quickly to credit being granted to financial projects. In addition, bank credit may not react immediately owing to decision lags and loan processing time. Nevertheless, the results remain robust if the sequence between the two variables is reversed.

that for residential property prices, the opposite was true. (This result may reflect structural differences between the residential and commercial sectors.) It is consistent with a long-term influence of macro-variables – including credit – on commercial property prices. Results are similar when we exclude RSR. The resolution of this observation with the variance decomposition, which showed prices to be more autonomous than credit, may be that the influence of the dynamic (differenced) variables is large compared to the long-run levels and may also be quite sustained. As regards the country pattern, it is noteworthy that long-run causality applies to credit in some of the most "bank-dominated" countries, namely Germany and Japan, as well as Denmark and the Netherlands.

We now move on to impulse responses. The aim is to provide some quantitative estimates of the interrrelationship between real commercial property prices and bank lending in the presence of related variables. While we do not show the full set of impulse responses for the VECM, two are particularly worth highlighting, firstly the response of commercial property prices to a shock to credit. In all countries except Australia, the Netherlands, Norway and Switzerland the long-term response is negative. Furthermore, in most cases this follows an initial boost to prices from lending, as predicted by the model and as indicated by the panel results. Figure 2 shows selected impulse responses of this type. Second, we highlight the response of commercial property prices to shocks to GDP. For most countries this is remarkably common, namely a gradual rise to a peak after three to six years followed by a decline, while the impulse remains positive after 10 years – again fully in line with the panel estimates. This is the case for Australia, Belgium, Denmark, France, Ireland, the Netherlands, Norway, Switzerland and the United States. Australia is shown in Figure 3 as a typical example. In five of the other countries – Germany, Italy, Spain, Sweden and the United Kingdom – a more complex pattern suggestive of cycles is present, as also shown in Figure 3. In Japan, there is a monotonic decline. Apart from Japan, these results are in line with the model, which as shown on page 11 highlights two possibilities: case (1) overshooting due to delivery lags then a gradual convergence on a higher equilibrium (as GDP and hence rents are higher[19]) – the case for most countries, or case (2) a cyclical pattern, for the countries other than Australia in Figure 3.

The VAR results for those countries where VECMs could not be estimated or have doubtful statistical properties are comparable to those for the VECM, with autonomy of commercial property prices and influence of GDP and commercial property prices confirmed for credit (Table 10). We find that in the impulse responses (Table 11) GDP is a major determinant of both credit and commercial property prices, while there are some cases of interrelation between property prices and credit.

Table 12 shows diagnostics for the VECM and VAR. In common with Hofmann (2001a) we find several countries where there is non-normality of VECM residuals. Lütkepohl (1993) shows that the Johansen approach does not strictly depend on the normality assumption, however. Other than that the estimates are satisfactory with minor exceptions; for the VAR there is also a degree of autocorrelation in Canada and Finland, and heteroskedasticty in Denmark, while for the VECM there is autocorrelation at 90% in Australia and the Netherlands.

Finally, Table 13 shows the cointegrating vectors in the VECM systems. This gives a further indication of long-run relationships between the variables. The coefficients are set out as an equation with the log of real commercial property prices on the left-hand side. The relationship to GDP is significant except in Switzerland, Ireland and Sweden, while credit is significant except in Spain and France. Investment is insignificant in Australia, Belgium and Norway, and the real short rate in Belgium, Spain and the Netherlands. The Spanish result appears to be unsatisfactory, with large coefficients perhaps reflecting low degrees of freedom.

The signs are broadly consistent with the individual country error correction models set out in Table 3. For the majority of countries, the cointegrating vector implies a negative relation of commercial property prices to GDP, and a positive one to credit (one exception is Japan, where the link to credit is negative). This relationship could be interpreted as one between commercial property prices and leverage at a macroeconomic level (ie credit as a proportion of GDP drives up such asset prices), as seen in as in Borio et al (1994). Certainly, financial liberalisation episodes were marked by rises in credit/GDP (Davis 1995). Alternatively, as suggested by Hofmann (2001a), there could be seen to be a positive relation of both commercial property and GDP to credit.

19 Note that the VECM impulse response differs somewhat from the model in that we have endogenous increases in GDP over time rather than a one-off upward shift – but qualitatively this is not important in terms of the result.

Meanwhile, investment is generally positively related to prices in the long run (in Switzerland, Germany, France, Italy, Japan, the Netherlands, the United Kingdom and the United States). So a complementary view is that in a boom period when investment is a high proportion of GDP, prices are relatively high before declining later when the buildings are complete, which in turn may be when investment/GDP is low. Finally, interest rates are positively related to commercial property prices in the long run in Australia, Switzerland, Germany, France, Japan, Norway, Sweden and the United States. There is a negative relation in Denmark, Ireland and the United Kingdom. Note that in the United Kingdom and Ireland floating rate financing predominates.

The relationship between these signs in the cointegrating vector and the VECM variance decompositions and impulse responses is not always direct. Notably, it depends on the sign and significance of the cointegrating relationship in each equation and the effects of cross-equation feed-throughs over time. This helps explain why in the impulse response charts the long-run response (over 10 years) of commercial property prices to shocks in GDP is positive and that to credit is negative, in line with the panel results and the theoretical model.

VI. Conclusions

Analysis of the theory and empirical determination of commercial property markets has burgeoned in the real estate literature, but empirical work on the link to bank lending is less well developed. In the light of extant work, we have investigated the properties of commercial property prices and the relationship to credit. We show in a theoretical model that commercial property can develop cycles given plausible assumptions, even if rational expectations hold. Macroeconomic shocks (GDP, interest rates) cause changes in property prices and bank lending, and their eventual impact depends largely on the attributes of property markets. Other suggestions from the model include a positive effect of credit on commercial property prices in the short run but a negative one in the long run. The model also implies that commercial property prices affect credit positively while GDP has a positive effect on credit, and interest rates a negative one.

Empirical work on 17 countries gives inter alia the following results:

- Panel estimation is in line with several of the model's predictions, such as a positive short-term response of commercial property prices to GDP and credit but a long-term effect which is positive in GDP but negative in credit. Impulse response functions in the VECM give similar results to the panel for most countries.
- Particularly strong links of credit to commercial property are found in the countries that experienced crises linked to property losses by banks in 1985-95. These include a positive long-run effect of credit on prices which is suggestive of possible bubbles.
- Estimating short- and long-run responses at a country level, determinants of commercial property prices differ markedly across countries.
- There is some evidence that credit expansion boosts the volatility of property prices, although the result only holds for a subset of countries.
- The cross-country correlations of commercial real estate prices fell in the 1980s and reached quite high levels in the 1990s. There is some evidence that correlated global GDP growth was an explanatory factor.
- Causality testing suggests on balance that it is commercial property prices that "cause" credit expansion rather than autonomous credit expansion boosting property prices. This is consistent with a key role for collateral generated by price rises, which permit lending, rather than prices responding to autonomous lending booms.
- Variance decomposition analysis in the VECM suggests that commercial property prices are fairly "autonomous", in that more than half of the variation is self-determined. Among various macroeconomic factors, GDP has a dominant influence on commercial property prices and on bank credit as well, implying an important role for shocks coming from outside the property price-credit nexus.

- As shown in the impulse responses of the VECM, in line with the model, GDP shocks may in some cases generate a cyclical response in commercial property prices although for most countries there is overshooting due to delivery lags then a gradual convergence on a higher equilibrium level of prices. Over 10 years the response to GDP shocks is positive and that to credit shocks is negative, in line with the theoretical model.
- The Johansen test used in the VECM implies a strong cointegrating relationship between credit and commercial property prices but also an important influence of GDP and real investment.

The work poses a challenge for bank managers and regulators to understand the dynamics of the commercial property cycle at a macro level and to detect deviations from fundamentals. Sound credit assessment of individual loans, diversification across projects and adequate capital are necessary but not sufficient to overcome the type of systematic shock that the downturn in the commercial property price cycle can generate. Credit needs to be appropriately priced and rationed inter alia to allow for high cyclical volatility which may be persistent over time and marked cross-country correlations in property markets.

Beyond this, as empirical evidence has suggested, the use of real estate as collateral provides a channel through which property price movements can positively feed into the credit market. Credit expansion in turn increases property prices. To prevent a bubble in the property market and to minimise the adverse impact of declining property prices on bank performance, banks need to be stricter with loan management. More precisely, portfolio limits on direct or indirect exposures to property prices may need to be enforced by banks as part of a wider risk management strategy. A high share of commercial property in the balance sheet may pose significant risks.

An example of resilience is Hong Kong, where commercial property prices have dropped by 70% from the peak year yet the banking system has remained resilient. Many economists have explained this as a result of the strong capital base and the government policy to impose a maximum loan-to-value ratio on property loans at an early stage. Another possible approach is that of Ireland, where supervisory guidelines imply that banks can lend a maximum of 200% of own funds to any single industrial sector, and 250% to two sectors sharing economic risks (eg property and construction).

Another noteworthy aspect of our analysis is the suggestion that the use of current market prices is important in generating the cyclic movement of property prices. This occurs despite the fact that expansion of bank credit increases market supply and will eventually cause the property price to fall. The long-term negative effect of bank credit implies that banks should adopt a valuation method that also takes into account the long-term perspective of the project seen also in the context of wider anticipated market developments. Research that examines the connection between long-run property prices, current prices and expected rent yields could provide insightful suggestions in that direction. It will also be relevant for further study to probe the influence of the commercial property cycle on banks' profitability at a micro level.

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Table 1

Unit root tests

	DLCPPR	DLCREDR	DLGDP	RSR	DLI
Australia	–4.3**	–4.0**	–4.6**	–2.1	–4.7**
Belgium	–2.8*	–2.7*	–3.4**	–2.1	–2.5
Canada	–2.1	–3.2**	–3.8**	–1.8	–3.5**
Denmark	–2.3	–3.3**	–4.8**	–0.9	–3.5**
Finland	–2.8*	–1.9	–4.0**	–0.8	–3.2**
France	–2.7*	–3.4**	–3.3**	–1.9	–3.3**
Germany	–2.3	–5.0**	–4.1**	–3.2**	–3.9**
Ireland	–3.6**	–2.8*	–2.1	–1.8	–3.0**
Italy	–1.6	–2.9**	–3.7**	–2.2	–4.1**
Japan	–2.5	–3.2**	–3.5**	–1.9	–3.7**
Netherlands	–3.3**	–3.0**	–2.5	–2.4	–3.1**
Norway	–3.7**	–2.7*	–3.0**	–1.9	–2.6*
Spain	–1.8	–2.8*	–3.3**	–1.3	–3.5**
Sweden	–2.3	–2.3	–4.1**	–3.0**	–3.8**
Switzerland	–2.7*	–2.4	–4.6**	–3.4**	–4.0**
United Kingdom	–4.5**	–4.6**	–4.3**	–1.8	–3.6**
United States	–2.4	–4.0**	–4.5**	–2.1	–4.8**

Note: DLCPPR is the first difference of the log of real commercial property prices; DLCREDR is the first difference of the log of real credit to the private sector; DLGDP is the first difference of the log of real GDP; RSR is the level of the real short rate; DLI is the difference of the log of real private sector investment. Absence of unit root accepted at ** 5% or *10%.

Regression dataset covers the following periods: Australia 1972-2002, Belgium 1977-2001, Canada 1986-2002, Denmark 1980-2002, Finland 1987-2001, France 1971-2001, Germany 1972-2002, Ireland 1983-2002, Italy 1984-2001, Japan 1978-2002, Netherlands 1971-2001, Norway 1971-2001, Spain 1981-2002, Sweden 1971-2001, Switzerland 1972-2002, United Kingdom, 1971-2002, United States 1978-2002.

Table 2

Panel error correction model of commercial property prices

	Pooled	**G7**	**Small open Economies**	**Bank-dominated**	**Market-oriented**	**Crisis countries**	**Crisis countries 1985-95**	**All countries 1985-95**
Constant	**Fixed effect**							
DLCREDR	0.75 (6.4)	0.92 (5.5)	0.71 (4.6)	0.84 (5.2)	1.22 (9.9)	0.67 (3.0)	2.4 (5.4)	1.2 (7.7)
DLGDP	1.78 (6.3)	1.13 (2.8)	1.14 (2.3)	1.47 (2.9)		1.8 (4.3)	3.5 (3.8)	2.18 (4.7)
DLI			0.28 (5.0)	0.29 (1.8)			–0.88 (3.7)	
LCPPR(-1)	–0.09 (5.3)	–0.04 (2.2)	–0.13 (5.0)	–0.16 (6.1)	–0.04 (1.9)	–0.093 (4.0)	–0.18 (4.3)	–0.13 (4.0)
LCREDR(-1)	–0.09 (2.4)	–0.08 (2.2)			–0.073 (2.1)	–0.14 (2.3)	0.4 (2.9)	
LGDP(-1)	0.17 (2.3)			0.067 (1.8)		0.21 (2.3)		
LI(-1)		0.15 (2.5)			0.096 (1.7)		–0.66 (3.7)	–0.31 (5.6)
RSR								
RSR(-1)	0.005 (2.4)		0.004 (1.6)	0.005 (1.9)				0.008 (1.8)
$\overline{R}^2$	0.35	0.39	0.32	0.34	0.51	0.38	0.64	0.65
SE	0.11	0.098	0.12	0.11	0.09	0.11	0.11	0.11
DW	1.37	1.23	1.42	1.54	1.00	1.35	1.66	1.52
OBS	439	185	239	285	126	201	88	194

Note: t-values in parentheses; those coefficients that are not significant at 5% are omitted from the equations.

LCPPR is the log of real commercial property prices; LCREDR is the log of real credit to the private sector; LGDP is the log of real GDP; LI is the log of real private sector investment; other variables are defined as in Table 1.

Table 3

Individual country error correction model of commercial property prices

	AU	BE	CA	DK	FI	FR	DE	IE	IT	JP	NL	NO	ES	SE	CH	UK	US
Constant	–0.24 (5.4)	–12.8 (5.4)	2.3 (1.0)	4.8 (2.8)	6.1 (5.9)	–0.04 (1.4)	–0.2 (3.4)	5.8 (2.7)	62.1 (2.5)	0.71 (2.1)	–1.6 (2.8)	3.4 (1.8)	–0.26 (4.7)	–0.13 (2.8)	–1.65 (2.9)	–1.92 (2.6)	19.9 (3.3)
DLCREDR	2.0 (5.0)				1.62 (6.9)	1.09 (2.2)		1.8 (6.2)		1.58 (9.9)		3.6 (5.6)				0.58 (2.6)	
DLGDP		3.8 (4.8)			1.86 (3.3)		5.5 (4.4)	–3.3 (3.5)				–4.2 (2.4)	12.5 (7.1)	7.5 (4.2)		2.9 (3.4)	–2.8 (2.3)
DLI			0.59 (3.2)	1.5 (4.6)				0.68 (2.9)	6.8 (4.5)		1.2 (3.1)				1.0 (5.6)		0.8 (2.7)
LCPPR(–1)	–0.25 (3.4)	–0.24 (3.7)	–0.44 (6.7)		–0.81 (7.5)	–0.12 (1.6)	–0.23 (3.2)	–0.38 (2.1)	–1.1 (3.7)	–0.16 (4.3)	–0.73 (4.6)	–0.82 (5.9)	–0.23 (3.7)		–0.18 (2.4)	–0.25 (3.4)	–0.33 (3.3)
LCREDR (–1)		–0.79 (5.2)	–0.82 (4.4)					0.92 (2.6)	2.8 (2.6)			0.49 (2.0)			–0.35 (3.2)	–0.26 (3.6)	1.3 (2.6)
LGDP(–1)		1.8 (5.4)	–1.82 (3.4)	–1.5 (3.5)	–1.2 (7.8)			–1.2 (2.7)	–12.5 (3.3)	–0.76 (5.4)	–1.1 (4.2)	–0.67 (2.0)					–3.7 (3.6)
LI(–1)			2,3 (8.7)	1.0 (3.5)	0.36 (32.4)				7.2 (4.3)	0.77 (5.4)	1.9 (4.8)				0.48 (3.0)	0.44 (2.6)	1.0 (6.2)
RSR				–0.03 (2.1)	–0.03 (4.6)												0.014 (2.4)
RSR(–1)	0.019 (3.1)	0.014 (2.8)		0.03 (2.3)			0.045 (3.2)		0.085 (3.2)	0.012 (3.7)					0.019 (2.8)		0.017 (2.5)
$\overline{R}^2$	0.54	0.68	0.92	0.51	0.97	0.13	0.4	0.88	0.75	0.92	0.53	0.6	0.73	0.35	0.49	0.67	0.89
SE	0.09	0.05	0.03	0.09	0.03	0.12	0.1	0.04	0.09	0.02	0.2	0.l3	0.13	0.18	0.05	0.08	0.02
DW	1.3	1.83	2.24	2.6	2.5	1.22	1.53	1.65	2.02	2.3	2.14	2.03	1.8	1.0	1.7	1.82	2.17
LM(2)	3.4*	0.74	0.46	1.33	0.88	3.3*	1.84	0.35	7.4**	6.5**	0.75	0.03	0.03	3.9**	0.17	0.18	5.9**
ARCH(1)	3.3*	1.6	0.12	0.28	2.6	0.59	2.05	1.13	0.29	0.88	0.024	0.47	1.8	0.06	0.12	3.9*	0.79
NORM(1)	1.7	0.73	0.28	2.3	0.22	1.84	0.47	0.9	0.04	0.36	19.0**	23.1**	0.34	2.6	1.1	1.8	0.83
RESET(1)	4.0*	0.7	0.1	0.02	0.22	8.1**	0.05	0.004	0.4	7.24**	0.35	1.1	0.28	0.07	0.33	0.38	0.72
CHOW	0.2	0.6	1.9	0.2	156*	1.4	0.8	0.5	0.1	0.5	0.5	0.9	0.9	1.0	1.2	0.4	1.5
OBS	31	25	17	23	15	31	30	20	18	25	31	31	21	31	31	32	25

Note: t-values in parentheses; * shows significance of the test statistic at 90%, while ** at 95%; those coefficients that are not significant at 5% are omitted from the equations.

List of countries: Australia (AU), Belgium (BE), Canada (CA), Denmark (DK), Finland (FI), France (FR), Germany (DE), Ireland (IE), Italy (IT), Japan (JP), the Netherlands (NL), Norway (NO), Spain (ES), Switzerland (CH), the United Kingdom (UK) and the United States (US).

Table 4

Variants on the basic equations

	Variant (1)		Variant (2)		Variant (3)
	DLCPPR(–1)	**DLCPPR(–1)^3**	**DUM(70-85) *DLCREDR**	**DUM(70-85) *LCREDR(–1)**	**Instrumented DLCREDR**
Pooled	0.6 (11.1)	–2.3 (3.5)	–0.64 (3.6)	Insig	0.38 (5.2)
G7	0.7 (8.7)	–5.3 (3.9)	–0.72 (3.4)	Insig	0.54 (4.5)
Small open economies	0.6 (8.4)	–1.7 (2.1)	–0.85 (3.5)	Na	0.34 (3.6)
Bank-dominated	0.5 (7.8)	–2.1 (2.8)	–1.02 (3.7)	Na	0.43 (4.4)
Market-oriented	0.8 (8.6)	–4.1 (2.6)	–0.6 (2.4)	0.03 (4.8)	0.75 (8.6)
Crisis countries	0.5 (3.3)	–2.3 (2.2)	–0.55 (2.3)	Insig	0.43 (3.4)
Crisis countries 1985-94	0.5 (2.9)	Insig	Na	Na	0.78 (3.6)
All countries 1985-94	0.53 (8.0)	Insig	Na	Na	0.53 (4.3)
Australia	0.56 (2.5)	Insig	Insig	Na	0.97 (3.4)
Belgium	Insig	22.2 (2.3)	Na	Insig	Na
Canada	Insig	11.6 (1.7)	Na	Na	Na
Denmark	0.8 (1.9)	Insig	Na	Na	Na
France	0.7 (2.7)	–9.2 (1.9)	-2.9 (4.5)	Na	1.2 (3.3)
Ireland	0.4 (4.5)	Insig	Na	Na	0.75 (3.1)
Italy	0.76 (2.3)	Insig	Na	Na	Na
Japan	Insig	Insig	Insig	Na	0.97 (8.0)
Norway	Insig	Insig	Insig	Insig	2.0 (5.5)
United Kingdom	Insig	–5.3 (2.3)	–0.5 (1.9)	–0.2 (2.0)	0.34 (2.1)
United States	0.4 (1.7)	Insig	Na	Insig	Na

Note: t-values in parentheses. There were no significant results for Finland, Germany, the Netherlands, Spain, Sweden and Switzerland.

Table 5

GARCH results for log difference of real commercial property prices

	Basic ARCH		DLCREDR(–1) in ARCH	EGARCH (γ)
	ARCH	**GARCH**		
Australia	0.16	0.6*	–0.009*	–
Canada	0.13	0.64**	–	–
Ireland	0.1	0.7**	0.0017**	0.46**
Japan	0.6**	0.5**	–	–
Switzerland	0.17**	0.82**	0.015**	0.35**
United States	0.23**	0.71**	–0.0039**	–0.21**

Note: * shows significance of the test statistic at 90%, ** at 95%; data are semiannual for Japan and quarterly elsewhere.

Table 6

Average correlations of difference of log of real commercial property prices

	1970s	1980s	1990s	Full sample
Australia	0.44	0.20	0.58	0.49
Belgium	0.40	0.33	0.55	0.49
Canada	na	0.15	0.59	0.58
Denmark	0.29	0.25	0.44	0.39
Finland	0.14	0.09	0.64	0.37
France	na	0.29	0.68	0.58
Germany	0.36	0.14	0.59	0.49
Ireland	0.11	0.04	0.32	0.23
Italy	0.39	0.09	0.60	0.49
Japan	na	0.07	0.67	0.29
Netherlands	na	0.00	0.58	0.42
Norway	0.48	0.15	–0.31	0.28
Spain	0.18	0.14	0.62	0.37
Sweden	0.13	–0.22	0.58	0.11
Switzerland	–0.05	0.14	0.45	0.34
United Kingdom	0.33	0.30	0.46	0.40
United States	0.21	–0.15	0.70	0.47
Average of 17	*0.26*	*0.12*	*0.51*	*0.40*

Table 7

Granger causality F-tests for change in real commercial property prices and change in real lending to the private sector

Australia	3.2(0.06)*	0.06 (0.94)
Belgium	2.1 (0.15)	3.1 (0.06)*
Canada	0.72 (0.51)	0.43 (0.66)
Denmark	3.0 (0.07)*	0.25 (0.78)
Finland	4.2 (0.03)**	1.2 (0.33)
France	3.4 (0.05)**	1.3 (0.3)
Germany	0.37 (0.7)	2.5 (0.11)
Ireland	4.4 (0.03)**	1.9 (0.19)
Italy	4.6 (0.03)**	3.8 (0.05)**
Japan	1.3 (0.29)	6.5 (0.01)**
Netherlands	3.7 (0.04)**	0.34 (0.71)
Norway	2.4 (0.11)	1.3 (0.29)
Spain	1.3 (0.3)	3.1 (0.08)*
Sweden	8.1 (0.01)**	2.6 (0.09)*
Switzerland	0.82 (0.45)	6.3 (0.01)**
United Kingdom	6.6 (0.01)**	3.8 (0.04)**
United States	0.7 (0.51)	0.11 (0.89)
Number of countries	*9*	*7*

Note: Significance level in parentheses: ** rejected at 5%, * rejected at 10%.

Table 8

Variance decomposition for VECM

After five years (percent)

	Real commercial property prices					**Real private sector credit**					
	GDP	CPP	CRED	I	RSR	GDP	CPP	CRED	I	RSR	Memo: lags
Australia	40	40	12	1	7	75	9	11	0	5	1
Belgium	41	28	28	1	2	1	2	85	11	1	1
Canada	Na	Na	Na	Na	Na	Na	Na	Na	Na	Na	Na
Denmark	56	34	3	5	1	66	2	20	7	6	1
Finland	Na	Na	Na	Na	Na	Na	Na	Na	Na	Na	Na
France	38	52	3	6	0	55	23	6	13	3	1
Germany	11	83	2	3	1	10	45	11	8	27	1
Ireland	14	44	9	6	26	37	23	3	14	28	1
Italy	Na	Na	Na	Na	Na	Na	Na	Na	Na	Na	Na
Japan	10	76	1	2	11	31	29	4	10	26	1
Netherlands	11	47	13	24	3	14	49	27	1	9	1
Norway	29	66	3	1	2	46	32	21	1	0	1
Spain	9	16	18	53	5	28	3	68	4	0	1
Sweden	32	44	22	0	0	20	19	58	2	1	1
Switzerland	7	40	46	5	2	1	3	94	1	1	1
United Kingdom	17	67	1	11	4	31	35	31	4	0	1
United States	43	18	1	30	8	42	11	28	13	7	1
Mean level	*26*	*47*	*12*	*11*	*5*	*33*	*20*	*33*	*6*	*8*	
Memo: without RSR	*18*	*58*	*11*	*14*		*34*	*19*	*43*	*4*		

Table 9

Significant ECMs for VECM

	GDP	**CPPR**	**CRED**	**I**	**RSR**
Australia		*			
Belgium		*			*
Canada	Na	Na	Na	Na	Na
Denmark	*		*	*	*
Finland	Na	Na	Na	Na	Na
France					*
Germany		*	*	*	
Ireland	*	*		*	
Italy	Na	Na	Na	Na	Na
Japan	*	*	*	*	
Netherlands		*	*		*
Norway	*				
Spain	*	*		*	
Sweden				*	*
Switzerland	*			*	*
United Kingdom	*	*		*	*
United States		*			
Number significant	*7/14*	*9/14*	*4/14*	*8/14*	*7/14*
Memo: without RSR	*5/15*	*9/15*	*4/15*	*9/15*	

Table 10

Variance decomposition for VAR

After five years (percent of variance)

	Lags	**Real commercial property prices**					**Real private sector credit**				
	GDP	**CPPR**	**CRED**	**I**	**RSR**	**GDP**	**CPPR**	**CRED**	**I**	**RSR**	**GDP**
Canada	1	8	37**	4	24**	24**	33*	18*	21*	15*	11
Denmark	1	58**	35**	1	5	0	36**	5	55**	3	0
Finland	1	3	86**	2	8	0	3	72**	17	6	1
Italy	2	31*	25*	30*	10	2	50**	11	32**	5	1
Norway	1	23	57**	4	2	14**	54**	10	33**	0	2
Switzerland	1	17*	41**	31**	7	3	19	3	73**	3	2
Average		*23*	*47*	*12*	*9*	*7*	*33*	*20*	*39*	*5*	*3*

Note: Lag length selected by Schwarz criterion; ** shows significance at 95% and * at 90%.

Table 11

Impulse response for VAR

(sign of responses significant at 95%)

	Commercial property prices				**Real credit**			
To:	**GDP**	**CRED**	**RSR**	**I**	**GDP**	**CPPR**	**RSR**	**I**
Canada			–	+	+	+		–
Denmark	+				+			
Finland						+		
Italy	+	+			+			
Norway			–		+	+		
Switzerland	+	+						
Using generalised impulse responses								
Canada		+		+	+			+
Denmark	+			+	+	+		+
Finland						+		
Italy	+	+		+				+
Norway		+	–		+	+		
Switzerland	+	+		+			+	+

Table 12

Diagnostics for VAR and VECM

	VAR				VECM			
	LAGS	**LM(2)**	**HET**	**NORM**	**LAGS**	**LM(2)**	**HET**	**NORM**
Australia					1	37*	196	14
Belgium					1	17	186	12
Canada	1	40**	160	14	na	na	na	Na
Denmark	1	24	181**	11	1	29	194	14
Finland	1	184**	na	14	na	na	na	Na
France					1	22	178	20**
Germany					1	23	186	13
Ireland					1	29	200	18*
Italy	2	na	na	25**	na	na	na	na
Japan					1	24	186	13
Netherlands					1	38*	182	16*
Norway					1	23	199	16*
Spain					1	24	177	16*
Sweden					1	20	188	13
Switzerland	1	16	158	22**	1	25	184	11
United Kingdom					1	20	206*	10
United States					1	25	181	14

Note: LM(2) is the Lagrange Multiplier test for second order autocorrelation, HET is the White heteroskedasticity test with no cross terms and NORM is the Jarque Bera test for normality; * implies failure of test at 90% and ** at 95%.

Table 13

Coefficients in Johansen estimation

(cointegrating equation LCPPR=a*LGDP+b*LCREDR+c*LI+d*RSR)

	LCPPR	LGDP	LCRED	LI	RSR
Australia	1 =	–4.4* (4.2)	2.5* (5.5)	–0.4 (1.1)	0.03* (3.1)
Belgium	1 =	5.7* (5.3)	–2.7* (3.5)	–0.25 (0.4)	0.0 (0.2)
Denmark	1 =	–10.0* (19.9)	7.2* (24.9)	–2.1* (7.5)	–0.3* (16.6)
France	1 =	–1.6* (6.6)	0.2 (1.0)	1.5* (6.2)	0.1* (11.0)
Germany	1 =	–22.4* (6.0)	4.6* (2.7)	14.9* (9.2)	0.25* (4.0)
Ireland	1 =	–0.03 (0.1)	0.5* (2.5)	–0.5* (4.7)	–0.06* (11.7)
Japan	1 =	–4.2* (4.3)	–2.9* (2.9)	9.7* (7.2)	0.14* (3.3)
Netherlands	1 =	–2.8* (6.4)	0.7* (5.4)	2.3* (7.3)	0.01 (1.4)
Norway	1 =	–0.7* (2.7)	0.3* (1.9)	0.14 (0.8)	0.06* (5.5)
Spain	1 =	564* (6.6)	–66 (1.2)	–358* (5.0)	1.1 (0.7)
Sweden	1 =	–0.8 (1.2)	4.4* (9.3)	–5.3* (6.9)	0.03 (0.8)
Switzerland	1 =	2.1 (1.5)	–3.5* (7.2)	2.8* (6.2)	0.25* (4.0)
United Kingdom	1 =	–7.0* (9.9)	1.8* (6.0)	1.3* (2.2)	–0.1* (4.5)
United States	1 =	–8.1* (22.2)	3.4* (17.5)	1.4* (7.8)	0.05* (7.9)

Note: * indicates significance at the 95% level.

Figure 1

Rolling average correlation of real commercial property prices

(in log difference; from year T-9 to T)

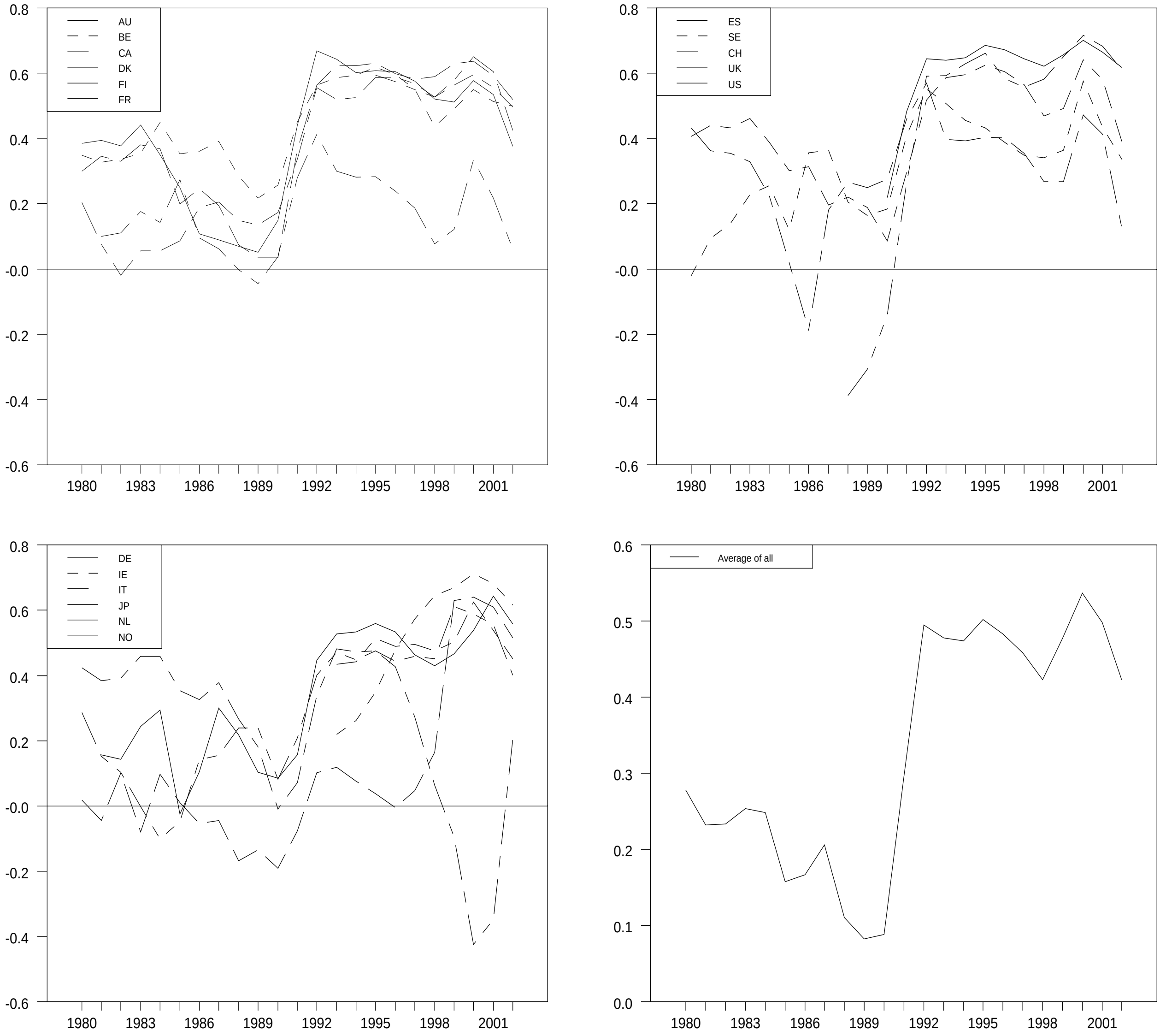


Figure 2

Selected impulse responses in VECM of commercial property prices to credit

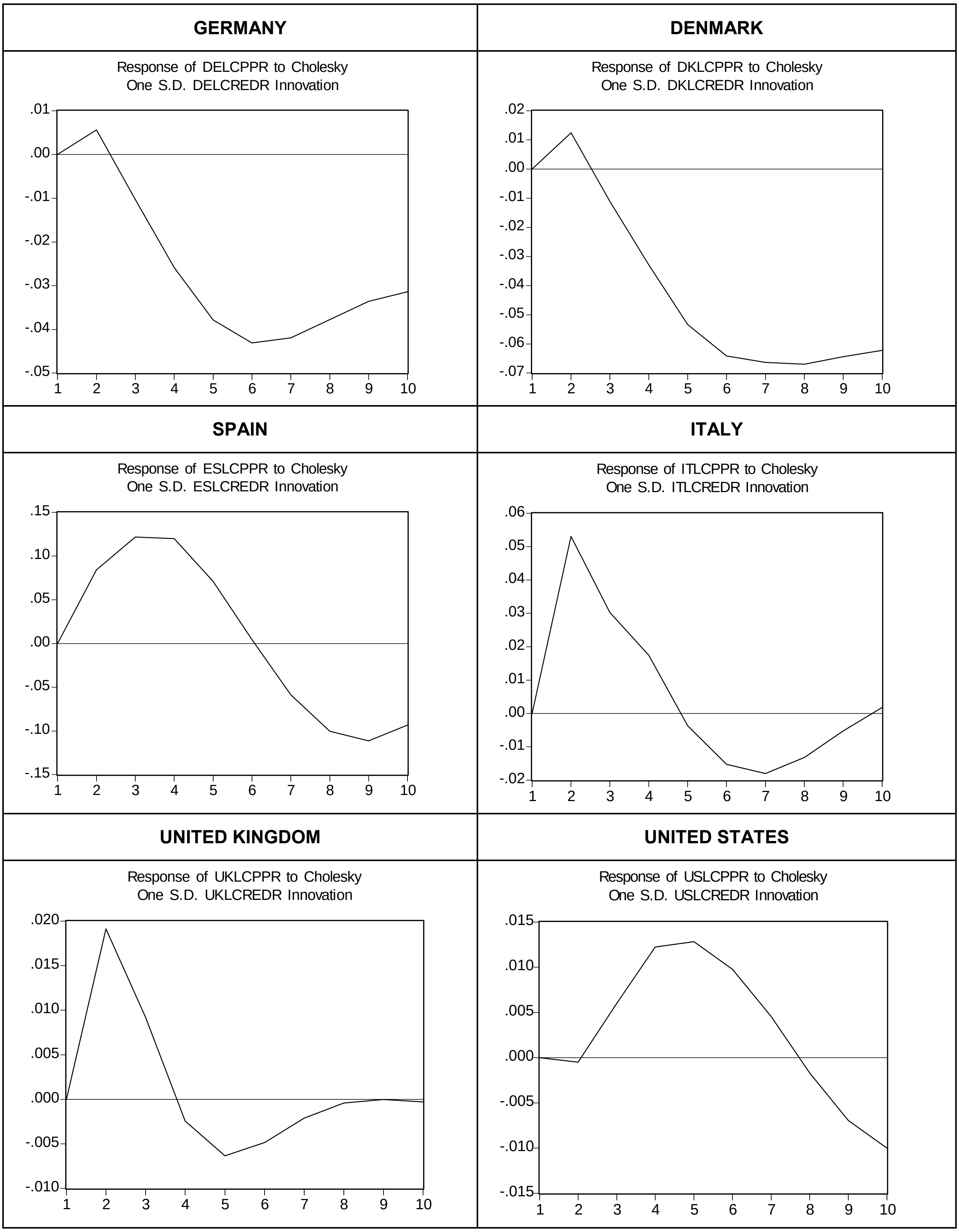
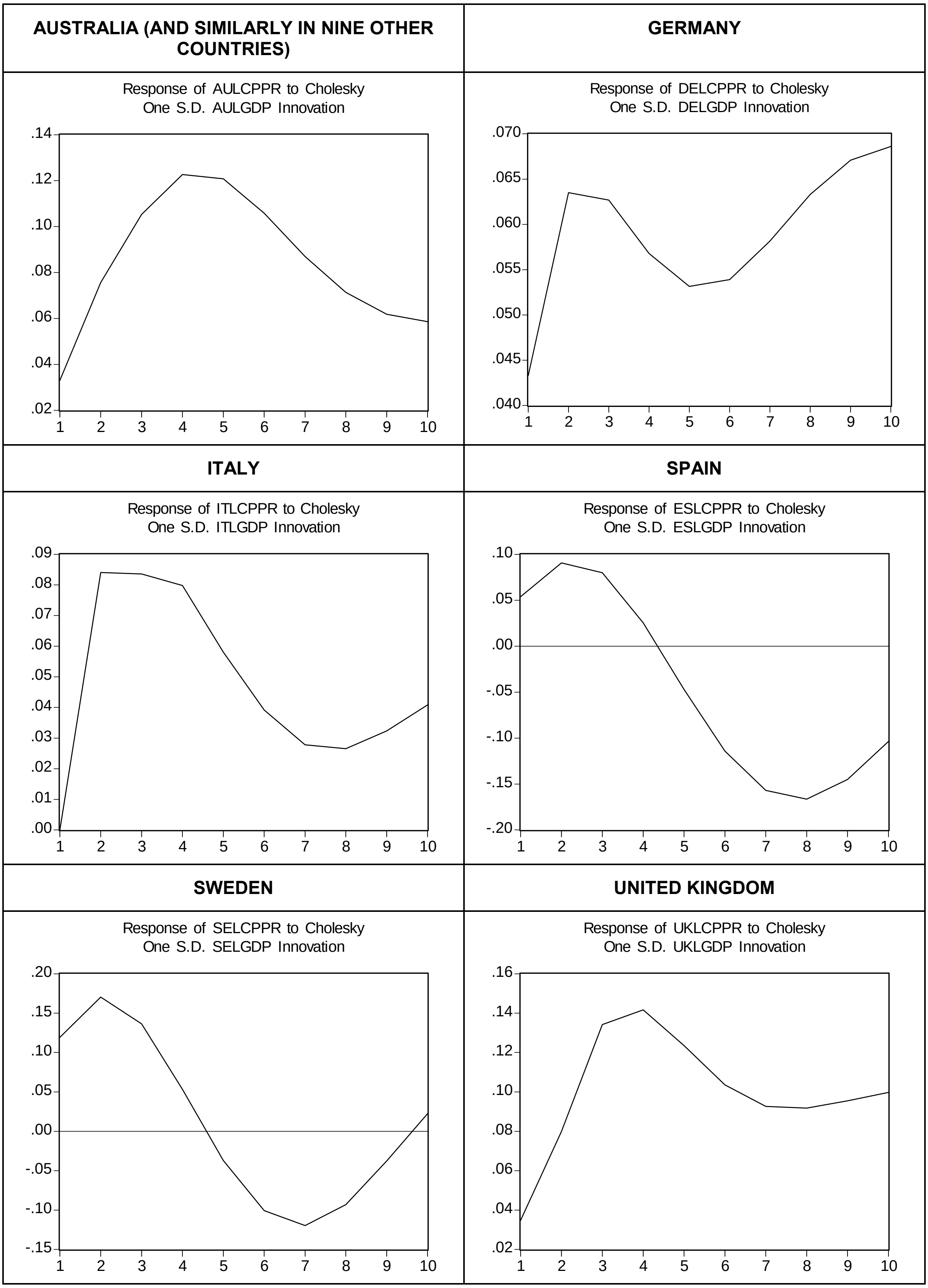


Figure 3

Selected impulse responses in VECM of commercial property prices to GDP



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