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Asset Prices and Real Economic Activity

E. Philip Davis

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by E. Philip Davis

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ABSTRACT / RÉSUMÉ

Asset prices and real economic activity

A survey of the literature on asset price impacts on the real economy shows a much wider range of work on consumption and related wealth effects than on investment. The existence of wealth effects on consumption is little contested, but there remains an issue of whether different effects should hold between countries and across assets. There is less empirical work available on investment, partly reflecting poor results for Tobin's Q, the user cost of capital and the financial accelerator. Panel investment functions for up to 23 OECD countries are estimated. Significant asset price effects from the financial accelerator and Tobin's Q are found especially for the G7 countries as well as uncertainty effects as proxied by asset price volatility, but they only matter for the smaller OECD countries.

JEL Codes: E22, E44, F31; G31

Keywords: Asset prices, wealth effect on consumption, aggregate fixed investment, uncertainty, Tobin's Q, financial accelerator, credit channel.

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Les prix des actifs et l'économie réelle

Un examen des études consacrées à l'impact des prix des actifs sur l'économie réelle montre que beaucoup plus de travaux portent sur la consommation et les effets connexes de patrimoine que sur l'investissement. L'existence d'effets de patrimoine sur la consommation n'est guère contestée, mais il reste à savoir si les différents effets sont valables d'un pays et d'un actif à l'autre. Les travaux empiriques sur l'investissement sont moins nombreux, en partie parce que les résultats sont médiocres pour le Q de Tobin, le coût d'usage du capital et l'accélérateur financier. On a estimé des fonctions d'investissement sur données de panel pouvant couvrir jusqu'à 23 pays de l'OCDE. On constate des effets sensibles de prix des actifs dus à l'accélérateur financier et au Q de Tobin en particulier pour les pays du G7, et également des effets d'incertitude établis à travers la volatilité des prix des actifs, mais ces derniers effets ne sont importants que pour les petits pays de la zone de l'OCDE.

Codes JEL : E22, E44, F31, G31

Mots clés : Prix des actifs ; effet de patrimoine sur la consommation ; investissement fixe total ; incertitude ; Q de Tobin ; accélérateur financier ; canal du crédit

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ASSET PRICES AND REAL ECONOMIC ACTIVITY[1]

E. Philip Davis

Introduction

1. The recent financial crisis and the resulting downturn, as well as the boom in asset prices accompanying rapid growth over 2002-7, have led to renewed interest in the role asset prices may play in real activity. This paper seeks to provide an overview of the principal channels whereby asset prices, in particular of equities, may influence the real economy. The paper has two main sections. In the first part a literature review is provided, summarizing thematically the state of play and major findings in key areas, as well as highlighting some outstanding questions. In the second part new estimates of equations for business investment for 23 OECD countries are provided. The paper provides a benchmark for assessing the impact asset prices have on this key area of economic activity, which influences both the demand and the supply side of the economy. It also provides background for assessing the impact of the recent financial crisis on investment.

2. The paper is structured as follows: The literature review in section 1 provides an overview of the various mechanisms by which asset prices can influence economic activity and reviews macromodel results for asset prices' impact on GDP. Section 1.2 summarizes analytically what is known about wealth effects on private consumption and reviews the literature on the size of these effects. Section 1.3 surveys the literature on the effects of asset prices on business investment, notably via Tobin's q, the user cost of capital, the financial accelerator and uncertainty.

3. In section 2 business investment equations are estimated for up to 23 OECD countries to show both the statistical and, more importantly, the economic significance of asset price changes for business investment for those countries for which suitable data are available. Hence the focus is on Tobin's Q, the financial accelerator and uncertainty effects, while also including other investment determinants, such as the bank credit channel. Section 2.1 describes the data and sample while section 2.2 shows the estimation of basic investment functions. Sections 2.3 and 2.4 successively assess the effects of the level and volatility of asset prices in that framework. Section 2.5 shows some variants and robustness checks. Section 2.6 considers how important these effects have been in explaining the recent history of business investment. Section 3 concludes.

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1. This is one of the background papers for the OECD's project on counter-cyclical economic policy written by Prof. E. Philip Davis. He is Senior Research Fellow at the UK National Institute of Economic and Social Research, Dean Trench Street, Smith Square, London SW1 and Professor Associate of Economics and Finance, Brunel University (E-mail: e_philip_davis@msn.com). The main paper was issued as the *OECD Economics Department Working Paper* No. 760. The author thanks Ray Barrell, Peter Hoeller, Dawn Holland, Iana Liadze, Nigel Pain and Douglas Sutherland for helpful comments, suggestions and assistance. He also gratefully acknowledges the input of Paul Ashworth and Joseph Byrne to their earlier empirical work on investment, which is background to this paper.

1. Literature survey on asset prices and economic activity

1.1 An overview

4. In general, the key channels through which asset prices impact on the real economy are via consumption and investment, which will be assessed in more detail in the sections below. In terms of consumption, the impact arises via the wealth effect, which supplements the traditional income effect. This arises mainly through changes in asset prices such as those of shares and residential property. The wealth effect is often claimed to become more powerful after financial liberalization, because illiquid wealth can then be more easily borrowed against to facilitate consumption, as an alternative to decumulating existing assets. Note that asset prices themselves are determined partly by income expectations, which also influence consumption directly. Non-income fundamentals affecting asset prices include interest rates and the risk premium. Also the possibility of bubbles cannot be ruled out. The major channels for asset price effects on consumption are summarised in Figure 1.

Figure 1. **Channels for asset price effects on consumption**

5. There may also be a major impact of share prices on business fixed investment, which may operate via Tobin's Q (the valuation of firms relative to the replacement cost of the capital stock), the user cost of capital (if it includes the cost of equity capital) and the financial accelerator (whereby the level of corporate net worth eases concerns of lenders over moral hazard, and hence external finance constraints during a boom, which is reversed in a downturn). Further asset price effects may occur via uncertainty and its impact on business confidence. Note again that share prices are influenced in part by output expectations that also influence investment directly (via the "accelerator"). Also long-term interest rates, which are another key influence on investment, are in part market determined. Figure 2 shows the principal effects of asset prices on investment.

Figure 2. **Channels for asset price effects on business investment**

6. A number of studies have focused on asset price impacts on GDP, without disaggregating its components. For example, Barrell and Davis (2005a) used a Vector-Error-Correction (VEC) approach for 13 EU countries and the United States using data for real GDP, real equity prices, the real interest rate and the government surplus as a per cent of GDP. Their results suggested that equity prices play a major independent role in the determination of output in both the European Union and in the United States, even in the presence of proxies for monetary and fiscal policy. This effect is consistent across both small and large countries, as well as in bank-dominated and market-oriented countries. Nevertheless, they found a noticeably stronger association between equity prices and GDP in market-based economies. For example, the contribution of equity prices to a variance decomposition of output is around 3 times greater in the United States, at 50 per cent, than in the larger euro area economies. This is consistent with a greater role of equity finance for firms, and in the balance sheet of households, in the United States than in the euro area, which is a recurrent theme in the literature on asset prices and the real economy.

7. In complementary work using the NiGEM macromodel, Barrell and Davis (2005*b*) showed that falls in equity prices have around a three times greater impact on output in the United States than they do in the euro area. They found that there were considerable cross country spillovers of equity price shocks from the United States to the euro area, driven by lower US demand as well as effects on euro area wealth of US shares that euro area investors hold, and share price falls in the euro area per se. These results are consistent with the patterns observed in the crisis of 2008. Monetary easing can help absorb such a shock in NiGEM. Fiscal policy loosening can also help offset the effects of a collapse in equity prices, but it will mean higher long-term real interest rates and hence it moderates one of the automatic shock absorbers provided by the market mechanism. Again, the degree of fiscal loosening and its potential medium-term impact on long rates is a key policy issue at present.

8. Detken and Smets (2004) looked at the effect of asset prices on real economic activity in 38 asset price boom periods since 1970 in 18 OECD countries, where such a boom is defined by a deviation of asset prices (equity and real estate) from trend[2] of over 10%. They distinguished between high-cost and low-cost booms. High cost booms are those which entail major output losses (more than a 3% decline in growth) when asset prices fall. Declines in real estate prices seem to be particularly damaging to output. In some cases of high cost booms there is a banking crisis also. They found that following high cost booms, residential and non-residential investment are both strongly affected. They fall over 6% on average in the first two years of the downturn, whereas consumption falls only by 0.2%. Distinguishing features of preceding booms include rapid growth of money and credit early in the boom, as well as rises in asset prices (but consumer price inflation remains subdued). Monetary policy is looser late in the boom. Real activity and especially investment is much higher relative to trend in high cost booms also, which tend to last longer than low cost booms (Table 1). The authors argue that the patterns are consistent with the financial accelerator mechanism, operating notably via the collateral value of real estate. There is of course now strong evidence that the recent boom up to 2007 was a remarkably high-cost one (section 2.6).

Table 1. **Asset prices and the real economy in low and high cost booms**

9. Given the strong relationship between banking crises and falls in real activity (see for example Hoggarth and Sapporta, 2001), it is also relevant to note the literature linking asset prices to banking distress. A key article is by Borio and Lowe (2002) who showed (using a signal extraction methodology) that deviations of credit and asset prices from prior trends were good indicators of future banking problems. This result is supported by other work such as Barrell *et al.* (2009) using logit estimation who showed that in OECD countries, a helpful predictor of banking crises is rising house prices lagged three years, as well as banking sector capital and liquidity ratios. The corollary is that regulatory policy can have a key role in protecting the economy from the impact of asset price falls on bank solvency, as well as possibly attenuating the initial rise in asset prices (Davis and Karim, 2010).

10. Having assessed overall impacts of asset prices on the economy, the focus turns to the empirical work relating asset prices to consumption and investment.

1.2 Wealth effects and private consumption

1.2.1 Theoretical considerations

11. It is usually assumed that aggregate consumption is largely a function of current real disposable incomes, and such an explanation is indeed consistent with the most basic textbook analysis of consumption based on Keynes' absolute income hypothesis and its popularisation by Hicks and Hansen. However, as discussed inter alia in Deaton (1992) and Muellbauer and Lattimore (1995), such an explanation is inadequate, because it leaves out flow and balance sheet effects relating to personal saving and wealth, which become of particular importance when financial systems are liberalised. These flow and balance sheet effects also imply an impact of asset prices on consumption that would be absent in the traditional income-based equations.

12. These additional effects and their link to income can be rationalised in the context of the life-cycle hypothesis of consumption and saving. This framework forms the baseline for a great deal of empirical work on consumption, suggesting that consumers accumulate assets during working life so as to live on the surplus during retirement (Ando and Modigliani, 1963). Accordingly, planned consumption is a function of total wealth, based on human wealth and non-human wealth. This can be seen in the version of

2. Based on a Hodrick-Prescott filter.

the life-cycle hypothesis as derived in Deaton (1992). In this model, planned consumption (C_t^*) is a function of total wealth. Total wealth is the sum of human wealth (H_t) and non-human wealth (W_{t-1}).

Planned consumption can accordingly be expressed as a function of H_t and W_{t-1}

$$C_t^* = m(H_t + W_{t-1}), \tag{1}$$

where *m* is the marginal propensity to consume (MPC) out of total resources on average across the population. Meanwhile, unobservable human wealth can be proxied by some function k of current labour income (*i.e.* $H_t = kY_t$). The coefficient on human wealth (*i.e.* income) will be boosted when there are liquidity constraints on the availability of credit, since it implies that current consumption is closely tied to receipts of current income. Ultimately, with liquidity constraints and no liquid wealth, the equation would reduce to the naïve Keynesian equation with income only.

13. More realistically, the ability to consume out of wealth, and in particular illiquid wealth, is enhanced when there are no liquidity constraints, and such wealth can be used to enhance consumption smoothing over time – either directly via decumulation or as security for borrowing. Hence one should expect that the dynamics of adjustment and the long-run equilibrium in consumption equations will be influenced by the existence of liquidity constraints and these in turn will be linked to financial liberalisation.

14. Aron and Muellbauer (2000) identify the following effects after liberalization. First, there are lesser credit constraints on households that expect income growth and are seeking to smooth consumption; second, smaller deposits are needed by first time buyers of housing and some durables; and third, there is a greater availability of collateral-backed loans for households that already own collateral, such as houses. Lacking these, one might expect to see a relatively larger role for recent changes in income in systems with more liquidity-constrained consumers, whilst financial and especially non-financial wealth may have less influence when liquidity constraints are important.[3]

15. An indicator of the incidence of liquidity constraints, and hence of asset prices, can be constructed from the relative size of both the short and long-run coefficients on income and those on financial and non-financial wealth terms in the consumption function. When there are no credit constraints, as in a liberalised financial system, the impact of current income in the short and long run should be lower, since consumers can borrow to cover shortfalls in income. Correspondingly, the short and long-run impact of wealth will be greater, since it can be either directly decumulated or used as collateral for borrowing (Iacoviello, 2004, 2005).

1.2.2 Research using net financial wealth

1.2.2.1 Error correction models giving rise to short and long-run effects

16. A number of recent studies at the macro level have estimated autoregressive-distributed lag consumption functions using net financial wealth[4] based on the theory above. Often this is set in an error

3. Al-Eyd and Barrell (2005) explore the impact of liquidity-constrained behaviour on income and wealth channels operating in aggregate consumption and investigate the dynamic implications this has for fiscal policies in Europe.

4. Some studies used other definitions of financial wealth such as gross financial wealth (Bertaut, 2002) and stock market capitalization (Ludwig and Slok, 2004), but the bulk of the literature considers that these are theoretically and practically inferior to either net financial wealth or net total wealth. This is because net

correction framework where short-run can differ from long-run effects, and long-run equilibrium is reached only gradually. Such error correction models can be single-equation or in vector error correction form where all relevant variables are mutually interdependent.

17. For example, in Davis and Palumbo's (2001) study of the US consumption function, they attempted to determine whether changes in net financial wealth affect the growth rate of consumer spending. They examined quarterly aggregate US data from 1960 to 2000 and modelled long-run relationships to investigate whether (logged) consumption (C), income (Y) and wealth (W) share a common trend, using the following equation, based on (1) above, before setting out short-run dynamics in an error-correction framework.

$$\ln C_t = c_0 + \alpha \ln Y_t + \beta \ln W_{t-1} + \xi_t \qquad (2)$$

18. They found that there is a statistically significant long-run wealth effect on consumer spending. Ludvigson and Steindel (1999) also examined wealth effects in a log-linear long-run consumption relationship and found a statistically significant wealth and income effect using dynamic OLS. They also showed using a vector-error-correction approach that these variables share a common trend, using quarterly US data.

19. Internationally, Barrell, Byrne and Dury (2003) found evidence of an effect of net financial wealth as well as real personal disposable income (RPDI) on consumption in the European economies, and tested in a panel context for differences between European countries. Using a pooled-mean-group methodology,[5] they found that it is possible to show that France, Germany, the Netherlands and Austria have similar consumption behaviour with significant financial wealth effects, but with some difference in the dynamics of adjustment.

20. Following the discussion of liberalisation and liquidity above, it can be argued that disaggregation of net financial wealth is appropriate given the differing characteristics of components of wealth, notably liquidity. Byrne and Davis (2003a) analysed the impact of disaggregated net financial wealth on consumption for the G-7 countries, and found that, contrary to earlier empirical work, illiquid financial wealth (equities, bonds, life insurance and pension assets less mortgage debt) scaled by personal disposable income, tends to be a more significant long-run determinant of consumption than liquid financial wealth (deposits and money market instruments less other debt). The results also held when income was proxied by labour income, where the latter is more theoretically correct since RPDI, commonly used in most macro consumption studies, includes part of the return on wealth (rent, interest, profits, dividends) as well as the return on human capital. But as noted by Dreger and Reimers (2009), consistent labour income measures are hardly available in an international setting.

21. Byrne and Davis (ibid) suggested that this pattern reflected a shift from liquidity constrained to life cycle behaviour following financial liberalisation, and also a more diversified pattern of wealth holding. It may also be that given its lower rate of return, liquid financial wealth is held more as a means of transactions, or for precautionary purposes than as a long-term store of value. Their results have implications for aggregate studies as the relationship of wealth to consumption may change if the composition of wealth changes.

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wealth is the most accurate indicator of households' balance sheet position which they will use in making their decisions to consume.

5. The pooled mean group approach to panel estimation typically allows for differing short-run effects but tests for similar error-correction or long run effects.

22. The log transformation in these and most other recent empirical papers is justified by the argument of Campbell and Deaton (1989) that the variables consumption, income and wealth are unlikely to be difference stationary in levels but they are in logs. A counter argument presented by Altissimo *et al.* (2005) is that the elasticity as generated by log models is constant only if the wealth consumption ratio is constant, which they suggest recommends direct estimation of marginal propensities to consume in a linear framework. Furthermore a log framework can only approximate the consumption relation derivable from the intertemporal budget constraint. In other words, the accumulation of wealth can only be modelled precisely with a linear specification.

23. A notable feature of the results highlighted above for net financial wealth – as well as those for wider measures of wealth cited below – is that the long-run wealth effect seems to vary significantly between OECD countries, being typically higher in the English-speaking countries. Table 2 summarises the results of international studies. It shows that United States and Canada in particular have high marginal propensities to consume out of net financial wealth (mpcw). Labhard *et al.* (2005), while finding similar results in a VAR based estimate of aggregate consumption for 11 OECD countries, contest the theoretical basis for differing elasticities and corresponding mpcws.[6] They note that in theoretical models, the determinants of the mpcw such as the intertemporal elasticity of substitution of consumption, the real interest rate and the probability of death (planning horizon) are similar and only taxes tend to differ markedly. Equally, as shown in Altissimo *et al.* (2005), time series estimates of the so-called deep parameters of theory based consumption functions such as Sefton and In't Veld (1999) and Willman *et al.* (2003) who estimate overlapping generations models are more similar across countries than are more conventional econometric estimates.

Table 2. **Estimates of long run effects of total wealth on consumption (marginal propensity to consume)**

24. Labhard *et al.* (2005) contend that other factors which might lead to cross-country variation, such as distribution of financial wealth, and differing forms of wealth, are not sufficient to account for the differences shown in Table 2. Rather, they suggest that estimated differences are attributable to measurement errors (notably in respect of unquoted equities, whose importance varies sharply between countries) and the influence of common shocks to consumption and wealth. In a pooled-mean-group panel relating the consumption/income ratio to the wealth/income ratio, but where short-run dynamics are allowed to differ, they found they could not reject a common long-run mpcw of 6%. Evidence of non-linearities (a lower mpcw for larger changes in wealth) and asymmetries (a larger mpcw for rising wealth) were also found.

1.2.2.2 Distinguishing transitory versus permanent shocks

25. Building on Lettau and Ludvigson (2001), which found fluctuations in the aggregate consumption/wealth ratio useful for predicting stock returns, Lettau and Ludvigson (2004) for the United States and Blake *et al*. (2003) for the United Kingdom examined the distinction between transitory and permanent shocks to wealth and their impact on consumption. They showed that most of the variability of consumption is driven by permanent shocks, whereas most of the variability of equity prices is transitory. Consistent with this is theoretical work by Millard and Wells (2003) who show that shocks to equity risk premia linked to equity volatility have no effect on consumption, while other shocks lead to a positive correlation of wealth and consumption.

26. Lettau and Ludvigson's work is also a critique of the conventional single-equation work on consumption and net financial wealth reviewed in section 1.2.2.1. This is because an empirical conclusion

6. Note that elasticities from log equations need to be adjusted by the consumption-wealth ratio to obtain the mpcw. So unless the ratio is the same, equal elasticities do not imply equal mpcws.

regarding the different impact of transitory and permanent shocks to wealth can only be drawn from a vector error correction system as opposed to a single equation error correction model. A single equation assumes that all the adjustment to long-run disequilibrium comes from consumption, whereas these studies find that it is wealth and not consumption that adjusts to restore the long-run equilibrium in the United States and the United Kingdom. A corollary is that conventional estimates of the mpcw may overstate the response of consumption to a change in wealth, if most changes in wealth are transitory.

27. Tan and Voss (2003) for Australia and Chen (2006) for Sweden report similar results. On the other hand Hamburg *et al.* (2005) for Germany find that it is income and not wealth or consumption that error-corrects, consistent with stability of asset values in that country. Failure to account for the transitory-permanent distinction may be another reason for the above-mentioned difference in cross-country estimates of the mpcw.

1.2.2.3 Selected micro studies

28. Our main focus in this paper is on studies using macroeconomic data. However, micro work using survey data can often answer questions that macro data cannot. For example, as noted by Paiella (2009) macro data cannot readily distinguish the hypotheses that the wealth effect is direct (*i.e.* due to higher wealth leading to greater consumption), indirect (due to easing of collateral constraints on borrowing) or driven by common macroeconomic factors as suggested by King (1990). These alternative paths of influence are shown in Figure 1 above. Using micro data allows tests to be run on the source of wealth effects from financial assets. For example, Maki and Palumbo (2001) for the US found evidence for a direct wealth effect, in contrast to Paiella (2007) for Italy whose evidence was more consistent with indirect effects.

1.2.3 Studies incorporating tangible wealth

1.2.3.1 Theoretical considerations

29. Net financial wealth obviously omits a major component of household wealth, namely housing. But some would argue that even in a liberalised financial system, a strong effect on consumption of non-financial wealth and notably housing is unlikely. The argument is that both housing and consumption could be affected jointly by other factors, notably income expectations (King, 1990). Even if there is a short-term effect of housing due to collateral effects, in the long run it can be argued that the positive effect of higher house prices is offset by the increase in opportunity cost of housing services (Buiter, 2004). Furthermore, the benefits of higher house prices to incumbents is offset by costs to new entrants (Aoki *et al.*, 2002) and higher rental prices for tenants. Housing unlike financial wealth may be held as an end in and of itself, and people may be unaware of short-run gains and losses (Case *et al*., 2005).

30. Despite these arguments, some studies have looked explicitly at tangible wealth as a consumption determinant, while noting this theoretical issue regarding the existence of a housing wealth effect, and bearing in mind that data problems in this area may be more severe than for financial wealth. On the other hand, omission of housing wealth effects, if they exist, could be important economically as consumption would tend to be underpredicted during housing booms. In this context, Paiella (2009) suggests that unlike for financial wealth there may be good reasons for housing wealth effects to differ across countries. For example, there may be differences in scope for mortgage equity withdrawal, as well as in the transactions costs of buying and selling houses that could affect this elasticity.

1.2.3.2 Macro studies of housing wealth effects

31. Most studies are national such as Murata (1994) for Japan, Barrell, Choy and Riley (2003) for the United Kingdom and Dvornak and Kohler (2003) for Australian States, which all found a positive effect of

tangible as well as financial wealth on consumption. Pichette (2004) finds for Canada also that the housing wealth effect exceeds the financial wealth effect, using a VECM approach similar to Lettau and Ludvigson (2001). Carroll *et al*. (2006) for the United States again found that the housing wealth effect is considerably larger than the financial wealth effect, with a short-run mpc from housing wealth of 2% but a long-run one of 9%. This is not in line with the theoretical implication that housing wealth effects should be smaller, being partly offset at a macro level. It may be that housing has a higher elasticity since it is more evenly distributed.

32. Internationally, Boone *et al*. (2001) obtained some significant long and short-run wealth effects on consumption in the G-7 when disaggregating wealth into financial, housing and other wealth. Barrell and Davis (2004) estimated consumption functions for the G-5, on a country-by-country and on a SUR panel basis (including pooled mean group estimation), which encapsulate roles for both financial and tangible wealth, where the latter is closely linked to the value of the stock of privately owned housing. Results suggest that housing-related tangible wealth plays a distinctive role in the determination of consumption in the short- and long-run. The restriction of an identical long-run elasticity for financial and tangible wealth could not be rejected by the data (implying that the mpcw varies with the consumption-wealth ratio). They also detected a marked negative effect of real interest rates. Case *et al*. (2005) found high housing wealth elasticities, well in excess of those for financial wealth, in a 14-country panel.

1.2.2.4 Studies using house prices as a measure of tangible wealth effects

33. An alternative indicator of tangible wealth is non-financial asset prices, although it may be seen as an inferior approach since it does not allow for asset accumulation via saving as an alternative source of rising wealth to increases in valuation of existing assets. Analysis suggests that these have played a role in the evolution of consumption in many countries. Using GLS panel estimation for 19 countries, Barrell, Davis and Pomerantz (2006) found such a role for house prices in consumption, where the short-run effect of a given rise in house prices on consumption far exceeded that of net financial wealth. One reason for this result may again be that housing is more evenly distributed than financial wealth, and also it can be readily used for collateral in borrowing in a liberalised financial system.

34. Ludwig and Slok (2004) also used house prices as a measure of tangible wealth (as well as stock prices for financial wealth[7]) and found that for economies with market-based financial systems such as the United Kingdom and the United States, the long-run elasticity of consumption to stock prices is 10% while in bank-based systems such as Germany and France it is 4%. Meanwhile the elasticity for house prices is double that of equity prices. Dreger and Reimers (2009), on the other hand, found consumption's elasticity with respect to house prices in the EU to be 2.5% while for financial assets it is slightly higher at 3%.

1.2.2.5 Complementary micro studies

35. As is the case for net financial wealth, micro studies permit a deeper investigation of factors underlying tangible wealth effects. For example, Attanasio *et al*. (2005) used micro data to investigate the role of house prices in UK consumption and found that households' responses are consistent with consumers responding to changing perceptions of income and productivity and not real wealth gains. It is hence inconsistent with a wealth effect and can rather be seen as a mis-measured income effect as argued by King (1990).

7. This measure meets the difficulty that stocks in a national market may be owned by foreigners rather than residents, while domestic investors may hold foreign stocks. Only national balance sheet data on wealth can overcome these difficulties.

36. They also found house prices affect the consumption of young people more heavily, a group also most likely to be credit constrained and less likely to own houses. This contrasts with a similar study for the United States where Campbell and Cocco (2005) found it was the old whose response to house prices was greater. Campbell and Cocco's results also differed from the UK results in suggesting that it is release of borrowing constraints (*i.e.* a true wealth effect) and not the common causality channel that accounts for housing wealth effects. Equity release in the US by existing homeowners is likely to be underlying the Campbell and Cocco result.

37. Looking at micro data for Italy, Guiso *et al*. (2006) found that home owners have a positive wealth elasticity, while for renters it is negative and counteracts a housing wealth effect in aggregate in that country in the way theory suggests. It could be argued that the relatively low levels of mortgage borrowing in Italy may underlie this result, by restraining the wealth effect for home owners. These different patterns across countries are consistent with the comment regarding the impact of different institutions by Paiella (2009) cited above.

1.2.4 Empirical work related to the Euler equation

38. The above research is based on structural or reduced form equations based on the life cycle hypothesis, giving a role for asset prices via the relationship of non-human wealth to consumption. There is an alternative approach to the theory of consumption based on the Euler equation, which seeks to aggregate the optimal intertemporal consumption decision of a representative consumer characterised by rational expectations (Hall, 1978). This suggests that consumption should be a random walk with a positive discount factor such as the real interest rate being the only relevant driving variable. The discount factor proxies the effect on consumption of intertemporal substitution ("the reward from saving"). Other asset price effects are accordingly excluded.

39. While there is extensive empirical work based on such equations for the United States, it has become increasingly clear that, in practice, consumption is predictable with the use of additional lagged variables, notably lagged income changes (Campbell and Mankiw, 1989) and wealth effects. Furthermore, the Euler approach in its purest sense leaves out long-run information on the relationship between assets, income and consumption – and may suffer worse aggregation problems than "solved out" equations incorporating lags (Muellbauer and Lattimore, 1995).

40. The theory is also vitiated by its assumption that all consumers are unconstrained in credit markets; instead observed behaviour may be the result of some consumers optimising along an Euler relationship whilst others adjust consumption in relation to their current income (Sarantis and Stewart, 2003). Consistent with this, Benito and Mumtaz (2006) looking at micro evidence on UK consumers' behaviour showed empirically that around 20-40% of consumers show excess sensitivity to income over and above the Euler equation, suggesting liquidity constraints or a desire for precautionary saving. Collateral from housing appears to be important in easing such constraints for the constrained group since capital gains boost their consumption. On the other hand, a key cause of excess sensitivity is a high level of debt, and especially negative home equity.

41. Barrell and Davis (2004, 2007) show that it is possible to nest an Euler specification within an autoregressive distributed lag (ARDL) model by including the current real interest rate in the equation. The results show that consumption is not appropriately modelled as a function of the interest rate alone, given the additional significance of differenced and levels terms in consumption itself, income and total wealth. Also since the estimated interest rate effect is negative, it suggests that the Euler view is not supported. Rather, the data support traditional intertemporal consumption theory with point expectations or certainty equivalent interest rates, which has a mix of substitution, income and wealth effects from interest rates – and the importance of asset prices is underlined.

1.2.5 The wealth effect and financial liberalisation

42. Some studies have probed the evolution of consumption behaviour as financial liberalisation proceeds and its effects filter through. One method is to split the sample at the point of liberalisation (Brechetta and Gerlach, 1997 and Miles, 1994). This obviously allows all of the coefficients to vary, at a cost of missing long-run patterns with relatively short samples. Some other tests have been rather restrictive in terms of allowable changes in behaviour. For instance, Miles (1994) introduced a flow variable, housing equity withdrawal, to proxy for financial liberalisation, which is defined as new borrowing secured on housing that is not invested in housing. Zero-one dummies for financial liberalisation are employed by Bayoumi (1993) with a path that rises with consumer credit and in Sefton and In't Veld (1999).

43. Barrell and Davis (2007) estimate the impact of financial liberalisation on consumption in 7 major industrial countries, by applying separate dummies based on dates of liberalisation to the components of an error-correction consumption equation. They find a marked shift in behaviour, notably a decline in short-run income elasticities and a rise in short-run wealth and interest rate elasticities, as well as a rise in long-run wealth effects. A corollary is that consumption equations estimated over both pre- and post-liberalisation regimes may be misleading, and either a form of testing as presented here or a shortening of the sample period may be appropriate for accurate forecasting and simulation.

44. As noted by Paiella (2009), a weakness of long time-series specifications with time-fixed coefficients is that they require a stable long-run relationship between consumption, labour income and wealth. Institutional changes such as financial liberalisation as well as aspects such as institutions, demographics and taxation vitiate this assumption. Carroll *et al.* (2006) proposes a new method for estimating the size of wealth effects on macro-data that exploits the sluggishness of consumption growth and does not require the existence of a stable co-integrating vector. Slacalek (2009) applies this approach to 16 OECD countries, testing for housing and financial wealth effects. He finds larger wealth effects outside the euro area than within it, and that housing wealth effects rose markedly after 1988 in the wake of financial liberalisation.

1.2.6 Conclusions on wealth effects for consumption

45. There is little question regarding the existence of wealth effects on consumption but rather there is controversy over their cross-country variation, and whether they extend to tangible as well as financial wealth.

46. It is clear that short-run effects are bound to vary due to differing financial systems and cultural attitudes. Whereas the arguments of Labhard *et al.* (2005) that long-term effects should be the same are quite persuasive, the weight of evidence still favours differing long-run effects, which as noted by Barrell and Davis (2007) may themselves vary as financial liberalisation proceeds.

47. Furthermore, the evidence for tangible wealth effects as well as financial wealth is well supported. This underlines the importance for all countries of ensuring that there is adequate, accurate and timely data on the complete balance sheet of the household sector. The arguments for different long-run housing wealth effects are arguably stronger than those for net financial wealth, given the wide differences in housing finance systems. On the other hand, there remains some evidence, notably at the micro level, that the housing wealth effect is actually an income-expectations effect.

48. The work on vector-error correction models shows that conclusions from single equation models on the adjustment of consumption, income and wealth needs to be accepted cautiously. These VEC models

are also a useful way of distinguishing transitory and permanent shocks to wealth which may have different effects on consumption.

49. Macro data are unable to address the issue of the precise channels of wealth effects. Complementary micro studies have shown conflicting results across countries in this regard. They also show that different groups in the population may have differing behaviour (notably arising from variation in liquidity constraints) that may impact on aggregate consumption equations. There may not only be cross-sectional heterogeneity but also over time, given changes in the environment for consumption such as financial liberalisation. A variety of studies have shown an evolution in consumer behaviour, generally entailing increased wealth effects over time.

50. Some areas where further research is needed include the impact of wealth effects on durables, and on disaggregation of financial wealth, for which there are very few recent studies.[8] Furthermore, research naturally concentrates on countries where there are established datasets – more work on transition countries could also be helpful. And the response of consumption to the current financial crisis warrants careful study, as it seems to have been accompanied by a return of liquidity constraints for some households.

1.3 Asset prices and business investment

51. A first strand of the literature on business investment and asset prices is on the effect of the level of asset prices. The second field of work looks at asset price volatility. These will be discussed in turn.

1.3.1 Basic considerations – the neo-classical model and Tobin's Q

52. Modern theories of aggregate investment behaviour, and resultant empirical work, have developed from the neo-classical model first proposed by Jorgensen (1963) and the Tobin's Q model originally due to Tobin (1969) and Brainard and Tobin (1968). As discussed inter alia in reviews of investment theory by Chirinko (1993) and Caballero (1999), both models assume that firms seek to maximise shareholder value.

53. The neo-classical model is itself an extension of simple accelerator models according to which it is output-expectations that determine investment, but augmented to include the effects of relative price variables, specifically the user cost of capital. This is ideally computed from the purchase cost of the additional capital, the rates of interest on bank loans and bond issues, the cost of equity finance, depreciation and the levels of relevant taxes. Alternatively, the Q-theory of investment argues that the level of investment is determined solely by the ratio of the future marginal returns on investment, relative to the current marginal costs of investment.

54. In the neo-classical model the firm maximises the discounted flow of all future profits, with adjustment costs assumed to be absent. If one assumes that the production function is characterised by a constant elasticity of substitution between capital and other inputs, then one can obtain the following familiar relationship between the desired capital stock, the level of output and the user cost of capital, from the static first order conditions of the firm's maximisation problem

$$K^* = \frac{\alpha Y}{C_k^{\sigma}} \tag{3}$$

8. Poterba and Samwick (1995) find a more important wealth effect for consumption of durable goods than for non-durable goods and services in the United States.

where K^* is the desired level of the capital stock, Y is the level of output, C_k is the user cost of capital (otherwise referred to as the rental cost), α is a function of capital and labour and other factors, and σ is the elasticity of substitution parameter between inputs in the production function. The user cost of capital may be defined as

$$C_k = P_k (r + \delta) \frac{(1 - tdep - tcred)}{(1 - t)} \tag{4}$$

where P_k is the purchase price of a unit of capital, r is the real post-tax financial cost of capital (weighted average cost of capital), δ is the depreciation rate of capital (assumed to be geometric), *tcred* is the rate of investment tax credit, *tdep* is the discounted rate of depreciation tax allowances and *t* is the rate of corporation tax. r in turn weights together the cost of equity, bank loans and bond issues. By assuming either that net investment is determined as a distributed lag process of changes in the desired capital stock, or that there are explicit costs of adjustment, it is possible to obtain an investment function for empirical estimation that equates the level of investment to the capital stock in the previous period, lags of the change in the level of output (the "accelerator") and the user cost of capital. Asset prices affect this approach to the extent that the equity risk premium enters the weighted average cost of capital, or varying risk premia on corporate bonds affect the marginal cost of debt finance.

55. Q theory argues that investment should be an increasing function of the ratio of the capitalised financial value of the firm relative to the replacement (purchase) cost of the unit of capital. Hence asset prices enter directly. Abel (1980), Hayashi (1982) and Lucas and Prescott (1971) have shown that if Tobin's Q is included in the firms optimisation problem with adjustment costs, then investment is dependent solely on the level of *marginal Q*. Marginal Q is the ratio of the future marginal returns on investment, relative to the current marginal costs of investment. Values of Q above one will provide a stimulus to investment. Marginal Q is unobservable, only average Q can be measured, which as noted is the ratio of the market value of the firm to the replacement cost of capital. However Hayashi (1982) demonstrated that when the production and adjustment cost functions adhere to certain homogeneity conditions (implying inter alia that there is no market power) then marginal and average Q are equal. So in practice empirical researchers have included measures of average Q in their investment equations. Then one can write the investment equation most simply as

$$I = \beta Q \tag{5}$$

where β is a strictly positive parameter. If Q is greater than one investment should be undertaken and the capital stock increased, because the cost of equity finance is below that of purchasing new equipment, whereas for values of Q less than one further investment should not be undertaken and the capital stock should in fact be reduced. No other variables should be needed to explain investment because all the expectations about future revenue are in the share price, in an efficient market, while desired investment is assumed to be financed in a perfect capital market without credit constraints. In practice there would remain costs of adjustment meaning that equation (5) is an equilibrium that would be adjusted to gradually.

1.3.2 Empirical work on Q and user cost

1.3.2.1 Macro equations using Q alone

56. Empirical work including Q alone in an investment function at macro level have generally been disappointing, for example Oliner *et al.* (1995) found Q in the United States wrongly signed, and

Robertson and Wright (2002) found it insignificant. Papers reviewed in the survey by Caballero (1999) report similar results.

57. In the words of Altissimo *et al*. (2005), and in contrast to the wealth effect on consumption, "in general empirical evidence linking share prices and investment is limited".[9] They suggest that this is due, first, to the fact when share prices are low, firms substitute debt for equity due to cost, while when share prices are high, firms use equity issues for restructuring and mergers rather than investment. Second, as for consumption, investment's response may depend on the source of the change in share prices, and whether it is seen as temporary or permanent (section 1.3.2.3). If markets are inefficient, then the possibility of errors by investors (speculation, fads, bubbles etc.) cannot be ruled out and firms may justifiably ignore the signal to invest. They may rather focus in indicators such as output or sales. Third, it is at times hard to disentangle the cost of capital channel from the financial accelerator/balance sheet channel as discussed below (section 1.3.3). There are particular difficulties in using Q to forecast, centred on the need to project equity prices forward.

58. Most studies in this field are focused on the firm's marginal conditions for optimisation as set out above. On the other hand, developing from Lettau and Ludvigson (2002), Price and Schleicher (2006) for the United Kingdom instead utilised a standard linearised present value asset price decomposition, where the value of the firm is the discounted present value of future profits. This approach does not require marginal Q. Testing outside the sample, they found that Q can not only predict investment over the medium to long term, but also debt accumulation and stock returns.

1.3.2.2 Macro studies using Q with other variables

59. Successful macro studies have typically included other variables in the investment function. This suggests that Q alone is either mis-measured or not a sufficient statistic for investment.

60. For example, Cuthbertson and Gasparro (1995) for the United Kingdom established a role for average Q along with the capital gearing ratio (financial accelerator) as well as output (simple accelerator) in determining manufacturing investment over 1968-1990. Assarsson *et al*. (2004) for Sweden similarly found that Q is a significant determinant of investment in aggregate Swedish manufacturing over 1951-1995 when one includes real output and capital gearing. They also found that the ratio of the equity price index to the deflator for fixed investment is a useful proxy for Q, particularly for forecasting.

61. There are rather few international studies. An early example was Sensenbrenner (1991) who found that Q was a significant determinant of aggregate investment when using an ARMA based dynamic specification, where lags of Q were used to proxy for expected future Q's, in the G-7 excluding Italy. In an error correction model of investment in the G-7, Ashworth and Davis (2001) found a role for the long-run effect of Tobin's Q for Japan and France only. The specification included other financial variables, namely user cost, as well as lagged investment and output growth, although user cost was not significant.

62. In a panel study discussed further in section 1.3.7, Davis and Stone (2004) found that Q was significant on average for 19 OECD countries, with a one per cent rise in Q leading to a 1.1 per cent rise in the level of investment in the long term, again in the context of an equation featuring output and real interest rates as a proxy for the cost of capital.

9. Indeed, Lettau and Ludvigson (2002) show that Q has a stronger relationship with other variables such as bond yields, the gearing ratio, the growth in debt and stock returns than with investment per se.

1.3.2.3 Studies distinguishing temporary and permanent changes in share prices

63. Following the insight that share price changes may be temporary, Bond and Cummins (2001) sought to measure average Q in the US using analysts' forecasts rather than share prices, and found the measure was superior, suggesting this is why share prices do not predict investment. Median analysts' forecasts are held to show better the fundamental or permanent component of share prices that may influence entrepreneurs seeking to boost the capital stock. Anderson and Subbaraman (1996) in Australia similarly sought to divide the fundamental and speculative components of share prices and again found only the former has an impact on investment.

64. In seeming contrast with these results, evidence for the United States also suggests that the stock market bubble of the late 1990s boosted corporate investment. Gilchrist, Himmelberg and Huberman, (2004) developed a model in which an increase in the dispersion of investor beliefs under short-selling constraints predicts a rise in stock price above its fundamental value, or bubble. The model predicts that managers respond to bubbles by issuing new equity and increasing capital expenditure. They tested these predictions (among others) using the variance of analysts' earnings forecasts – a proxy for the dispersion of investor beliefs – to identify the "bubble" component in Tobin's Q. When comparing firms traded on the NYSE versus the NASDAQ, they found that the model captures key features of the 1990's technology boom. They provided further evidence in favour of the model using a panel-data VAR framework, and found that shocks to dispersion have positive and statistically significant effects on Tobin's Q, net equity issuance, and real investment.

65. As for Gilchrist, Himmelberg and Huberman, (ibid), Goyal and Yamada (2004) for Japan found that speculative aspects of share prices affect investment in bubbles, but the fundamental component is crucial in busts. They also found that bank-dependent firms in Japan react to share prices more strongly than those with access to other sources of funds, consistent with the work of Audretsch and Elston (2002) for Germany.

66. These results can be reconciled by different impacts of measured Q during bubble and non-bubble periods, where the former are quite rare and well-defined (mainly occurring in the United States in the 1990s and Japan in the 1980s). Furthermore, during bubble periods median analyst forecasts may themselves be subject to "euphoria", and hence biased upwards compared to fundamentals. So the median as well as the dispersion may be affected by the bubble. These results may also collectively help to explain the poor results for aggregate Q equations highlighted in section 1.3.2.1-2.

1.3.2.4 Micro studies

67. Regarding micro studies, in line with the macro results, these have typically found a need to focus on additional variables besides Q. For example, Alonso and Bentolila (1992) found internal finance or cashflow as well as Q influenced capital investment by Spanish industrial companies. This result was thought to be related to the low level of development of Spanish equity markets at the time. Van Ees and Garretsen (1994) for the Netherlands found that once sales and financial variables are included, the effect of Q on investment by a panel of companies is low. Audretsch and Elston (2002) estimated a Q equation for German firms where financial constraints also entered the specification. They found Q to be significant for the smallest firms (who have less access to external finance) and second largest firms.

68. Jovanovic and Rousseau (2009) showed that investment of US firms responds asymmetrically to Q. Investment of established firms, what they call 'intensive' investment, was found to react negatively to Q whereas investment of new firms, "extensive" investment, responds positively and elastically to Q. They suggested that this asymmetry reflects a difference in the cost of adopting new technologies. A fall in the compatibility of new capital with old capital raises measured Q but reduces the incentive of established

firms to invest. New firms do not face such compatibility costs and step up their investment in response to the rise in Q.

69. These studies, notably those for the United States and Germany may also help explain the poor results for macro studies because firms behave differently with respect to Q. This is likely to distort its impact at the macro level, particularly over time as the distribution of firms changes. Multivariate studies including Q may indeed be capturing the investment responses of different groups of firms with each variable.

1.3.2.5 Q and housing investment

70. Whereas most studies look at non-residential investment, Jud and Winkler (2003) present estimates of a Q model of housing investment, using quarterly data for the United States. The empirical model is estimated using building permits, housing starts, and housing investment as measures of investment. The current and lagged values of the Q ratio are found to be positively and significantly associated with housing investment, whichever way investment is measured. The findings suggest that the housing market indeed functions as Tobin has theorised. Housing suppliers appear to respond to the demands of housing consumers, building more new homes when existing home prices are high relative to new home prices.

71. Berg and Berger (2005) find similar results for Sweden. Over 1993-2003 quarterly data show a high degree of correlation between the Q ratio and the (logarithm of) two different variables for housing investment. An error correction regression model, controlling for structural breaks, indicates also a stable long-run relationship between the log of building starts and the Q ratio between 1993-2003 but not between 1981-1992 (the boom and bust period that culminated in the Swedish banking crisis). The latter results suggests again that bubbles – and structural change in the financial system – may blur the effects of Q. Barot and Yang (2002) again find Q significant in the long run for the housing market in Sweden and also in the short and long run for the United Kingdom, based on an error correction approach over 1970-98. House prices may be more domestically focused than share prices, and housing investment more homogeneous, explaining the positive results of these studies. On the other hand, Altissimo *et al*. (2005) comment that effects of house prices on housing investment may be country specific and depend on availability of mortgage finance and the link of house prices to construction costs.

1.3.2.6 Studies incorporating the user cost of capital

72. As regards user cost, the consensus in the 1980s and 1990s was that it was equally weak empirically as Q. But recent evidence suggests otherwise, for example Chirinko *et al.* (2002) who used US panel data and Ellis and Price (2004) in the United Kingdom both found well determined elasticities of around 0.4-0.5. The latter estimated the capital stock and investment separately but simultaneously in a structural VECM framework. They criticise the bulk of the existing literature for incorporating both of these processes in one equation.

1.3.2.7 Conclusions on Q and user cost

73. Concluding this section, it is clear that Q has firm theoretical foundations but has often been disappointing in empirical studies. Possible reasons for this are that omitted variables vitiate the estimates, that there are different effects of temporary and permanent share price changes, or between bubble and non-bubble periods, or that there may be asymmetries between types of firms. Also average Q could proxy marginal Q only with a margin of error.

74. Paradoxically, Q seems to be more consistently effective in housing that in business investment studies. Another promising approach may be to embed Q in a present value rather than optimising

framework. User cost has had similarly disappointing results, but studies estimating the capital stock and investment separately have had superior outcomes. One further reason for difficulties with Q is that implicit in studies using Q alone is an assumption of perfect capital markets with no role for capital market imperfections. Other approaches make these imperfections central to their modelling strategies.

1.3.3 Balance sheets and investment

75. Two more recent developments in the literature suggest that aspects of the financing of investment by firms through borrowing could yield some additional information regarding the determinants of the level of business investment, namely the financial accelerator and the bank lending channel effect. Whereas both of these concepts rely on the effects of asymmetric information on credit rationing of external finance, the former applies to all debt financing, while the latter focuses more closely on the special nature of bank lending.

76. Broad lending (from banks or bond markets) is constrained by firms' net worth, while bank lending concerns firms that do not have access to capital markets and for which the only source of external finance is bank lending: *e.g.* firms in countries with shallow capital markets and small firms. This has an impact on the real economy via the distribution of firms. Sectors with a larger number of small firms (such as services) are more affected by the bank lending channel. Only the financial accelerator is linked directly to asset prices (since falling asset prices are one way in which net worth may change). While share prices do not affect the bank lending channel directly, they may do indirectly via the effect of share prices on bank balance sheets, making them more or less willing to lend.

77. Meanwhile, a further strand of the literature focuses on trade credit as a marginal source of external finance when other sources are unavailable. However, empirical studies suggest that this is mainly relevant for inventory investment in OECD countries (see Guariglia and Mateut, 2006 and Bougheas *et al*., 2008 for the United Kingdom, for example).

1.3.4 The financial accelerator

1.3.4.1 Theoretical motivation

78. The supply of external debt finance, be it intermediated or not, is problematic, as a consequence of asymmetric information between borrowers and lenders and the inability of lenders to write complete contracts covering borrowers' behaviour in every eventuality. These give rise to the well-known agency problems of the debt contract, linked to adverse selection in advance of lending and moral hazard after the financing has taken place. These effects may vary over time, giving rise to cyclical changes in credit supply (as suggested by Holmstrom and Tirole, 1997 and Rapullo and Suarez, 2000).

79. Mishkin (1991) suggests that variations in agency costs affecting credit supply may occur, for example, via a decrease in the valuation of assets (*e.g.* a stock market decline provoked by a change in future profit expectations), which lowers collateral values, sharply increasing adverse selection for lenders; rises in interest rates causing adverse selection to increase sharply, provoking a substantial decline in credit availability; and a parallel mechanism operating via the link of net worth to moral hazard. The agency problem is greater when borrowers have low net worth as they have less to lose from default.

80. Such movements can give rise to a "financial accelerator" or "broad credit channel" effect (Bernanke, Gertler and Gilchrist, 1999). Changes in cash flow or asset prices over the cycle give rise to pro-cyclical feedback effects of agency costs on the cost of external debt finance (both from banks and securities markets) and hence on real corporate expenditure. This will operate, in particular, for borrowers whose net worth is most heavily affected during a recession, and via borrowers whose activities are riskier or harder to monitor. Small firms are examples in each case.

1.3.4.2 Micro studies

81. Following the insight that credit constraints may be greater for certain types of firm, most work in this area has been micro based. Early empirical tests of the hypothesis for the United States included Bernanke, Gertler and Gilchrist (1996), who showed that after a monetary tightening, the relationship between internal funds and investment becomes stronger for smaller firms than larger firms. Additionally, small firms experience much more pro-cyclical variation in economic activity than do large firms. Oliner and Rudebusch (1996) found similar results. Hu (1999) using individual firm data showed that monetary contractions reduce investment more for highly leveraged firms than for less leveraged ones.

82. Outside the United States, Vermuelen (2002) applied the financial accelerator approach to Germany, France, Italy and Spain using micro data and showed that weak balance sheets are more important in explaining investment during downturns than strong balance sheets during upturns, while effects of the accelerator are greatest for small firms and in France and Italy. Chatelain *et al*. (2003) used micro datasets for the same countries and found that investment responds to user cost, sales and cash flow movements. Martinez-Carrascal and Fernando (2008) looking at micro data for six euro area countries, found inter alia that a high level of debt can lead to balance sheet adjustments in the form of companies deferring or foregoing investment projects, consistent with the financial accelerator. The largest sensitivity of investment to indebtedness was in the Netherlands and Italy, while German firms were least sensitive, possibly due to banking relationships.

83. At the national level, Von Kalckreuth (2001) estimated investment functions for German firms featuring user costs (price effect), sales (accelerator effect) and cash flow/capital stock (financial effect). He used Bundesbank credit ratings as a regressor and attributed its effect to the financial accelerator. Looking at the United Kingdom, Guariglia (1999) found a significant link from financial variables to inventory investment, which is stronger for firms with weak balance sheets, during periods of recession and when monetary policy is tight.

84. Some studies have successfully combined financial accelerator variables with Q. Aivazian *et al*. (2005) for Canada found in a Q investment function that leverage (long-term debt/assets) is negatively related to investment. This negative effect is greater for firms with low growth opportunities, as proxied by a Q below 1.

1.3.4.3 Macro studies

85. As noted by Altissimo *et al*. (2005), the fact that micro studies show that small firms are most likely to be subject to financial accelerator effects means that macro effects are likely to be difficult to obtain. This is because small firms are likely to be either unquoted or form a trivial part of the aggregate debt-equity ratio.

86. One exception is the United States, which is unique[10] in having disaggregated flow of funds data between non-corporate and corporate firms, which enables disaggregated studies at a macro level. Using such flow of funds data, Christiano *et al.* (1996) showed that following a monetary policy shock, borrowing of large corporate firms rises for some time, before falling off in the subsequent recession (perhaps because cash flows fall before expenditure can be adjusted). In contrast, the borrowing of small non-corporate firms (whose net worth may be hit by the monetary policy action) is much weaker. Similar work is not feasible in other countries since corporations are generally aggregated in the national balance sheet data.

10. See Byrne and Davis (2003*b*).

87. Nevertheless, Ashworth and Davis (2001) in their study of aggregate investment in the G-7 corporate sectors did allow for a broad credit channel by including the corporate debt/equity ratio in a "Jorgensen" investment function featuring the cost of capital and the accelerator. They found evidence that the long-run level of investment is lower when the debt to equity ratio increases in the United States, Canada, the United Kingdom, France and Germany. The size of the effect appeared to be similar in both the North American and European countries, with the exception of Canada where the effect was three times as great as in any other country. A leveraged effect of a recession could also be found for Canada alone. No effects were found in Italy or Japan. Equally Davis and Stone (2004) using a similar specification found that the debt to equity ratio was a significant long-run determinant of investment in a panel of 19 countries. These results suggest that positive outcomes for macro studies remain feasible.

1.3.5 The bank lending channel

1.3.5.1 Theoretical motivation

88. Whereas the accelerator focuses on total external finance, the bank lending channel focuses more directly on the special nature of such loans, and suggests that after a monetary tightening, bank lending falls relatively more than other types of debt, thus having a separate effect on investment. The bank lending channel emphasises the effects a change in monetary policy has on supply and demand for bank loans and potential asymmetry between the effects of positive and negative monetary shocks on final activity variables.

89. An increase in the interest rate may result in a worsening in the financial position of banks, which could be caused either by a fall in deposits, as a result of financial losses by the lender in other markets, or a fall in asset prices, in each case leading to a reduction in the supply of credit. Banks are also constrained by the requirements to keep a minimum capital to risk-weighted assets ratio of 8% or greater by international agreement, so if they are close to this ratio they cannot increase their supply of credit without first increasing their capital.

90. Effects of monetary policy tightening on bank capital help further to rationalise the separate credit channel (Rapullo and Suarez, 2000). Equally, a rise in bank share prices may increase their willingness of capacity to lend – and vice versa (Altissimo *et al*., 2005).

91. Whereas the literature on the bank lending channel incorporates a wide range of work on bank characteristics and lending (see for example Ehrmann *et al.* (2001) and its references) as well as the impact of bank loans on corporate investment, the focus here is on the latter for its more direct relevance to the work in hand.

1.3.5.2 Micro studies

92. Most work on this hypothesis has again typically disaggregated by firm size and is focused on the United States; not all studies have focused on fixed investment. For example, Gertler and Gilchrist (1994) found a larger role for bank credit in explaining inventory fluctuations for small firms than large ones, as well as a larger and speedier impact of monetary policy on small firms' expenditure and borrowing. They attributed these patterns to the credit channel, interacting with the high costs faced by small firms in switching sources of credit. Gertler and Gilchrist (1992) observed a perverse increase in loans for large companies following a monetary tightening, while there is an immediate reduction for small firms. They attributed this to large firms meeting cash flow shortages by both running down "buffer stock" deposits and increasing loans. With small firms facing higher costs of access to credit, such distress borrowing is not a possibility.

93. Complementing these results, Kashyap *et al*. (1993) showed that bank-dependent firms lacking bond ratings and with low liquidity are most likely to cut inventories in periods of monetary tightness. Morgan (1994) found sizeable increases in loans made under commitment, likely to be held by larger and stronger borrowers, during periods of tight money. Research by Bernanke (1993) shows that loans made at sizeable spreads relative to the US prime rate, to small and risky firms, shrink as a proportion of total loans as monetary policy becomes restrictive.

94. Outside the United States, Hoshi *et al*. (1993) have shown for Japan that liquidity is more important for the investment by firms that do not have a main bank link during periods of tight money, and that the credit mix is a significant determinant of investment and inventories. In Germany, the study by Von Kalckreuth (2001) shows that financially constrained German firms (sorted by unfavourable Bundesbank credit ratings) exhibit increased sensitivity to internal funds and decreased sensitivity to user cost. However, there is no distinction between small and large firms, suggesting that at least up to 1997, German relationship banking did not discriminate against the latter. Valderrama (2001) found that in Austria investment of firms with close banking relationships and access to trade credit was less vulnerable to changes in corporate liquidity than is otherwise the case. Butzen *et al*. (2001) for Belgium found that the credit channel as proxied by the impact of the cashflow-capital ratio is larger for smaller firms and those in manufacturing.

1.3.5.2 Macro studies

95. Aggregate evidence is again quite scanty, which as for the credit channel would be anticipated given the effect is more important for small firms. Looking at the G-7, including the bank loans to total debt ratio as a proxy for the bank credit channel, Ashworth and Davis (2001) found significant evidence of a long-run negative effect in both the United States and Japan, *i.e.* investment is lower when bank loans are a higher proportion of debt. Davis and Stone (2004) found that the loan to debt ratio was a significant long-run determinant of investment in a panel of 19 countries.

1.3.5.3 Conclusions on balance sheet effects

96. Both the credit channel and the financial accelerator are usefully dealt with together since there are strong parallels in the patterns of empirical work. Generally work has been dominated by micro studies, given the insight that vulnerability to credit rationing due to these channels is itself dependent on firms' characteristics. It is also likely to vary strongly between countries, with respect for example to the closeness of banking relationships (which may itself vary over time). Because of the differing behaviour at the micro level, there have been few attempts to capture these effects using macro data, although the results of the few existing studies are quite promising. A challenge is to further integrate the insights of these areas of work with that on Q, which as noted often assumes perfect capital markets.

1.3.6 Volatility of asset prices and investment

1.3.6.1 Theoretical considerations

97. According to Dixit and Pindyck (1994), the effect of uncertainty on investment stems from the option characteristics of an investment project, given the option of delaying the project and its irreversibility once begun, together with the uncertainty over future prices that will determine its profitability. The value of the option stems from the fact that delaying the project may give a more accurate view of market conditions. The call option implies a difference between the net present value (NPV) of an investment and its current worth to the investor. To lead to expenditure, the NPV has to exceed zero so as to cover the option value of waiting. The expectation is that heightened uncertainty, by leading to delay in projects, would lead to a fall in aggregate investment. There may also be threshold effects i.e. rates of

return below which investment is not undertaken, depending on investors' risk aversion. Abel *et al*. (1996) extended this theory of irreversibility to show that there could be both a call and put option feature in investment, in terms of options to expand or contract the capital stock in the future.

98. On the other hand, the literature is not unanimous in suggesting a negative effect of uncertainty on investment. Hartman (1972) and Abel (1983) show counter to the above that where there is perfect competition and constant returns to scale as well as symmetric adjustment costs, an increase in uncertainty may also raise the value of a marginal unit of capital and hence the incentive to invest. Lee and Shin (2001) argue that the balance between the positive and negative effects of uncertainty may depend on the labour share of firms' costs.

1.3.6.2 The choice of variable measuring uncertainty

99. Carruth *et al.* (2000) in a key survey paper suggested there is a broad consensus that the effect of uncertainty on aggregate investment is negative. This holds for a range of indicators, for which there are diverse theoretical considerations. Looking for example at share price volatility, it is argued in Carruth *et al*. (ibid) that the use of stock market based measures may reveal cash flow uncertainty for the firm, but are not relevant indicators of future economic shocks and policy changes. Moreover, stock prices may be vulnerable to bubbles rather than reflecting fundamentals. Hence they argue that macroeconomic variables such as price, output and exchange rate volatility are theoretically preferable.

100. Byrne and Davis (2005*a*) query this approach, since share prices take into account all information relevant to the future profitability of the firm (or at a macro level the corporate sector). Furthermore, one can argue that investment is discounted by the long-term interest rate plus a risk premium, where the latter may be linked to equity market volatility (Davis and Madsen, 2008). Such conflicting views suggest a need to take a comprehensive empirical view of possible measures and their impact.

101. For example, Byrne and Davis (2005a) assessed the impact of a comprehensive range of potential sources of uncertainty on aggregate business investment across the G-7 using Pooled Mean Group Estimation (PMGE) and GARCH methods to model uncertainty. These variables are the CPI, long-term interest rates, nominal and real trade weighted effective exchange rates, industrial production and the stock market index. Volatility of financial rather than real variables was found to be most important. Notably, a significant negative long-run effect from exchange rate volatility was found for the G-7 and in poolable subgroups including all four larger EU countries. Volatility of long rates has additionally influenced investment in recent years. For most estimates, a one standard deviation rise in conditional exchange rate volatility leads to a 2-4% fall in investment, although some samples gave greater declines. Meanwhile there were no positive results for industrial production or inflation volatility.[11]

102. In studying investment by US firms, Bond and Cummins (2004) partly follow the approach of asset price volatility for measuring uncertainty (*i.e.* stock return volatility). But they supplement this by the variance of analysts' forecasts and the variance of forecast errors for such profit forecasts. They find that the latter variables are also highly predictive, with the level of disagreement among analysts providing the most informative uncertainty indicator.

1.3.6.3 Alternative approaches to measuring uncertainty

103. As regards measurement of uncertainty, in common with Byrne and Davis (2005*a*), Huizinga (1993) and Price (1995) used ARCH or GARCH measures of macroeconomic variables when modelling

11. Other studies, including Byrne and Davis (2004) looking at US inflation uncertainty, have found macro as well as financial effects, however.

investment and uncertainty. Huizinga (1993) considered conditional volatility of US inflation, real wages and real profits and generally finds a negative effect on investment at an industry level. Price (1995) utilised the conditional variance of the growth rate of GDP, and finds a negative effect on UK manufacturing investment at the second lag.

104. The question of whether there is a different effect from forward and backward looking measures of uncertainty has been raised by Ferderer (1993). He attempts to produce a forward looking measure based on the risk premium from the term structure. For the United States he finds that the effect on investment is negative. Driver and Moreton (1991) model uncertainty using the standard deviation of 12 months forward predictions of output growth and inflation across 12 forecasting teams. They find a negative long-run effect from output growth on investment but no long-run effect from inflation on investment.

105. All of these approaches are in a sense conditional measures of volatility. Other studies have used unconditional measures, such as Darby *et al*. (1999), who use 8-period moving average variance. Goldberg (1993) and Campa and Goldberg (1995) derived their measure of exchange rate volatility from the standard errors of the residuals from a moving average representation of the exchange rate using US data.

106. The question of whether unconditional or conditional volatility is most appropriate is an important one. As argued in Byrne and Davis (2005*a*), the key is the distinction originally due to Knight (1921) between risk and uncertainty. Risk can be defined as the danger that a certain contingency will occur, a measure often related to future events susceptible to being reduced to objective probabilities, while uncertainty is a term applied to expectations of a future event to which probability analysis cannot be applied, such as a change in policy regime or a financial crisis (Shafer, 1986). The response of an uncertain market – and the response of investment thereto – may appear out of scale with the proximate causes of a given stimulus, if it leads participants to change the way they form their decisions.

107. In this context, heightened unconditional volatility alone may merely reflect a greater incidence of large random and independent shocks, *i.e.* greater risk, without a change in underlying perceptions as to the situation on the part of firms considering investment.

108. On the other hand, heightened conditional volatility, besides indicating risk, may also indicate greater (unmeasurable) uncertainty on the part of the market regarding the direction of the variable and the intentions of the authorities, including market responses to shocks per se (an increased tendency for shocks to have persistent effects on the market) which may be more likely to affect investment. More generally, conditional volatility highlights periods of concentrated volatility which might be expected to maximise uncertainty and hence the option value of waiting to undertake investment, while the rolling measures could just be capturing background volatility with occasional outliers that firms learn to live with. A similar point is made by Serven (2003), who considers use of GARCH essential to measure exchange rate uncertainty as opposed to “sample variability”.

1.3.6.4 Studies focusing on exchange rate volatility

109. A number of studies concur in finding a link from exchange rate volatility to investment. Darby *et al.* (1999) using a model based on Dixit and Pindyck (1994) suggest that there are situations where exchange rate uncertainty will depress investment (*e.g.* when there are perceptions of misalignments) and situations where it will not. In the empirical section of their paper Darby *et al.* (1999) find, using a neoclassical model, Tobin’s Q and moving average unconditional exchange rate variance, that uncertainty has a significant and negative impact on investment for the United States, Germany and France. There are additional dynamic effects which are negative for Italy and the United Kingdom. There are negative misalignment effects for the United States, France, Italy and the United Kingdom.

110. Serven (2003) using GARCH measures of uncertainty, found a negative and highly significant impact of real exchange rate uncertainty on private investment in a sample of developing countries, after controlling for standard investment determinants. The impact is larger at higher levels of uncertainty – in line with the analytical literature underscoring 'threshold effects'. Moreover, the effect on investment of real exchange rate uncertainty is shaped by the degree of trade openness and financial development: higher openness and weaker financial systems are associated with a more strongly negative uncertainty-investment link. Openness is often linked to country size, with smaller countries being more open.

111. Byrne and Davis (2005*b*) examined the relationship between aggregate investment and exchange rate uncertainty in the G-7, using panel estimation and a decomposition of volatility derived from a Components GARCH model. The dynamic panel approach was considered to take account of potential cross sectional heterogeneity, which can lead to bias in estimation. They found for a poolable subsample of European countries, that it is the transitory and not the permanent component of volatility which adversely affects investment. To the extent that short-run uncertainty in the Components GARCH model characterises higher frequency shocks generated by volatile short-term capital flows, these are most deleterious for investment. One would expect similar and possibly larger effects on smaller countries.

1.3.6.5 Conclusions on investment and uncertainty

112. This corpus of work strongly suggests that there is a negative link from uncertainty to investment, and at least for OECD countries, the volatility of asset prices is the best proxy for such uncertainty. Accordingly, there are numerous results suggesting a negative impact of such asset price volatility. Theoretically, it can be argued that GARCH or other conditional measures of volatility are superior to simple volatility, while a principal focus could justifiably be on exchange rate volatility. Missing from the current literature are disaggregated studies looking at the differing response of small and large firms to asset price volatility, and whether the response interacts in some way with credit market imperfections.[12] Also, there is a question whether the response is linear or whether extreme volatility has a greater impact.

1.3.7 Investment and financial crises

113. Financial crises can generate additional effects on investment beyond those of traditional variables. They are likely to generate increased uncertainty beyond those indicated by asset price volatility as well as credit rationing beyond that predicted by the financial accelerator or credit channel. Indeed, as shown in Table 1 from Detken and Smets (2004), investment (and inventory contractions) are the main contributors to lower GDP growth after high cost booms, which often feature banking or currency crises at their peak.

114. Davis and Stone (2004) assessed the impact of crises in both a neoclassical and Tobin's Q specification of investment functions, using dummies to capture the extra impact of financial crises. Their econometric analysis suggests that financial crises have a greater impact on investment expenditure and the financing of corporate sectors in emerging market economies (EMEs) than in OECD countries. OECD countries appear to benefit from a pick-up in bond issuance in the wake of banking crises. Although companies in EMEs hold more precautionary liquidity, this is evidently not sufficient to prevent a stronger response of expenditure to shocks.

2 Estimation of investment functions

115. In the light of the above, investment functions have been estimated with a view to obtaining new evidence on asset price effects on real non-residential fixed investment. The work is in two parts, following

12. For a study linking firm size to macroeconomic uncertainty, see Ghosal and Loungani (2000).

the above, with work being first on effects of levels of asset prices on investment (largely via Tobin's Q and the debt-equity ratio). Then, work on the relation between asset price volatility and investment is undertaken. The work expands earlier work in both fields considerably, by providing results for over 20 OECD countries, and using data up to 2008. This in turn also provides background for an assessment of investment in the recent crisis.

2.1 Data

116. In all cases, the estimations are based on annual data. This is partly due to the use of annual data for sectoral balance sheets and the capital stock, which are crucial for estimating most of the asset price effects. However, we also contend that annual data ensures that dynamics can be simple and comparable, while it facilitates a focus on the long-run properties of the data.

117. The sample begins in 1970 for all estimates, which thus excludes the 1960s when a different regime was in force for exchange rates, and both domestic and international financial markets were generally not liberalised. Already by 1971 came the breakdown of Bretton-Woods and heightened asset price volatility, as well as growth of international capital markets and progressive liberalisation of domestic ones, benefiting the corporate sector at an early stage. In order to maximise use of available information, all the data available between 1970 and 2008 are used for each estimate. This does make for different samples, given the restricted availability of flow of funds balance sheet data compared with asset prices and real economy variables. Robustness checks are reported later using the same size and composition of panels for each equation – results are very similar.

118. The data are almost exclusively from the OECD, which should ensure a high degree of harmonization. The time period for each data series is given in Appendix 1. We use real business investment (IB) as our dependent variable. Wider private sector aggregates often include housing investment and the housing stock, which has a different cyclical pattern as business investment. Business sector data also overcome the problems of transfer from public ownership, by including business sector investment whatever its ownership. Meanwhile, for measuring real output, real GDP is used. For the cost of capital the real long-term interest rate (deflated by the deflator for GDP, PDGP) is employed, although the OECD's estimate of the user cost of capital and the BBB bond yield was also used. The cost of capital is calculated as the tax-adjusted purchase price of a unit of capital, multiplied by the real post-tax financial cost of capital plus the depreciation rate (Schreyer *et al.*, 2003).

119. There are arguments favouring other possible deflators for the long rate. Ideally the real interest rate should reflect the prices of goods and services in the domestic economy. The GDP deflator does this quite well but can behave in a counter intuitive manner in an oil crisis since it includes import prices as a negative item. The investment deflator, PIB, might be seen as closer to the dependent variable but tends to be highly volatile which reduces its usefulness in measuring a real interest rate (which is of course trying to proxy future inflation expectations). There are also arguments for a consumption-based deflator such as the CPI or consumers' expenditure deflator (CED). Besides being commonly focused on by authorities in macro management, they are also close to the desired measure of overall goods and services prices – the deflator for total final expenditure is not so readily available. We consider the choice for our current work to be an empirical matter and find PGDP to be best able to capture the negative effects of the cost of capital on investment, and hence utilise it throughout. Variants are provided in section 2.5 with alternative measures of the risk free rate using PIB and the CPI.[13]

13. A set of results using CPI is available from the author on request. In practice, the results for CPI and PGDP are very similar for the various tests of asset price effects. It is in its ability to capture the cost of capital effect on investment that PGDP stands out.

120. For estimating effects of levels of asset prices on investment, these data are combined with annual balance sheet data for the corporate sector, derived from the OECD national accounts database. These include, in particular, data on the three main corporate financial liabilities, namely the stock of equity outstanding at market value, the stock of bonds and the stock of bank loans as well as trade credit. These series are all annual, which further justifies the use of annual data in our estimation. Complementing these we use annual data for the non-financial corporate sector nominal net capital stock, which is obtained from the OECD's STAN database. As a variant, given the limited data on nominal capital stocks, a volume measure of the real net total productive capital stock is also used, which is translated into an estimated nominal value by using the business investment deflator.

121. For estimating effects of volatility of asset prices on investment, the data above are combined with GARCH estimates of the conditional volatility of exchange rates, share prices and long-term interest rates derived in turn from first differenced monthly underlying data for the same series (in logs for exchange rates and share prices and in levels for interest rates). We also use unconditional measures of volatility as a robustness check. Unconditional variance is measured as the non-overlapping annual variance series derived from monthly per cent changes in underlying variables. The share price indices came from the IMF's IFS database, the rest from the OECD.

122. To be concise, details of the GARCH estimates are not provided (full details of conditional variance estimation results are available from the author). It suffices to note here that significant GARCH effects were present in each case and that the GARCH process in the conditional-variance equation was in virtually all cases covariance stationary with $a1+b1<1$. We note, following Engle (1983) that GARCH generates a model-dependent outcome, although the approach adopted, of differencing the conditional-mean equation sufficiently to avoid autocorrelation, is fairly standard.

123. Table 3 shows the Im-Pesaran-Shin panel unit root tests for the regression variables, which show that logs of investment and GDP have unit roots in levels, as would be expected given these are trended variables. The conditional variances are all stationary, as is the real long rate and user cost of capital. We also anticipate that the logs of financial ratios will be stationary, since they cannot be trended in the long term, but this is not the case for the debt-equity ratio, Tobin's Q or the trade credit/GDP ratio. This is probably due to the short time series that are available. In practice, variables other than investment and GDP are treated as stationary in the estimations, given these are the only variables with a fundamental trend in them.

Table 3. **Panel unit root tests (Im-Pesaran-Shin)**

2.2 Basic specification

124. Following the discussion above, in this section a baseline "Jorgensen" investment function is developed which can be extended both for testing the long-run relationship between levels of asset prices and investment and also uncertainty and investment. We follow Bean (1981), Driver and Moreton (1991) and Darby *et al*. (1999) in estimating a dynamic error correction model of investment including both short and long-run terms in output, investment and the cost of capital. Consistent with these authors, the long-run homogeneity of output as implied by the CES production function is tested. A flexible accelerator based investment function is used (testing for additional cost of capital effects) by panel estimation with country fixed effects.

125. The flexible accelerator model is represented by a short and long-run relationship between investment and output, such that a desired output-capital relationship is maintained. This ignores, however, possible substitution effects between factor inputs, unlike the neoclassical model of Jorgensen

(1963). To take account of possible substitution effects the neoclassical model incorporates factor prices in the form of the user cost of capital (C_t). Hence as noted above, the desired capital stock (K_t*) is as follows:

$$K_t^* = \frac{\alpha Y_t}{C_t^\sigma} \tag{6}$$

where Y_t is output, α is a constant and σ is the elasticity of substitution between factor inputs.

126. As discussed in Carruth *et al*. (2000), empirical investigators typically assume either that net investment is determined as a distributed lag process of changes in the desired capital stock, or that there are explicit costs of adjustment. Then, it is possible to obtain an investment function for empirical estimation that equates the level of investment to lags of the change in the level of output and the user cost of capital, without the need for a capital stock in the final estimation. This is illustrated in the following four equations, where equations (7) and (8) show the evolution of investment in terms of the capital stock, (where δ is the depreciation rate and g is the steady state growth rate), (9) integrates this into the equation (6) and (10) sets out the long run equation in logarithmic form:

$$I_t = \delta K_t + dK_t \tag{7}$$

$$I_t = (g + \delta)K_t \tag{8}$$

$$I_t = \alpha(g + \delta)Y_t / C_t^\sigma \tag{9}$$

$$\ln(I_t) = \theta_0 + \theta_1 \ln(Y_t) - \varepsilon \ln(C_t) \tag{10}$$

In addition, the dynamics are specified. Following the approach of Cuthbertson and Gasparro (1995), Carruth *et al*. (2000) and Byrne and Davis (2005*a* and *b*) to modelling investment, the basic equation is as follows:

$$\Delta \ln(IB)_{it} = \phi_i \left(\ln(IB)_{i,t-1} - \theta_{0i} - \theta_1 \ln(YB)_{it}\right) + \sum_{j=1}^{p} \delta_{ji} \Delta \ln(IB)_{i,t-j} + \sum_{j=0}^{q} \varphi_{ji} \Delta \ln(YB)_{i,t-j} + \varepsilon_{it} \tag{11}$$

where IB is business investment and YB is GDP, and cost of capital effects are added in the short and long run. The basic equation can also be augmented with Tobin's Q effects as an alternative to the cost of capital (section 2.3) and other variables of interest affected by the level and volatility of asset prices.

127. Results of estimation for the full sample are provided in Table 4, where the real long-rate is used to proxy the cost of capital. As can be seen, the specification for all 23 countries has virtually all variables significant. In terms of dynamics, the accelerator term in the growth of GDP is over 2.5 and lagged investment growth is also significant with a coefficient of 0.18. The change in the long rate has a correct sign and is significant. Lagged GDP growth is not significant, however.

Table 4. **Basic investment functions**

128. In terms of the long run, we note first that the log of investment, log of GDP and real long rate are cointegrated according to the Kao and Pedroni panel cointegration tests. The Kao test is preferred, given that Gutierrez (2003) sees Kao as superior to Pedroni for small samples, and that both are superior to the Larsson test. But for completeness the Pedroni v-test is also included. The error correction term on lagged investment can be used to derive long-run values, also shown in the Table (the long-run effect is

minus the coefficient on the lagged level terms divided by the error correction coefficient). As in Byrne and Davis (2005a and b) there is no evidence of long-run homogeneity of investment and output, with the implicit output coefficient being 1.4, more than 2 standard errors away from 1.[14] The error correction term is 0.15, implying quite slow adjustment from disequilibria. Meanwhile, the long-run real rate term is again not significant, with a long run effect of -0.009, close to unity bearing in mind the long rate is in levels and the rest of the equation in logs.

129. In this and other estimates, two subcategories, the G-7 countries and the smaller OECD countries, are distinguished. This can be justified by their openness, relative dominance by multinational enterprises and resulting different vulnerability to external shocks, as well as typical degree of monetary policy autonomy (since small countries often target exchange rates while G-7 ones have more scope for floating). In the G-7, the main distinction from the full sample is that the lagged income growth term is also significant. The accelerator is smaller at 2.1. The long run income coefficient is 1.5, with again no evidence for homogeneity. Furthermore, the error correction term is higher at 0.21 implying more rapid adjustment to equilibrium. In contrast, for the smaller countries, there is no lagged output effect detectable, while there is a larger accelerator term (2.7), slower error correction adjustment and again no long-run homogeneity. The real long rate is only significant at 90% for the smaller countries, but consistently has a correct sign in levels and differences, and close to unit long run elasticity.

130. As an alternative, a specification using the OECD measure of the user cost of capital was tested, as set out in Schreyer *et al.* (2003) instead of the real long rate. The results are shown at the bottom of Table 4. Because of short time series, the samples are much smaller. The variable is not significant except for the difference term for the G7, which has the wrong sign. A further test was with real BBB bond yields, which have very limited data (only 102 observations for the full sample). Although this is more appropriate for firms than the risk free long rate, probably due to the short samples, the level and difference are insignificant in all cases. Accordingly, the real long rate is retained as the cost of capital term for the rest of the work reported here.

131. This specification was used as a test bed for asset price effects on investment, bearing in mind that the long rate itself is a form of asset price determined by supply and demand for government bonds. Owing to data limitations, the level estimations often have less observations and countries than the results shown in Table 4. In contrast, owing to the availability of long time series for monthly data for exchange rates, share prices and long rates, the variance results in section 2.4 are more comparable in country and time coverage. Some standardised samples are reported in section 2.5, which have similar patterns to those reported here, however.

2.3 Levels of asset prices and investment

132. In line with Ashworth and Davis (2001) and Davis and Stone (2004) the basic "Jorgensen" style equation is augmented with variables reflecting the balance sheet and cost of capital effects discussed in sections 1.3.2-1.3.4. Accordingly, we incorporated one at a time the log of the corporate debt-equity ratio to allow for the financial accelerator, the log of the bank lending to total debt ratio to capture the credit channel, and finally Tobin's Q (as a substitute for the real long rate) as an alternative cost of capital term. Q is determined using respectively data for the nominal net capital stock (as is theoretically correct) but also using an estimate of the nominal capital stock derived from real productive capital and the business

14. The results are consistent with Jones (1995) who reports evidence of increasing investment/output ratios for the industrialised countries in the post war period and Davis and Madsen (2008) who note a sharp rise in the capital/output ratio in the major industrial countries. It may also be linked to an increase in the depreciation rate (where the basic model assumes a constant rate) and increased capital mobility as well as a decline in the relative price of capital goods.

investment deflator. The latter is likely to be less accurate, but has a longer time series. A variable for trade credit is also assessed, the log of trade credit as a proportion of GDP, while noting that existing empirical work does not tend to support an effect of trade credit on fixed investment (as opposed to inventories) in advanced countries.

133. As specified above, the debt-equity ratio and also Tobin's Q directly capture the effect of equity prices on corporate investment, whereby in both cases a positive relationship is expected. In contrast, the credit channel does not explicitly include equity prices but may be affected indirectly if falls in bank share prices affect their willingness to lend. Trade credit is not directly related to asset prices. A Q effect, leaving out all other investment determinants, is also assessed.

134. Concerning the financial accelerator and the credit channel, data covering 20 countries but only around 300 observations over 1970-2008 exist as opposed to over 800 in the basic equation. The OECD balance sheet data for most countries begin only in the 1990s (see Appendix 1), although the US data begin in 1960 and Canada in 1970. As shown in Table 5, in general, certain results are positive for both the financial accelerator and the credit channel for this group of countries. The debt-equity ratio (LDER) is significant for the G7 at 90%, albeit not for the smaller OECD countries or for the full group of countries. Since there are fixed effects, we are not merely capturing cross-country differences. The bank lending to total debt ratio (LBANK) is significant for both the G-7 (at 90%) and the full group of countries. The trade credit to GDP variable (LTCY) is insignificant, confirming that there is not an important role for trade credit in fixed investment determination.

Table 5. **Signficance of financial variables in basic investment functions**

135. Tobin's Q is entered in levels and differences. Using the "correct measure" of Q, we suffer from a lack of data for the nominal net capital stock, which even more severely limits the observations that can be used, as well as the country coverage, to 13 countries and around 170 observations. The incorporation of average Q into the basic investment function as a substitute for the real long-term interest rate is successful for the G7, with the variable being significant even in the presence of the accelerator (growth of GDP) term. This is not the case for the total and smaller country groups where Q is not significant, perhaps reflecting less well-developed equity markets. The "estimate" of Q (LQE) has more observations but broadly identical results, except that it is significant in levels for the smaller countries also, at the 90% level.

136. However, as shown in Table 6, if only Q is included in a dynamic equation with lagged investment (as is theoretically justified) it becomes significant in both the short and long run for all the country groups (albeit with a low level of overall explanation for the equation). Whereas the short-run effect of Q is around 0.1, the long-run elasticity with respect to investment is 1.3 for the full group of countries, and 1.8 for the G-7, with 0.8 for the smaller countries. There are similar results for the estimated LQE variable. In practice, the estimates of long-run Q are often not significantly different from 1, as is theoretically expected, while Wald tests showed that the long-run coefficients are insignificantly different from one another in the four EU countries, and are close to being identical across the whole G-7. This result is a major contrast to work cited in the literature surveys by Oliner *et al*. (1995), Robertson and Wright (2002) and papers reviewed in the survey by Caballero (1999). It may be that the error correction framework for Q helps generate such positive results, with firms overcoming financial constraints to desired investment in the long run.

Table 6. **Simple Q equations**

137. Overall, these results indicate that Q remains worthy of monitoring by policymakers, and in combination with the result for the debt-equity ratio, it was shown that equity prices are important

determinants of investment, notably in the G7. The positive results for the bank lending/total debt channel again favour monitoring this variable, as is the debt/equity ratio for the G-7.

138. The insignificant results for balance sheet effects in smaller countries are noteworthy, and it was assessed whether they result from a few outliers with poor data that could be dropped and all of the errors in excess of 2 equation standard errors were dummied out (not shown in detail). Unfortunately there was no improvement in the significance of the variables in question, either for the debt-equity ratio, the share of bank lending or Q. Also pooled-mean-group estimators were used (not reported in detail) to see whether allowing for heterogeneous dynamics would allow for significant long-run balance sheet effects in the smaller countries, but the result of insignificance remained. Possible reasons for the poor results for the smaller countries, besides data quality and short data periods, could include close banking relationships that overcome credit constraints, or heterogeneous corporate sectors where equity markets and hence related macro indicators are dominated by large globally active firms such as Nokia. If there is little or no corporate bond market activity, as is often the case in small countries, the credit channel effect will be hard to identify at a macro level. Finally, the relatively poor results for balance sheet variables could reflect the short sample, notably for small countries (Table A1); as shown in Table 3 only the bank lending variable is I(0), even for the whole sample, while the others are I(1). Since I, Y and IRLAR cointegrate, other I(1) variables may end up excluded.

Table A1. **Data availability**

2.4 Volatility of asset prices and investment

139. Turning to effects of asset price volatility, the annual average conditional volatility of nominal effective exchange rates, long rates and share prices were entered into the basic equations set out in section 2.2 and shown in Table 4. In line with the error correction specification, both the difference and lagged level of these proxies for uncertainty were entered. Because of extreme volatility in Mexico during the hyperinflation of the 1980s, that country was omitted from the estimation.

140. As shown in Table 7 (Panel A), a marked difference between the G-7 and the smaller OECD countries was found, in that the uncertainty variables tend to be highly significant for the smaller countries (and accordingly the full sample) but not the G-7. Across the whole sample, there is a significant positive effect of both exchange rate and long-rate volatility both in the short run and the long run. There is also a significant effect of share price volatility in the short run.

Table 7. **Significance of financial asset price volatility in basic investment functions**

141. For the smaller countries a similar pattern obtains, except the share price volatility term is significant only at 90%, while there is no short-term effect of exchange rate volatility. However, the pattern does not hold for the G-7 where all of the volatility terms are insignificant, in contrast to Byrne and Davis (2005*a*). It was also tried omitting the cost of capital terms as well as estimating by pooled-mean-group, but the result of insignificance for the G7 remains robust. Possible explanations could be that markets in these countries tend to be less volatile owing to a wider range of participants and hence liquidity. The time period of estimation differs from Byrne and Davis (2005*a*), being longer here. Also large countries are less vulnerable to currency crises and tensions than smaller countries. A further point may be that derivatives markets are better developed in larger countries, enabling firms to better protect their cashflows against asset price volatility. The result is consistent with that of Serven (2003) cited in section 1.3.6, who found trade openness to be a key indicator of vulnerability of investment to uncertainty.

142. Following the arguments cited in section 1.3.6.3, conditional volatility measures are considered to be superior to unconditional volatility, and that the GARCH based measure offers more of the theoretical characteristics of uncertainty than an unconditional measure would. On the other hand there can

also be arguments favouring unconditional volatility, such as the possibility of omitted variables from the mean and conditional variance equation in GARCH (1,1) and that some contend financial markets are better modelled with non-linear GARCH models. Accordingly, and also as a robustness check, results for unconditional volatility are reported, namely the non-overlapping annual variance series derived from monthly per cent changes in underlying variables. As shown in Table 7 (Panel B), the results are consistent with the same pattern of overall results, namely significant results for a negative effect of uncertainty in the overall sample, apparently driven by the smaller countries. We now obtain long run effects of share price volatility across the whole sample, at 90% significance. And there is a wrong-signed long-run effect of long rate volatility for the G-7.

143. A further experiment was to test for non-linear effects of uncertainty by introducing cubed-variance terms as well as levels of variance. As suggested by Serven (2003) there may be threshold effects on investment that only operate at high levels of volatility. The outcome is shown in Table 7 (Panel C). As can be seen, for the exchange rate in all countries and the smaller ones, the cubed term is significant and renders the lagged levels term insignificant. This strongly suggests that it is extreme exchange rate volatility, *e.g.* during a currency crisis, which is most damaging to investment.

144. A similar effect obtains for the cubed effect of long rate-volatility for the small countries, at 90% significance. Extreme long-rate volatility may accompany a currency or fiscal crisis. It displaces the long-run level effect shown in Table 7A.

145. Finally for share prices it is the level of variance and not the cubic term that is significant for all countries. In the G-7 there are opposing effects, both significant at 90%, with the level having a negative sign and the cube is positive. All share price terms are insignificant for the smaller countries. So the extreme volatility effect does not seem to be present for share prices in the same way.

2.5 Further robustness checks and variants

146. All available data from 1970-2008 were used, which varies between samples in terms of number of observations and country coverage. This is motivated by the desire to make maximum use of available data. In Appendix 2 the main results for a standardised sample are reported, namely that of the basic flow of funds balance sheet variables. Note that three countries are now omitted and for many countries observations exist only from 1995-2007. Results are very similar to the main results, underlining the robustness of the specification (note that it is only the basic equations from Table 4 and the uncertainty equations from Table 7 that differ since their data sets are shortened – the balance sheet results in Appendix 2 are identical to the main case).

147. The main difference to the basic equations (Table A.2.1) is that there are now no significant short-run cost of capital effects, nor is there a long-run effect for the smaller countries. The error correction terms are larger, showing a more rapid convergence to the long run. There are also stronger dynamics from the lagged income terms for the G-7 and all countries samples, and from the lagged difference of investment in each case. The Pedroni test rejects cointegration but with this smaller sample the superiority of the Kao test is yet more marked.

Table A.2.1. **Basic investment function**

148. The conditional volatility estimates (Table A.2.2) lose their significance for the share price and exchange rates for all countries, and although the long rate effect remains, it has the wrong sign. For the G-7 the wrong sign for the long rate volatility is repeated and other variables remain insignificant. In the smaller countries, there remain only significant difference terms for exchange rate and long rate volatility. This shift may result from the omission of the volatility of the early 1990s as well as in the 1970s and 1980s from the small country sample. These were driving the strongly significant negative effects of

volatility in the smaller countries, while by finishing the sample in 2007 the economic and financial crisis is also omitted. The longer samples reported in Table 7A are more relevant, in our view.

Table A.2.2. **Significance of financial asset price conditional volatility in basic investment functions**

149. Using again the shorter sample, an attempt was made to integrate both the level and variance terms in a general equation for investment, but the results did not add value and they are not reported. For the G-7 significant wrong-signed volatility terms for long rates were found and a significant debt-equity. For all countries, there is only a significant lagged long-rate volatility effect, but again with the wrong sign due to the short sample. And for smaller countries, there is only a significant lagged long-rate volatility effect with the correct sign.

150. Using the main results sample, it was further checked whether outliers are a major problem, notably for the smaller countries. Dummies for each residual in excess of 2 equation standard errors were created and the basic equation (Table 4) was run for all countries and the smaller ones, as well as the uncertainty results for the smaller countries. The basic equation was little affected by the dummies, but interestingly the uncertainty results became much weaker. This shows again that it is the extreme observations that generate much of the significance of the uncertainty effect on investment in those countries.

151. Using the intuition that credit constraints are more likely to bind in a recession, while credit is more freely available in an upturn, switching regressions between Q in a boom and the debt/equity ratio in a recession were estimated. But unfortunately the results were not favourable to the hypothesis – Q tended to be significant but not the financial accelerator or credit channel.

152. Alternative deflators for the long real rate in the basic equations were assessed to see whether the results could be improved with the deflator for business investment (PIB) or the consumer price index (CPI) instead of PGDP in calculating the real interest rate. Note that the user cost estimate cannot be changed, as it is a pre-defined variable. In terms of the basic equation, Table A.2.3 shows that each of the alternatives is statistically inferior. Accordingly, PGDP was retained in the real rate for the basic results.

Table A.2.3. **Significance of alternative real interest rate measures in basic investment functions**

153. Structural change over the sample in the basic equations was tested by incorporating leveraged coefficients in the equations. In other words, the variables were multiplied by a dummy which is 1 from 1995 onwards and 0 earlier on. The rationale for this date is that the internet was becoming generally used and computers and associated hardware a much greater component of aggregate investment. Accordingly, there might have been changes in the relationship of investment to its determinants in the short and long run. In fact as shown in Table A.2.4, there are some significant changes but these are solely in the dynamics, with the long-run coefficients being unchanged at 95%. This is seen as a justification to continue with the long sample wherever feasible, particularly since the main focus is on the long run results.

Table A.2.4. **Significance of leveraged coefficients from 1995-2008 in basic investment functions**

2.6 Tracing the recent history of fixed investment

154. In the light of the above, as well as the financial crisis of 2008-09, we considered the behaviour of investment since 2007 Q3 and looked at its determinants over 2006-08. Table 8 reveals that OECD countries have faced differing patterns of investment over this period. For most countries, investment continued to rise until 2008 Q2, despite the advent of banking difficulties in 2007 Q3. The exceptions are Iceland, Ireland, Italy and Denmark where the peak was in 2007 Q3 or Q4. As regards the overall change

since 2007 Q3, Australia, Belgium and Finland show a rise in investment up to the last observation. The opposite extreme is shown in Iceland, where investment in 2009 Q1 was over 60% lower than at the outset, and Ireland, where it is nearly 30% lower. Investment is down more than 10% in Canada, Germany, Italy, Japan, New Zealand and the United States, while elsewhere the falls are less than 10% in the year to 2007 Q3 (albeit the fall is often greater from the peak in early 2008).

Table 8. **Business fixed investment in the financial crisis**

155. In Table 9 changes in some of the key determinants of investment, namely real GDP, real interest rates, share prices and the variances of asset prices are shown. What factors distinguish countries such as Denmark, Iceland, Ireland, Italy, Japan and Spain where investment fell in 2008, as well as the United States and Canada which saw sharp subsequent falls? Of course, banking problems affected Iceland, Ireland and the US severely, but the question remains whether these operated via normal cyclical variables or whether they were additional. For example, Denmark, Ireland, Italy and Japan saw a fall in GDP in 2008 which helps explain the fall in investment, given the estimated short-run elasticity with respect to output of over 2. New Zealand and Sweden on the other hand saw output fall but investment held up over the year as a whole, while in Spain investment fell despite a slight rise in GDP. It has to be borne in mind that the existing stock of capital and its utilisation rate is also a factor in investment decisions, and in Spain there is a major overhang of unsold residences.

Table 9. **Key determinants of investment in 2006-08**

156. As regards real long rates, these fell sharply in 2008 in most countries, albeit insufficiently to stem the decline in investment growth. In 2008, long real rates were negative in Australia, Canada, Iceland and Norway. The heaviest falls in long rates were in Iceland and Ireland, which experienced acute banking difficulties and (for Iceland) a currency crisis also.

157. Looking finally at the volatility of asset prices, the conditional variance of share prices rose in all countries, but especially where markets are relatively thin, for example in Greece, Austria and New Zealand, as well as in Ireland and Iceland. Long rate volatility rose markedly in Iceland, but also more than doubled compared to 2007 in Australia, Japan, Mexico and the United States. Elsewhere, for example in Norway, Sweden and Switzerland, it was little changed. As regards exchange rate volatility, again besides Iceland and Ireland it rose markedly in Mexico, the United Kingdom, Switzerland and Italy.

158. On balance, none of these measures correspond perfectly with the relative declines in investment, but it is notable that Iceland and Ireland are the hardest hit according to most of these indicators. The results are hence consistent with an additional effect of banking crises on uncertainty and credit rationing, as suggested by Davis and Stone (2004).

159. In order to underpin these descriptive comments, a simple cross sectional regression was estimated using the main variables of the panel work to decompose the factors underlying the falls in investment in 2008. This is tentative work, but potentially illuminating. We regressed the fall in investment in 2008, and also the sharper fall over 2009 Q1/2008 Q1 on annual changes in GDP, share prices, real interest rates, and share price, exchange rate and long rate volatility as well as the main lagged levels variables.

160. Using most levels terms in cross section requires demeaning (which in a panel is taken care of by the fixed effects). Intuitively, countries may have different mean levels of the debt/equity ratio, share of bank lending and the investment/GDP ratio, relating to the economic and financial structure so that simply inserting levels is unlikely to be meaningful. Instead, what could be relevant is to see whether the 2007 (*i.e.* lagged) level of these variables is higher or lower than its country-mean, and whether that cross-country difference helps to explain the fall in investment. We exclude the long term real rate as its effect

should be broadly homogeneous across countries. Note that Q cannot be used as there are very few observations for 2007. Tentative results are shown in Table 10. We have cross section data for 20 countries for the year of 2008 over the year of 2007, and 15 for 2009Q1 on 2008Q1. The former result is better-determined.

Table 10. **Cross section regressions for the fall in investment**

161. The result for 2008 on 2007, in line with the investment functions over time, features a strong positive income effect (with a coefficient of 4.9). Also negative effects of uncertainty as proxied by the rise in share price volatility in 2008 can be detected. There is a negative sign on the lagged long-term interest rate, but no significant balance sheet variable effects were found.

162. The result for 2009Q1, when the falls in investment are often at their largest, is less well determined, probably because country-specific factors not captured by the variables are influencing investment. That said, an output effect is retained, which is much smaller than for the year on year regression. Also exchange rate volatility is significant with a negative sign.

163. These cross-section results are tentative and more research is needed. Nevertheless, they are of interest as they show that it is indeed the conventional variables (output and cost of capital) as well as uncertainty proxies (based on conditional volatility) which can discriminate between countries on a cross-sectional basis, so as to explain in each case many of the differences in the fall in investment to the global shock of the 2008 financial crisis. Tables 11 and 12 show the allocation of effects as calculated by the equations. The errors are quite small in most cases, although one needs to be cautious in attributing economic as opposed to statistical importance to these calculations. The volatility measure as well as the output variable seem to be doing much of the "work" in discriminating between countries between 2007 and 2008. Meanwhile output is important for the 2009 Q1 sample, for example in predicting the fall in investment in many countries. Exchange rate volatility mainly distinguishes Iceland from the other countries in the sample.

Table 11. **Decomposition of annual percentage change in investment using cross section regress for 2008 over 2007**

Table 12. **Decomposition of annual percentage change in investment using cross section regression for 2009Q1 over 2008Q1**

3 Conclusions

164. A survey of the literature on asset price impacts on the real economy has shown a much wider range of work on consumption and related wealth effects than on investment. The existence of wealth effects on consumption per se is little contested, but there remains an issue of whether different effects should hold between countries and across assets. In terms of investment there is less work overall, partly reflecting poor results historically for Tobin's Q, user cost and the financial accelerator. Nevertheless there are numerous studies implying that uncertainty and balance sheet effects on investment can both be detected, albeit the latter more in micro than macro studies.

165. In the light of the investment literature, panel investment functions on a macro basis were estimated for up to 23 OECD countries. Developing earlier work, it was found that the main significant effects arising from asset prices come from the financial accelerator, credit channel and Tobin's Q (especially in the G7) and uncertainty as proxied by asset price volatility (especially in smaller OECD countries). There is also evidence for non-linearities in volatility.

166. The absence of balance sheet effects in the small countries besides data quality and short data periods could be due to close banking relationships that overcome credit constraints, or heterogeneous corporate sectors where equity markets and hence related macro indicators are dominated by globally active firms such as Nokia, as well as foreign multinationals. If there is little or no corporate bond market activity, as is often the case in small countries, the credit channel effect will be hard to identify at a macro level. Meanwhile, the absence of uncertainty effects for the large countries may be due to markets in these countries being less volatile owing to a wider range of participants and hence liquidity, large countries being less vulnerable to currency crises and tensions than smaller countries, and derivatives markets being better developed, enabling firms to better protect their cashflows against asset price volatility.

167. Descriptive analysis as well as tentative cross-sectional regression showed that both balance sheet and uncertainty channels played a role in the recent financial crisis, when investment fell sharply, although the simple accelerator was also important.

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Tables and Figures

Figure 1. **Channels for asset price effects on consumption**

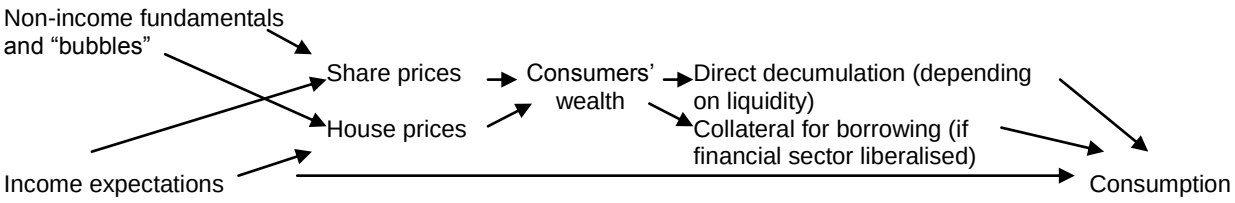

Figure 2**. Channels for asset price effects on business investment**

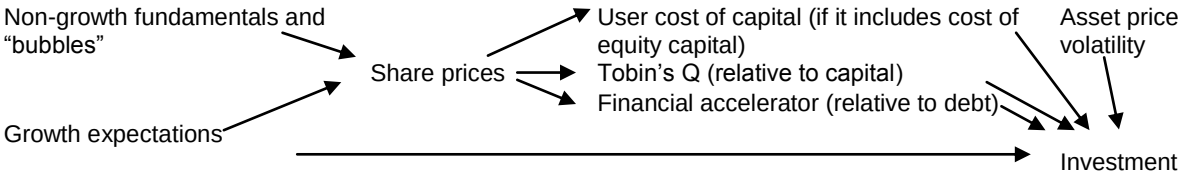

Table 1. **Asset prices and the real economy in low and high cost booms**

Change in:	Average 2 years pre		Average boom		Average 2 years post	
	High cost	Low cost	High cost	Low cost	High cost	Low cost
Equity prices	12.7	8.1	11.2	13.7	-10.8	-6.6
Real estate prices	0.7	3.8	**9.3**	**6.2**	**-7.3**	**-1.3**
GDP	3.3	3.5	**4.2**	**3.3**	**0.1**	**1.6**
Consumption	3.2	3.5	**4.1**	**3.3**	**-0.2**	**2.3**
Investment	6.1	7.2	7.6	6.3	**-6.2**	**-2.2**
Housing investment	2.7	5.7	4.7	3.5	**-6.9**	**-0.1**
Credit	3.5	4.7	**9.7**	**6.2**	**-0.9**	**1.6**

Source: Detken and Smets (2004). Bold figures show a significant difference between the patterns for high and low cost booms.

Table 2. **Estimates of long run effects of total wealth on consumption (marginal propensity to consume)**

	Wealth definition	**Canada**	**France**	**Germany**	**Italy**	**Japan**	**UK**	**US**
Ludwig and Slok (2004)	NFW	4.0	1.4	2.0	3.0	4.0	4.9	4.0
Byrne and Davis (2003)	NFW	4.0	3.0	2.0	2.0	1.0	2.0	6.0
Labhard *et al.* (2005)	NFW	7.8	0.8	7.8	2.8	4.2	5.6	3.7
National estimates			1.6	4.4	1.5-2		2.0	4-6
Bertaut (2002)	NTW	8.3					4.3	5.4
Barrell and Davis (2007)[1]	NTW		3.6	3.7		2.4	4.8	6.6
Barrell and Davis (2007)[2]	NTW		2.9	2.5		1.3	2.6	7.1
Memo: average of studies		**6.0**	**2.2**	**3.7**	**2.4**	**2.6**	**3.7**	**5.4**

1. Prior to liberalisation (based on 1980 consumption/wealth ratio).
2. Post liberalisation (based on 2001 consumption/wealth ratio). Wealth definitions: NFW: Net financial wealth, NTW net total wealth.

Source: Altissimo *et al*. (2005), Byrne and Davis (2003*a*), Barrell and Davis (2007).

Table 3. **Panel unit root tests (Im-Pesaran-Shin)**

Data sample 1970-2008	**Level**		**Difference**	
Variable	ADF	Prob	ADF	Prob
I	4.8	1.00	-17.5	0.00
Y	0.9	0.81	-16.2	0.00
IRLAR	-2.9	0.00		
ERVAR	-10.7	0.00		
LRVAR	-21.5	0.00		
SPVAR	-10.4	0.00		
LDER	-1.0	0.17	-7.8	0.00
LBANK	-4.8	0.00		
LQ	0.5	0.70	-3.6	0.00
LQE	1.4	0.93	-6.3	0.00
UCC	-2.8	0.00		
LTCY	-1.4	0.08	-7.1	0.00

Key: I=log of real business investment, Y=log of real gross domestic product, IRLAR=long term interest rate less GDP deflator, ERVAR= annual average conditional volatility of nominal effective exchange rate (derived from GARCH (1,1) equations), LRVAR= annual average conditional volatility of long term interest rates (derived from GARCH (1,1) equations);SPVAR= annual average conditional volatility of share prices (derived from GARCH (1,1) equations). LDER log of debt/equity ratio, LBANK log of bank loan/total debt ratio, LQ log of average Q (market value of firms divided by net capital stock at current replacement cost), LQE, log of average Q using an estimate of the capital stock based on multiplying a volume measure of the real net total productive capital stock by the business investment deflator, UCC user cost of capital as defined in Schreyer et al (2003), LTCY log of trade credit as corporate liability/nominal GDP.

Source: OECD, except for share prices – IMF.

Table 4. **Basic investment functions**

Unbalanced panel, 1970-2008	All 23 countries, 778 observations		G7 countries, 273 observations		16 smaller OECD countries, 505 observations	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
C	-2.056657	-7.8***	-3.891214	-9.8***	-1.543394	-4.6***
DY	2.541518	22.0***	2.126941	16.5***	2.734334	17.5***
DY(-1)	0.054222	0.4	0.406774	2.3**	0.024486	0.1
DI(-1)	0.178643	5.1***	0.222612	4.3***	0.157090	3.5***
I(-1)	-0.148396	-9.7***	-0.211946	-8.9***	-0.142468	-7.4***
Y(-1)	0.207078	10.1***	0.325019	9.9***	0.184625	7.3***
DIRLAR	-0.001482	-2.2**	-0.002243	-2.0**	-0.001381	-1.6*
IRLAR(-1)	-0.001396	-2.2**	-0.002243	-2.5**	-0.001425	-1.7*
Adjusted R-squared	0.477094		0.632913		0.460599	
S.E. of regression	0.063732		0.035849		0.073694	
Sum squared resid	3.038240		0.332845		2.617617	
Log likelihood	1053.245		528.4832		612.1653	
Long run income effect	1.395442		1.533499		1.295905	
Long run long rate	-0.00941		-0.01058		-0.01	
Memo:	Statistic	Prob	Statistic	Prob	Statistic	Prob
Kao panel cointegration+	-5.71	0.00	-3.66	0.00	-4.07	0.00
Pedroni v-test+	3.07	0.00	1.63	0.11	2.58	0.01
Memo: using UCC instead of IRLAR	18 countries, 394 observations		7 countries, 163 observations		11 countries, 231 observations	
DUCC	-0.027569	-0.1	1.537335	3.2***	-0.724605	-1.4
UCC(-1)	-0.325360	-1.4	-0.100614	-0.4	-0.366292	-1.1

Key, see Table 3. * indicates significance at 90%, ** at 95% and *** at 99%. + tests for cointegration of I, Y and IRLAR.

Table 5. **Significance of financial variables in basic investment functions**

Unbalanced panel, 1970-2008	All countries		G7 countries		Smaller OECD countries	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
	20 countries, 337 observations		7 countries, 168 observations		13 countries, 169 observations	
LDER(-1)	-0.011602	-1.2	-0.023861	-1.9*	-0.000554	0.1
Long run effect	-0.03654		-0.07597		-0.00168	
	20 countries, 337 observations		7 countries, 168 observations		13 countries, 169 observations	
LBANK(-1)	0.092239	2.0**	0.089260	1.6*	0.107165	0.9
Long run effect	0.288351		0.288685		0.324916	
	13 countries, 176 observations		6 countries, 98 observations		7 countries, 78 observations	
DLQ+	0.013604	0.6	0.059430	2.0**	-0.050614	-1.4
LQ(-1)+	0.013038	0.8	0.043097	2.1**	-0.025515	-0.9
Long run effect	0.039		0.147		-0.066	
	17 countries, 239 observations		7 countries, 122 observations		10 countries, 117 observations	
DLQE+	0.012903	0.7	0.058001	2.5**	-0.029490	-1.2
LQE(-1)+	0.003230	0.3	0.039480	2.2**	-0.033912	-1.7*
Long run effect	0.011		0.122		-0.121	
	16 countries, 233 observations		countries, 152 observations		10 countries, 101 observations	
LTCY(-1)	-0.0051	0.3	0.031479	1.4	-0.025967	1.1
Long run effect	-0.01512		0.101327		-0.05474	

Key: Basic equations as in Table 4, for variable definitions see Table 3. +Q is included in levels and differences as a substitute for the real interest rate in Table 4. * indicates significance at 90%, ** at 95% and *** at 99%.

Table 6. **Simple Q equations**

Unbalanced panel, 1970-2008	All countries, 13 countries, 176 observations		G7 countries, 6 countries, 98 observations		Smaller OECD countries, 7 countries, 78 observations	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
C	1.480571	2.7***	1.272885	2.2**	2.277080	1.5
DLQ	0.107163	3.2***	0.099577	2.2**	0.109916	2.1**
LQ(-1)	0.077960	3.3***	0.103734	3.3***	0.064511	1.6*
I(-1)	-0.058240	-2.7***	-0.058719	-2.6**	-0.083352	-1.5
Adjusted R-squared	0.051355		0.098221		-0.002500	
S.E. of regression	0.061379		0.057833		0.066005	
Sum squared resid	0.602775		0.297677		0.296249	
Log likelihood	249.8160		144.9830		106.6800	
Long run effect of LQ	1.33		1.77		0.774	
Memo: with LQE	17 countries, 239 observations		7 countries, 122 observations		10 countries, 117 observations	
DLQE	0.117614	4.7***	0.135144	4.0***	0.092603	2.6**
LQE(-1)	0.099472	5.7***	0.159640	7.0***	0.039573	1.5
I(-1)	-0.116273	-4.6***	-0.171977	-5.8***	-0.042642	-1.0
Long run effect of LQE	0.855		0.928		0.928	

Key: For variable definitions see Table 3. * indicates significance at 90%, ** at 95% and *** at 99%.

Table 7. **Significance of financial asset price volatility in basic investment functions**

Panel A. Conditional volatility

Unbalanced panel, 1970-2008	All countries (excluding Mexico), 22 countries, 749 observations		G7 countries, 7 countries, 266 observations		Smaller OECD countries (excluding Mexico)	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
DERVAR	-18.73541	-2.2**	-7.426388	-0.4	-15.26938	-1.4
ERVAR(-1)	-42.02803	-3.6***	4.376449	0.2	-50.02430	-3.4***
Long run effect	-298.832		20.48861		-375.716	
	22 countries, 731 observations		7 countries, 273 observations		15 countries, 458 observations	
DSPVAR	-0.696092	-2.0**	-1.566338	-1.1	-0.665184	-1.6*
SPVAR(-1)	-0.643844	-1.4	-2.392385	-1.3	-0.591834	-1.1
Long run effect	-4.33828		-11.3185		-4.06312	
	22 countries, 763 observations		7 countries, 273 observations		15 countries, 490 observations	
DLRVAR	-0.029047	-5.5***	0.025698	0.8	-0.030601	-5.0***
LRVAR(-1)	-0.023799	-3.4***	0.032289	1.3	-0.026842	-3.2***
Long run effect	-0.16538		0.152626		-0.19378	

Key: Basic equations as in Table 4. For variable definitions see Table 3. Conditional volatility is the variance series derived from GARCH (1,1) estimates. * indicates significance at 90%, ** at 95% and *** at 99%.

Panel B. Unconditional volatility

Unbalanced panel, 1970-2008	All countries (excluding Mexico), 22 countries, 733 observations		G7 countries, 7 countries, 259 observations		Smaller OECD countries (excluding Mexico), 15 countries, 474 observations	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
DEERUV	-11.16270	-2.1**	-1.196374	-0.1	-11.18723	-1.7*
EERUV(-1)	-18.79882	-2.7***	-15.81590	-1.2	-17.01811	-2.0**
Long run effect	-126.165		-69.1221		-119.067	
	22 countries, 727 observations		7 countries, 273 observations		15 countries, 454 observations	
DSPUV	-0.970486	-2.8***	-0.817787	-0.9	-0.943368	-2.3**
SPUV(-1)	-0.855200	-1.6*	-1.386076	-1.2	-0.763722	-1.2
Long run effect	-5.605		-6.56553		-5.10015	
	22 countries, 759 observations		7 countries, 273 observations		15 countries, 486 observations	
DLRUV	-0.026593	-2.8***	0.027456	1.3	-0.032883	-2.9***
LRUV(-1)	-0.032687	-3.0***	0.039503	1.7*	-0.041459	-3.1***
Long run effect	-0.22304		0.187275		-0.2941	

Key: Basic equations as in Table 4. For variable definitions see Table 3. Unconditional variance is the non-overlapping annual variance series derived from monthly per cent changes in underlying variables. * indicates significance at 90%, ** at 95% and *** at 99%.

Panel C. Cubed conditional volatility

Unbalanced panel, 1970-2008	All countries (excluding Mexico), 22 countries, 749 observations		G7 countries, 7 countries, 266 observations		Smaller OECD countries (excluding Mexico), 15 countries, 483 observations	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
DERVAR	-24.23693	-2.8***	-7.542809	-0.4	-22.80927	-2.1**
ERVAR(-1)	8.971590	0.5	4.803911	0.2	9.414866	0.4
ERVAR(-1)**3	-7021745.	-4.4***	-425171.5	-0.1	-7048557.	-3.4***
	22 countries, 717 observations		7 countries, 266 observations		15 countries, 454 observations	
DSPVAR	-0.578144	-1.7*	-0.619708	-0.4	-0.555293	-1.4
SPVAR(-1)	-1.316159	-1.8*	-4.616102	-2.0**	-1.169841	-1.3
SPVAR(-1)**3	70.39422	1.2	17320.24	1.7*	58.13668	0.8
	22 countries, 749 observations		7 countries, 266 observations		15 countries, 486 observations	
DLRVAR	-0.028610	-5.5***	-0.003118	-0.1	-0.030016	-4.9***
LRVAR(-1)	-0.003768	-0.3	-0.008427	-0.2	-0.007388	-0.5
LRVAR(-1)**3	-0.000242	-1.0	0.006279	0.1	-0.000228	-1.6*

Key: Basic equations as in Table 4. For variable definitions see Table 3. * indicates significance at 90%, ** at 95% and *** at 99%.

Table 8. **Business fixed investment in the financial crisis**

	AUS	AUT	BEL	CAN	DNK	FIN	FRA	DEU	GRC	ISL	IRL	ITA
2007:Q3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2007:Q4	101.7	99.9	103.5	100.4	104.4	107.4	101.8	103.5	98.6	79.4	111.6	100.7
2008:Q1	105.7	101.4	105.1	100.6	101.5	106.7	104.1	104.1	99.4	78.0	113.2	98.6
2008:Q2	108.9	102.6	106.3	99.9	104.6	102.8	102.9	102.9	103.2	65.2	88.7	98.6
2008:Q3	111.9	100.9	105.2	100.4	105.3	109.8	102.3	104.5	101.5	65.6	100.6	95.4
2008:Q4	112.6	97.4	103.0	96.1	97.6	105.1	99.4	100.8	105.9	64.2	75.1	87.7
2009:Q1	106.5		99.8	87.4	99.7	98.5	96.2	87.9		35.6		

	JPN	KOR	MEX	NLD	NZL	NOR	ESP	SWE	CHE	GBR	US
2007:Q3	100.0	100.0		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2007:Q4	100.9	104.2		99.1	101.6	100.4	101.6	102.1	102.0	102.8	101.6
2008:Q1	106.0	102.9		104.9	102.8	100.0	100.9	106.9		100.1	102.1
2008:Q2	104.4	103.6		107.2	108.8	101.5	100.3	104.8		103.2	102.5
2008:Q3	99.8	103.7		106.3	97.4	99.7	96.9	103.8		100.8	100.9
2008:Q4	93.2	97.0		99.2	94.8	100.9	91.9	99.3		99.2	95.5
2009:Q1	85.3			91.6	87.1	96.8		90.9		90.5	84.4

Source: OECD.

Table 9. **Key determinants of investment in 2006-08**

	AUS	AUT	BEL	CAN	DNK	FIN	FRA	DEU	GRC	ISL	IRL	ITA
DI												
2006	7.72	2.32	5.59	10.01	14.33	6.96	5.58	10.06	-2.37	23.06	4.75	3.41
2007	11.65	4.29	8.51	3.68	4.21	13.57	7.50	6.54	14.51	-24.54	19.01	2.14
2008	11.14	1.47	7.12	0.23	-3.96	4.84	2.62	5.25	Na	-27.18	-31.27	-5.02
DY												
2006	2.63	3.29	3.02	2.85	3.34	4.86	2.42	3.17	4.50	4.46	5.72	2.10
2007	4.19	3.04	2.60	2.53	1.65	4.09	2.26	2.59	4.04	5.51	6.00	1.46
2008	2.31	1.72	0.97	0.41	-1.20	0.83	0.33	0.95	2.93	0.34	-2.27	-1.04
IRLAR												
2006	0.90	1.85	1.54	1.64	1.82	2.16	1.40	3.24	0.84	0.38	0.34	2.21
2007	2.08	2.10	1.94	1.11	2.33	1.19	1.80	2.30	1.63	4.28	2.93	2.08
2008	-0.63	1.90	2.68	-0.35	0.32	2.27	1.75	2.47	1.36	-1.14	4.85	1.83
DSP												
2006	19.22	30.76	22.28	18.88	19.17	24.90	20.33	25.42	26.44	39.72	23.95	15.72
2007	20.67	16.37	13.04	13.40	23.96	24.39	11.70	24.23	22.31	28.35	6.60	9.77
2008	-20.95	-18.04	-29.12	-8.55	-22.67	-23.99	-25.24	-22.17	-32.77	-50.84	-44.71	-30.64
SPVAR												
2006	0.1485	0.2889	0.1252	0.1757	0.1317	0.1675	0.2228	0.1864	0.3905	0.6341	0.2364	0.1661
2007	0.1071	0.2623	0.1523	0.1438	0.1408	0.1522	0.2105	0.1667	0.3539	0.7155	0.2670	0.1839
2008	0.4734	1.5672	0.4562	0.2720	0.3137	0.3505	0.4646	0.4065	0.9704	11.7950	0.6442	0.3195
LRVAR												
2006	0.0328	0.0202	0.0210	0.0221	0.0351	0.0249	0.0273	0.0218	0.0232	0.7814	0.0576	0.0237
2007	0.0363	0.0238	0.0220	0.0194	0.0334	0.0266	0.0278	0.0238	0.0233	0.7372	0.0561	0.0254
2008	0.0644	0.0393	0.0290	0.0288	0.0394	0.0371	0.0346	0.0348	0.0263	7.5117	0.0605	0.0324
ERVAR												
2006	0.0377	0.0022	0.0036	0.0236	0.0027	0.0074	0.0025	0.0052	0.0072	0.3873	0.0050	0.0032
2007	0.0795	0.0022	0.0037	0.0255	0.0025	0.0072	0.0022	0.0048	0.0065	0.1930	0.0046	0.0029
2008	0.2504	0.0023	0.0047	0.0447	0.0035	0.0082	0.0037	0.0058	0.0073	0.5918	0.0112	0.0058

Note: ERVAR and SPVAR are multiplied by 100 to allow for the log transform.

Table 9. **Key determinants of investment in 2006-8 (continued)**

	JPN	KOR	MEX	NLD	NZL	NOR	ESP	SWE	CHE	GBR	US
DI											
2006	2.32	7.63	Na	9.74	-0.31	14.46	7.80	9.10	7.45	-6.92	7.50
2007	5.68	6.98	Na	4.92	5.11	9.47	5.67	8.73	8.49	11.86	4.92
2008	-3.99	0.20	Na	7.05	3.54	7.42	-0.46	3.95	Na	1.68	1.63
DY											
2006	2.04	5.18	5.13	3.39	2.72	2.28	3.89	4.54	3.38	2.85	2.78
2007	2.34	5.11	3.32	3.61	2.97	3.13	3.66	2.70	3.33	2.56	2.03
2008	-0.72	2.22	1.38	2.00	-1.04	2.13	1.16	-0.39	1.63	0.74	1.11
IRLAR											
2006	2.64	5.30	0.80	2.01	-4.46	3.49	-0.26	2.25	0.80	1.72	1.57
2007	2.32	3.28	3.11	2.69	2.56	2.12	1.13	1.32	1.16	2.13	1.94
2008	2.36	2.81	1.45	1.48	-5.15	2.42	1.31	0.41	0.65	1.97	1.49
DSP											
2006	28.17	26.27	45.76	20.28	5.77	41.12	26.07	26.35	25.82	14.56	8.16
2007	2.25	26.71	40.99	12.91	10.69	24.54	21.80	18.79	12.99	8.79	15.44
2008	-28.63	-10.56	-9.60	-24.92	-26.07	-19.29	-22.84	-30.30	-23.32	-18.25	-14.56
SPVAR											
2006	0.1658	0.2483	0.4405	0.1344	0.1100	0.3628	0.1533	0.2057	0.1682	0.1770	0.0805
2007	0.1739	0.2659	0.3449	0.1662	0.1096	0.2762	0.1507	0.1790	0.1629	0.1377	0.0921
2008	0.5361	0.3786	0.4224	0.5571	0.1634	0.9151	0.3606	0.4687	0.2303	0.5771	0.1721
LRVAR											
2006	0.0200	0.0891	0.2800	0.0229	0.0248	0.0447	0.0240	0.0353	0.0240	0.0235	0.0260
2007	0.0175	0.0734	0.0699	0.0219	0.0447	0.0426	0.0248	0.0345	0.0237	0.0268	0.0308
2008	0.0376	0.1165	0.2790	0.0302	0.0537	0.0433	0.0297	0.0354	0.0259	0.0409	0.0606
ERVAR											
2006	0.0394	0.0730	0.1447	0.0044	0.0154	0.0355	0.0242	0.0158	0.0132	0.0185	0.0127
2007	0.0412	0.0621	0.1190	0.0041	0.0170	0.0415	0.0242	0.0183	0.0139	0.0151	0.0119
2008	0.0656	0.1015	0.2222	0.0053	0.0191	0.0465	0.0245	0.0176	0.0273	0.0292	0.0182

Note: ERVAR and SPVAR are multiplied by 100 to allow for the log transform.

Table 10. **Cross section regressions for the fall in investment**

	2008 over 2007		**2009Q1 over 2008Q1**	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic
C	8.079910	1.7	-3.415213	1.5
DY	4.902112	4.8	1.294699	2.7
DSPVAR	-1.599140	-2.2		
IRLAR07	-4.571209	-2.0		
DERVAR			-2455.610	8.4
Adjusted R-squared	0.704655		0.849733	
S.E. of regression	5.764113		4.478286	
Sum squared resid	531.6000		240.6605	
Log likelihood	-61.18036		-42.09911	
Observations	20		15	

Table 11. **Decomposition of annual percentage change in investment using cross section regression for 2008 over 2007**

	Actual	Fitted	Constant	dy	dspvar	irlar07
AUS	11.14	9.31	8.08	11.32	-0.59	-9.51
AUT	1.47	4.81	8.08	8.43	-2.09	-9.61
BEL	7.12	3.47	8.08	4.75	-0.49	-8.88
CAN	0.23	4.82	8.08	2.01	-0.20	-5.06
DNK	-3.96	-8.71	8.08	-5.88	-0.28	-10.63
FIN	4.84	6.39	8.08	4.07	-0.32	-5.44
FRA	2.62	1.07	8.08	1.62	-0.41	-8.22
DEU	5.25	1.59	8.08	4.66	-0.38	-10.76
ISL	-27.18	-27.56	8.08	1.67	-17.72	-19.59
IRL	-31.27	-17.06	8.08	-11.12	-0.60	-13.41
ITA	-5.02	-6.73	8.08	-5.10	-0.22	-9.50
JPN	-3.99	-6.66	8.08	-3.53	-0.58	-10.63
KOR	0.20	3.80	8.08	10.88	-0.18	-14.98
NLD	7.05	4.96	8.08	9.80	-0.63	-12.30
NZL	3.54	-6.79	8.08	-5.10	-0.09	-9.69
NOR	7.42	5.80	8.08	10.44	-0.09	-11.70
ESP	-0.46	8.27	8.08	5.68	-0.34	-5.16
SWE	3.95	-0.33	8.08	-1.91	-0.46	-6.03
GBR	1.68	1.27	8.08	3.63	-0.70	-9.74
US	1.63	4.53	8.08	5.44	-0.13	-8.86

Table 12. **Decomposition of annual percentage change in investment using cross section regression for 2009Q1 over 2008Q1**

	Actual	Fitted	dervar01	dy01	Constant
AUS	0.28	-2.87	0.04	0.44	-3.42
BEL	-2.58	-7.63	-0.15	-4.09	-3.42
CAN	-11.33	-7.12	-0.95	-2.79	-3.42
DNK	-3.22	-9.19	-0.15	-5.64	-3.42
FIN	-6.67	-11.57	-0.14	-8.00	-3.42
FRA	-7.22	-7.79	-0.13	-4.27	-3.42
DEU	-13.12	-12.88	-0.16	-9.29	-3.42
ISL	-48.47	-48.67	-40.96	-4.28	-3.42
JPN	-20.55	-15.51	-0.74	-11.32	-3.42
NLD	-12.80	-9.14	-0.14	-5.60	-3.42
NZL	-6.00	-6.25	0.05	-2.93	-3.42
NOR	-5.81	-4.57	-0.61	-0.34	-3.42
SWE	-10.93	-12.47	-0.52	-8.52	-3.42
GBR	-9.65	-11.41	-1.47	-6.53	-3.42
US	-16.07	-7.08	-0.49	-3.21	-3.42

Appendix 1.

Data availability

	AUS	AUT	BEL	CAN	DNK	FIN	FRA	DEU	GRC	ISL	IRL	ITA
Quarterly data												
Real business investment	60:1-09:1	60:1-08:4	60:1-09:1	61:1-09:1	71:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-07:4	60:1-09:1	60:1-08:4	60:1-08:4
Nominal business investment	60:1-09:1	60:1-08:4	60:1-09:1	61:1-09:1	71:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-07:4	60:1-09:1	60:1-08:4	60:1-03:4
Deflator for business investment	60:1-09:1	60:1-08:4	60:1-09:1	61:1-09:1	71:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-07:4	60:1-09:1	60:1-08:4	60:1-03:4
Real GDP	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-08:4	60:1-09:1
Nominal GDP	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-08:4	60:1-09:1
Deflator for GDP	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-08:4	60:1-09:1
CPI	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-08:4	60:1-09:1
Monthly data												
Long term interest rate	69:7-09:9	64:11-09:9	60:1-09:9	60:1-09:9	60:1-09:9	60:12-09:9	60:1-09:8	60:1-09:9	97:1-09:8	92:1-09:9	70:12-09:8	60:1-09:8
Effective exchange rate	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8
Share price index	60:1-09:8	60:1-09:8	60:1-09:8	60:1-09:8	60:1-09:8	60:1-09:8	60:1-09:8	65:1-09:8	88:10-09:8	93:1-09:8	60:1-09:8	60:1-09:8
Annual data												
Market value of firms	87-07	95-07	94-07	70-07	94-07	95-07	95-07	91-07	95-07		01-07	95-07
Stock of bank lending to firms	87-07	95-07	94-07	70-07	94-07	95-07	95-07	91-07	95-07		01-07	95-07
Stock of bond issues by firms	87-07	95-07	94-07	70-07	94-07	95-07	95-07	91-07	95-07		01-07	95-07
Nominal net capital stock	60-05	76-05	95-05			75-05	78-05	91-05				80-05
Real net productive capital stock	84-07	84-05	84-04	84-08	84-05	84-05	84-08	84-08			84-07	84-08
User cost of capital	84-07	84-05	84-04	84-08	84-05	84-05	84-08	84-08			84-07	84-08

Source: OECD, IMF (share prices).

	JPN	KOR	MEX	NLD	NZL	NOR	ESP	SWE	CHE	GBR	USA
Quarterly data											
Real business investment	60:1-09:1	75:1-08:4	80:1-96:4	60:1-08:4	61:3-08:4	62:1-09:1	64:1-08:4	63:1-09:1	90:1-07:4	66:1-09:1	60:1-09:1
Nominal business investment	60:1-09:1	75:1-08:4	80:1-96:4	60:1-08:4	61:3-08:4	62:1-09:1	64:1-08:4	63:1-09:1	90:1-07:4	66:1-09:1	60:1-09:1
Deflator for business investment	60:1-09:1	75:1-08:4	80:1-96:4	60:1-08:4	61:3-08:4	62:1-09:1	64:1-08:4	63:1-09:1	90:1-07:4	66:1-09:1	60:1-09:1
Real GDP	60:1-09:1	70:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	65:1-09:1	60:1-09:1	60:1-09:1
Nominal GDP	60:1-09:1	70:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	65:1-09:1	60:1-09:1	60:1-09:1
Deflator for GDP	60:1-09:1	70:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	65:1-09:1	60:1-09:1	60:1-09:1
CPI	60:1-09:1	60:1-09:1	69:1-09:1	60:2-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	60:1-09:1	91:1-09:1	60:1-09:1
Monthly data											
Long term interest rate	66:6-09:8	82:5-09:8	78:1-09:9	60:1-09:9	70:1-09:9	61:9-09:9	66:1-09:9	60:1-09:9	60:1-09:9	60:1-09:9	60:1-09:9
Effective exchange rate	70:1-09:8	70:1-09:8	88:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8	70:1-09:8
Share price index	60:1-09:8	78:1-09:8	84:1-09:8	60:1-09:8	01:1-09:8	60:1-09:8	61:1-09:8	60:1-09:8	89:1-09:8	60:1-09:8	60:1-09:8
Annual data											
Market value of firms	80-07	02-07	97-07	90-07		89-07	89-07	95-07	99-07	87-07	60-07
Stock of bank lending to firms	80-07	02-07	97-07	90-07		89-07	89-07	95-07	99-07	87-07	60-07
Stock of bond issues by firms	80-07	02-07	97-07	90-07		89-07	89-07	95-07	99-07	87-07	60-07
Nominal net capital stock	96-05			87-05		70-05		00-05		60-08	70-05
Real net productive capital stock	84-07			84-05	84-06		84-06	84-06	84-06	84-05	84-08
User cost of capital	84-07			84-05	84-06		84-06	84-06	84-06	84-05	84-08

Source: OECD, IMF (share prices), UK (nominal net capital stock).

Appendix 2.

Variants and robustness checks

Results for common basic sample (1970-2008 but limited to availability of flow of funds data)

Table A.2.1. **Basic investment functions**

Unbalanced panel, Basic Sample	20 countries, 344 observations		G7 countries, 168 observations		13 smaller OECD countries, 168 observations	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
C	-5.755016	-10.7***	-5.880708	-8.0***	-6.076445	-5.3***
DY	2.252770	14.1***	2.200804	12.0***	2.333516	8.0***
DY(-1)	0.406054	2.1**	0.630419	2.5**	0.328517	1.0
DI(-1)	0.281596	6.3***	0.247435	3.8***	0.291073	4.6***
I(-1)	-0.342575	-11.8***	-0.326291	-8.1***	-0.362845	-8.5***
Y(-1)	0.511881	12.0***	0.495131	8.3***	0.547707	8.4***
DIRLAR	-0.001425	-1.0	0.001632	0.7	-0.001900	-1.0
IRLAR(-1)	-0.002727	-2.6**	-0.004153	-2.9***	-0.001356	-0.6
Adjusted R-squared	0.619534		0.669832		0.570443	
S.E. of regression	0.039211		0.035514		0.042675	
Sum squared resid	0.487392		0.194230		0.284095	
Log likelihood	640.0894		329.6830		316.0126	
Memo:	ADF	Prob	ADF	Prob	ADF	prob
Kao panel cointegration+	-6.97	0.00	-5.09	0.00	-4.80	0.00
Pedroni v-test+	1.11	0.22	0.614	0.33	0.917	0.26
Memo: using UCC instead of IRLAR	17 countries, 258 observations		7 countries, 131 observations		10 countries, 127 observations	
DUCC	1.127855	2.5**	1.656439	3.1**	0.316893	0.4
UCC(-1)	0.178646	0.6	0.201726	0.5	0.110487	0.2

Key, see Table 3. * indicates significance at 90%, ** at 95% and *** at 99%. + tests for cointegration of I, Y and IRLAR.

Table A.2.2. **Significance of financial asset price conditional volatility in basic investment functions**

Unbalanced panel, Basic Sample	All countries (excluding Mexico), 20 countries, 342 observations		G7 countries, 7 countries, 166 observations		13 Smaller OECD countries (excluding Mexico), 176 observations	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
DERVAR	-14.79152	-0.5	39.68191	1.3	-103.9620	-2.0**
ERVAR(-1)	1.201136	0.1	18.75878	0.5	-42.61294	-0.7
	20 countries, 344 observations		7 countries, 166 observations		13 countries, 176 observations	
DSPVAR	0.595618	1.1	-0.663953	-0.2	0.678619	1.1
SPVAR(-1)	0.489970	0.7	-2.004697	-0.7	0.619306	0.7
	20 countries, 344 observations		7 countries, 168 observations		13 countries, 176 observations	
DLRVAR	0.058517	1.4	0.082135	2.1**	-0.430552	-2.0**
LRVAR(-1)	0.087694	2.7***	0.108834	3.2***	0.026609	0.2

Key: Basic equations as in Table 4. For variable definitions see Table 3. * indicates significance at 90%, ** at 95% and *** at 99%.

Table A.2.3. **Significance of alternative real interest rate measures in basic investment functions**

Unbalanced panel, 1970-2008	All 23 countries, 773 observations		G7 countries, 268 observations		16 smaller OECD countries, 505 observations	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
DIRLAR (PIB)	0.001050	1.6*	-0.000524	-0.6	0.001411	1.7*
IRLAR (PIB) (-1)	-0.000258	-0.4	-0.001662	-2.3**	0.000135	0.2
DIRLAR (CPI)	-0.001242	-1.4	-0.003248	-2.4**	-0.000823	-0.7
IRLAR (CPI) (-1)	-0.000413	-0.5	-0.001540	-1.6*	-0.000355	-0.3

Key: Basic equations as in Table 4. For variable definitions see Table 3. * indicates significance at 90%, ** at 95% and *** at 99%.

Table A.2.4. **Significance of leveraged coefficients from 1995-2008 in basic investment functions**

Unbalanced panel, 1970-2008	All 23 countries, 764 observations		G7 countries, 273 observations		16 smaller OECD countries, 505 observations	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
C	-2.090306	-4.6***	-3.191029	-5.4***	-1.755316	-2.8***
DY	2.361072	17.4***	2.005249	13.9***	2.517814	13.3***
DY(-1)	0.459284	2.7***	0.185344	0.9	0.499553	2.2**
DI(-1)	0.138690	3.1***	0.319484	4.9***	0.101814	1.8*
I(-1)	-0.154544	-9.8***	-0.227028	-8.8***	-0.153150	-7.4***
Y(-1)	0.213627	8.7***	0.315492	8.5***	0.201669	6.3***
DIRLAR	-0.001061	-1.5	-0.001689	-1.4	-0.001036	-1.2
IRLAR(-1)	-0.001691	-2.3**	-0.001266	-1.2	-0.001886	-2.0**
DY95	0.547080	2.5**	0.598190	1.9*	0.505170	1.8*
DY95(-1)	-1.647268	-5.4***	0.665004	1.3	-1.762821	-4.5***
DI95(-1)	0.148469	2.1**	-0.261383	-2.3**	0.202903	2.3**
I95(-1)	-0.008261	-0.5	-0.024706	-1.2	-0.004606	-0.2
Y95(-1)	0.008613	0.6	0.023673	1.2	0.005278	0.3
DIRLAR95	0.000183	0.1	-0.001548	-0.3	0.000651	0.2
IRLAR95(-1)	0.002856	1.2	-0.007519	-1.9*	0.003743	1.2
Adjusted R-squared	0.508319		0.637479		0.492594	
S.E. of regression	0.061877		0.035558		0.071511	
Sum squared resid	2.783497		0.309763		2.393279	
Log likelihood	1060.807		521.0365		622.5146	

Key: For variable definitions see Table 3. * indicates significance at 90%, ** at 95% and *** at 99%.

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