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## Asset prices and macroeconomic outcomes: A survey

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**ASSET PRICES AND MACROECONOMIC  
OUTCOMES: A SURVEY**

Stijn Claessens  
M. Ayhan Kose

Working Paper 1718  
November 2017

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# Asset Prices and Macroeconomic Outcomes: A Survey

Stijn Claessens and M. Ayhan Kose\*

November 2017

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**Abstract:** This paper surveys the literature on the linkages between asset prices and macroeconomic outcomes. It focuses on three major questions. First, what are the basic theoretical linkages between asset prices and macroeconomic outcomes? Second, what is the empirical evidence supporting these linkages? And third, what are the main challenges to the theoretical and empirical findings? The survey addresses these questions in the context of four major asset price categories: equity prices, house prices, exchange rates and interest rates, with a particular focus on their international dimensions. It also puts into perspective the evolution of the literature on the determinants of asset prices and their linkages with macroeconomic outcomes, and discusses possible future research directions.

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*“...They [economists] turned a blind eye to the limitations of human rationality that often lead to bubbles and busts; to the problems of institutions that run amok; to the imperfections of markets – especially financial markets – that can cause the economy’s operating system to undergo sudden, unpredictable crashes ...”*

Paul Krugman (2009a)

*““Hello, Paul, where have you been for the last 30 years?”... Pretty much all we have been doing for 30 years is introducing flaws, frictions and new behaviors... The long literature on financial crises and banking ... has also been doing exactly the same....”*

John H. Cochrane (2011a)

*“I believe that during the last financial crisis, macroeconomists (and I include myself among them) failed the country, and indeed the world. In September 2008, central bankers were in desperate need of a playbook that offered a systematic plan of attack to deal with fast evolving circumstances. Macroeconomics should have been able to provide that playbook. It could not...”*

Narayana Kocherlakota (2010)

*“... What does concern me of my discipline, however, is that its current core – by which I mainly mean the so-called dynamic stochastic general equilibrium (DSGE) approach – has become so mesmerized with its own internal logic... This is dangerous for both methodological and policy reasons... To be fair to our field, an enormous amount of work at the intersection of macroeconomics and corporate finance has been chasing many of the issues that played a central role during the current crisis... However, much of this literature belongs to the periphery of macroeconomics rather than to its core...”*

Ricardo Caballero (2010)

*“One can safely argue that there is a hole in our knowledge of macro financial interactions; one might also argue more controversially that economists have filled this hole with rocks as opposed to diamonds; but it is harder to argue that the hole is empty.”*

Ricardo Reis (2017)

*“The financial crisis ... made it clear that the basic model, and even its DSGE cousins, had other serious problems, that the financial sector was much more central to macroeconomics than had been assumed...”*

Olivier Blanchard (2017a)

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# 1. Introduction

The past quarter century has seen dramatic movements in asset prices and real economic activity. Equity prices rose significantly during the second half of the 1990s and then fell abruptly in 2000–01 with the unwinding of the high-tech bubble. The large decline in equity markets coincided with recessions in many advanced economies. House prices increased substantially over 1996–2007 but declined sharply after that. The collapse in house prices was accompanied by the Great Financial Crisis (GFC) of 2007–09, which led to deep recessions in almost all advanced economies after an extended period of macroeconomic stability – the so-called Great Moderation.<sup>1</sup> Policymakers reduced interest rates to zero or even below as they attempted to mitigate the adverse effects of recession and establish a durable recovery. Exchange rates also swung widely, especially during periods of intense financial stress.

These developments highlight the importance of understanding the linkages between asset price movements and macroeconomic outcomes. Specifically, the GFC was a bitter reminder of how pronounced fluctuations in asset prices can have a dramatic impact on the balance sheets of households, corporations, financial intermediaries and sovereign nations. As asset prices fell sharply and the global financial system edged to the brink of collapse in late 2008, the global economy experienced its deepest contraction in more than half a century. This led to unprecedented challenges for fiscal, monetary and financial sector policies.

The links between asset prices and macroeconomic outcomes are obviously at the centre of broader macro-financial linkages – the two-way interactions between the real economy and the financial sector. Shocks arising in the real economy can be propagated through asset prices via the operations of the financial sector, thereby amplifying business cycles. Imperfections in financial markets can intensify shocks to asset prices and consequently lead to more pronounced macroeconomic fluctuations. Conversely, developments in financial markets can be sources of shocks, which can, in turn, result in more pronounced asset price movements and macroeconomic fluctuations. Through cross-border connections, these developments can lead to international spillovers.

This paper surveys the literature on the linkages between asset prices and macroeconomic outcomes. Given the enormous volume of work on this topic, we focus on three specific questions. First, what are the basic theoretical mechanisms linking asset prices and macroeconomic outcomes? Second, what is the empirical evidence supporting these linkages? And third, what are the main challenges to the theoretical and empirical findings? Our survey only scratches the surface of this large literature by providing a broad perspective on these questions in the context of the following asset price categories: equity prices, house prices, exchange rates and interest rates.<sup>2</sup>

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<sup>1</sup> A number of books, academic studies and “popular” literature pieces, discuss various macro-financial linkages that have contributed to the devastating impact of the GFC on the real economy: Krugman (2009b), Sorkin (2009), Wessel (2009), Lewis (2010), Kose and Prasad (2010), Paulson (2010), Gorton (2012), Turner (2012), Bernanke (2013), Blinder (2013), Borio (2014), Claessens et al (2014a), Mian and Sufi (2014), Wolf (2014), Geithner (2014), Farmer (2016), King (2016) and Taylor (2016). Lo (2012) reviews a set of 21 books on the GFC.

<sup>2</sup> Reference books analysing the dynamics of asset prices and their connections to macroeconomic outcomes include: Campbell et al (1996), Duffie (2001), Cochrane (2005, 2006, 2017), Singleton (2006), Pennacchi (2007), Brunnermeier et al (2013), Quadrini (2014), Morley (2016) and selected chapters of Constantinides et al (2013). See also Campbell (2014) who discusses the research on asset pricing conducted by the laureates of the 2013 Nobel Prize in Economics (Eugene Fama, Lars Peter Hansen

Our survey contributes to the literature on the links between asset prices and macroeconomic outcomes in several dimensions. First, it presents a broad review of the theoretical and empirical work on the main determinants of asset prices and the basic linkages between asset prices and economic activity. Second, it documents that basic models are able to capture many linkages as documented by a wide range of empirical studies. However, it also shows that a number of puzzles remain regarding the behaviour of asset prices and their interactions with macroeconomic outcomes. Third, it emphasises the global dimensions of asset price determination, the linkages between asset prices and economic activity and the critical role of such prices in the transmission of shocks across borders. Finally, to help guide future research, the survey attempts to identify the major gaps in knowledge on these issues.

Given the complex nature of the linkages between asset prices and macroeconomic outcomes, a survey on the topic comes with a number of caveats. First, both asset prices and macroeconomic outcomes are endogenous variables and, as a result, the nature of the relationships between them ultimately depends on the models employed for the analysis. Our objective here is to present the basic linkages in the context of standard models and review the most relevant empirical studies that test for the presence of these links. Second, while we study the linkages between asset prices and macroeconomic outcomes, we are keenly aware that many micro-level factors drive macro-level variables. Hence, whenever possible, we draw lessons from theoretical and empirical studies at the microeconomic level for macroeconomic aggregates.

Third, our focus is mostly on standard models, ie models that do not necessarily account for financial market imperfections. We consider these “frictionless” models as the benchmark frameworks to study the linkages between asset prices and macroeconomic outcomes. We present a discussion of models with financial imperfections in our companion survey (Claessens and Kose (2017)). Finally, although we did our best to include all major studies on the topic, it is unavoidable that a survey on such a vast literature would miss some contributions.

We start with a general discussion of the determinants of asset prices with standard models of “complete markets”. These models often apply to all types of asset. But to simplify the presentation, we first focus on equity and house prices within a closed economy context. We then analyse the international dimensions of asset prices. Next, we discuss in more detail two other major asset prices: exchange rates and interest rates (and related bond prices). In order to make our survey more accessible, each section provides a self-contained review of the relevant segments of the literature. We also structure each section to address systematically the three questions posed above.

Section 2 starts with a brief analysis of the determination of asset prices in standard models. Models operating within a “complete markets” paradigm provide the basic analytical foundations for the determination of asset prices. Asset prices, like other prices, are endogenous and adjust to clear markets, including “anonymous” financial markets in these models. The standard models provide useful frameworks as they highlight the basic linkages between asset prices and agents’ decisions, including through the well-known channels associated with wealth and substitution effects. Asset prices also provide economic agents with signals that allow them to make optimal saving and investment decisions. They also carry information about future profitability and income growth.

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and Robert Shiller). Woodford (2003) analyses interest rates and prices and the role of monetary policy in shaping them. Sarno and Taylor (2002), Klein and Shambough (2010), Chinn (2012), Rossi (2013) and Engel (2014) provide extensive surveys of different aspects of exchange rates.



This section then turns to the empirical literature, analysing the linkages between asset prices, especially equity and house prices, and real variables. Empirical studies support many of the predictions of standard models with respect to linkages between asset prices and macroeconomic outcomes. First, movements in asset prices are associated with changes in investment and consumption that are broadly consistent with the predictions of many standard models. In particular, studies that use microeconomic data support various theoretical predictions regarding the impact of asset prices on household and firm behaviour. Second, asset prices appear to play a “signalling role” as they tend to comove with (or lead) various measures of current and future activity.

Although the basic models provide helpful guidance, a number of puzzles remain, particularly with respect to inconsistencies between the predictions of models and the data. First, asset prices are much more volatile than fundamentals would imply. They can at times deviate substantially, or at least appear to, from predicted values based on fundamentals. Second, there are many questions about the quantitative importance of the linkages between asset prices and macroeconomic aggregates. The strength of these empirical linkages appears to depend on various factors. Investment and consumption, for example, respond differently to changes in asset prices than standard models would predict, with a significant role for non-price factors in influencing agents’ behaviour. Third, there are limits to the predictive power of asset prices for economic activity. Empirical evidence also suggests that the channels leading to the predictive power of prices may be different from those suggested by the basic models.

Section 3 briefly reviews the international dimensions of linkages between asset prices and macroeconomic outcomes. Given the extent of cross-border integration of real and financial markets today, any discussion of the linkages between asset prices and activity has to take into account the international dimensions. Like their closed economy counterparts, however, many of the international asset pricing models are based on partial equilibrium analysis. Moreover, these models often do not consider whether international asset holdings are consistent with observed prices. While recent theoretical studies have taken significant steps to remedy these shortcomings and analyse the dynamics of asset prices in richer, general equilibrium environments, there is a broad realisation that gaps remain.

Empirical studies find that certain asset prices tend to move together and emphasize the importance of common (global) shocks (factors) in explaining fluctuations in asset prices. This is a natural outcome of the major role that international financial integration has played in shaping asset price movements in recent decades. In addition, the empirical literature documents that domestic financial development and trade integration affect the degree of comovement of asset prices across countries. Even prices of non-tradable assets, such as real estate, tend to move together across countries, suggesting that there are indeed global factors driving asset price movements.

However, there are many puzzling aspects associated with the international dimensions of asset prices. First, international financial integration appears to amplify both the volatility and comovement of asset prices beyond what standard models would suggest. Second, the lack of international diversification of portfolio investment, the so-called home bias, has been hard to reconcile with the predictions of most asset pricing models. Moreover, the prices of internationally-traded assets continue to depend on local risk factors, suggesting some *de facto* segmentation of markets despite the removal of many barriers to cross-border trading (especially of equities).

Section 4 starts with a brief review of the determinants of exchange rates. The theoretical literature on exchange rate determination has gone through several phases, from basic arbitrage-related models to fully fledged general equilibrium models. These models point to

long-run relations between exchange rates and a wide range of real and nominal variables. They also show that the exchange rate can play an important role in the transmission of monetary policy for small open economies. The more recent literature, often classified under the rubric of “new open economy macroeconomics”, is making increasing use of advances from the closed-economy macroeconomic literature to help explain the properties of exchange rates in environments featuring nominal rigidities, imperfect competition and rational agents.

There has been a large theoretical literature analysing the linkages between fluctuations in exchange rates and macroeconomic fundamentals. Theoretical models are used to study how changes in exchange rates relate endogenously to various macroeconomic variables and how these relationships are affected by a variety of factors, including: the heterogeneity of sectors; economies of scale and imperfect competition; type of exchange rate regime; country-specific elements and time horizons. However, some of the theoretical linkages remain ambiguous, including the impact of exchange rates on investment and the effects of devaluations on output. Recent models employ richer environments and consider the roles of financial variables and valuation effects to get a better understanding of existing linkages between exchange rates and real and financial aggregates.

Empirical studies provide mixed evidence about the strength of linkages between exchange rates and macroeconomic outcomes. First, while most studies show that a depreciation (appreciation) tends to be associated with a contraction (expansion) of investment, the potency of this relationship varies across sectors, countries and time horizons. Second, while the exchange rate appears to play a supportive role in facilitating the reversal of current account imbalances, the quantitative importance of this role is ambiguous. Third, the exchange rate is a transmission channel through which monetary policy could affect the real economy but the strength of this channel appears to depend on many factors, including the sensitivity of interest rates to exchange rates, the degree of openness, the exchange rate regime, and the currency composition of debt and, related, any mismatches.

Moreover, a number of puzzles remain about the interactions between exchange rates and macroeconomic variables, and even more so about the linkages between exchange rates and financial variables. The key puzzle is the disconnect between exchange rates and macroeconomic aggregates, as reflected in the limited success of exchange rate models relating future exchange rates to underlying short-run fundamentals. The roles played by financial variables in driving the behaviour of exchange rates have yet to be explained satisfactorily.

Section 5 reviews the links between interest rates and macroeconomic outcomes. Interest rates, real and nominal, play key roles in financial intermediation and can drive macroeconomic outcomes. The theoretical mechanisms that relate changes in (short-term) interest rates to fluctuations in output are well captured by standard models. The short-term nominal interest rate is, of course, closely related to the conduct of monetary policy. One of the main channels of monetary policy transmission, the direct interest rate channel, for example, focuses on the impact of interest rates on investment and consumption.

Empirical research confirms the special role played by interest rates in shaping activity. First, interest rates have a substantial effect on investment, consumption and overall activity. Second, there is evidence supporting the presence of a direct interest rate channel of monetary policy. Third, long-term interest rates relate to short-term rates through expectations and arbitrage in ways that are often consistent with the predictions of the standard models. Moreover, the spread between long- and short-term interest rates and other characteristics of the yield curve help predict the timing of recessions and the behaviour of some macroeconomic aggregates.

Much evidence supports the key channels but research also suggests there are other factors that affect the transmission of monetary policy. First, the quantitative importance of the direct interest rate channel has been debated. While empirical results are not necessarily inconsistent with the existence of a direct channel, they do suggest the need to consider firm, household and financial system heterogeneity, and variations over time, including in the state of domestic and international financial conditions. Second, there has been debate about the predictive value of the (slope of the) yield curve for future economic activity. More generally, the shape of the yield curve is determined by a variety of factors, including risk premia that can vary with economic and financial conditions. Lastly, the experience with unconventional monetary policies (UMP) since the GFC has introduced new aspects about the linkages between asset prices and activity that require further research.

Section 6 concludes with a summary and a discussion of future research. It highlights the key findings and documents some of the major gaps in the literature. It also discusses possible directions for future research, stressing the need for richer theoretical models, more robust empirical work and better quality data so as to advance knowledge and help guide policymakers going forward.

## 2. Asset prices and macroeconomic variables

This section examines the basic determinants of asset prices and their linkages to macroeconomic variables in the context of standard models without frictions. These models, which often assume a world of complete markets in an Arrow-Debreu sense (as discussed below), provide the basic analytical foundations for the determination of asset prices.

The section comprises three parts. It starts with a brief summary of the basic price determination mechanisms contained in standard models and the implications of changes in asset prices for economic activity. It then reviews empirical studies, providing evidence relating to these mechanisms. It concludes with a summary of the major shortcomings of the models.

### A. Basic mechanisms

#### Determination of asset prices

In competitive market models without frictions, the prices of assets, like the prices of goods, are determined by the forces of supply and demand. Assets studied typically include a broad array of tradable claims, such as bonds, equities, real estate, plant and equipment, patents etc. In these models, asset prices, as for other prices, reflect the equilibrium outcome of aggregate demand and supply forces, with no clear feedback from asset prices to aggregate demand or supply. This is clear in the most complete version, ie in an Arrow-Debreu world, where contingent claims span every possible state of the world, allowing agents to insure against any event, which in turn simplifies the choices they make.<sup>3</sup> The absence of feedback effects in these models makes them different from classes of models with a so-called financial accelerator or other feedback mechanisms arising from frictions that give rise to macro-

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<sup>3</sup> This is also referred to as the Arrow-Debreu-McKenzie model. For a short conceptual review of asset pricing, see Geanakoplos (2008), and for an extensive treatment, see Cochrane (2005). For an overview of the empirical determinants and properties of various asset prices, see Hordahl and Packer (2007).

financial linkages (see Claessens and Kose (2017)). That said, by providing signals to economic agents, asset prices “help” households and corporations in making optimal decisions with respect to saving, investment and consumption.

In these models, asset prices reflect the present (discounted) value of future cash flows or services. They recognise that asset ownership constitutes a claim on the income derived from an asset (ie it is not the asset itself that is valued). The price of an asset is simply the present value of its future cash flows (dividends). The canonical representation of this idea is described by the “Gordon equation”, which is often used in the context of the determination of equity prices (Gordon (1959 and 1962)). It implies that the price of an asset with a perpetual stream of dividends can be expressed as its current dividend divided by the appropriate discount rate for holding the asset minus the nominal growth rate of the dividends it pays. This calculation requires one to project the path of future cash flows. Depending on the type of asset under consideration, this entails the analysis of a wide range of factors influencing the stream of cash flows, including macroeconomic variables – such as output, household consumption, corporate investment and productivity – as well as uncertainty relating to these variables and correlations among them.

In addition, asset price determination requires the use of the “right” discount rate. The risk-adjusted discount rate used in present value calculations is the sum of the risk-free rate and the risk premium applicable to a specific asset. The risk-free rate can often be observed, eg the interest rate on Treasury bills or government bonds. The risk premium depends on the specific behaviour of an asset’s cash flow and can be determined using an asset pricing model, assuming that markets are complete and without financial frictions. In partial equilibrium models – for example, when only the behaviour of financial variables is modelled – this is relatively easy as the risk-adjusted discount rate simply reflects movements in financial variables. For example, in the basic capital asset pricing model (CAPM), the required premium is determined by the degree to which an asset’s risk is non-diversifiable with respect to all other assets, captured by its *beta*, and the excess of the rate of return on all assets (the market rate of return) over the risk-free rate.<sup>4</sup>

In general equilibrium, preferences, technology and real factors (physical endowments) determine the discount rate and cash flows. In his seminal general equilibrium model, Lucas (1978) links the required rate of return on assets to investors’ risk aversion and endowments (“cash flows”). Other general equilibrium asset pricing models extend this basic idea. The pricing model (“kernel”) has gradually become more complex in these frameworks, but the underlying principle has remained the same: preferences, technology and the behaviour of real factors determine jointly the risk-adjusted discount factor. In turn, they affect investment and consumption decisions, with capital stocks and shocks to technology subsequently driving future cash flows and output. Shocks to technology and/or preferences can then generate correlated movements in investment, consumption, output and asset prices. The joint role of

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<sup>4</sup> The CAPM was developed (in several stages) by Treynor (1962), Sharpe (1964), Lintner (1965) and Mossin (1966). In a simple, one-factor CAPM, *beta* is equal to the regression coefficient of the observed rate of return of an asset on the market rate of return. In more general settings, *beta* equals the covariance of the cash flows of an asset with the cash flows of all assets traded in the economy relative to the variance of the cash flows of all assets. The determination of the rate of return, or of the cash flow process, is often left unspecified in such partial equilibrium models.

technology and preferences can be seen most easily in the context of a special class of general equilibrium models, the so-called consumption capital asset pricing models (CCAPMs).<sup>5</sup>

These general equilibrium models are highly stylised, however, and rely on a wide range of assumptions. The standard ones, including those used in the real business cycle (RBC) literature, most often assume complete markets, an absence of transaction costs and no financial imperfections. These assumptions are typically similar to those made in deriving the path-breaking Modigliani-Miller result of the irrelevance of financing structures for firm value (see Brealey et al (2016) for a textbook treatment).

In particular, as Modigliani and Miller (1958) showed, the market value of a firm is independent of the way it is financed under the following assumptions: (i) neutrality of taxation between debt and equity; (ii) no capital or financial market frictions (ie no transaction costs, agency issues, asset trade restrictions or bankruptcy costs); (iii) symmetric access to credit markets (ie firms and investors can borrow or lend at the same rate); and (iv) no information relating to prospective financial policies of the firm. Other common assumptions include no barriers across (international) markets, no heterogeneity among participants and perfect divisibility of real and financial assets.

The main implication of these assumptions is that the price of any asset, like the market value of a firm, is solely determined by the present value of the cash flows it generates.<sup>6</sup> While many of the assumptions underlying the Modigliani-Miller irrelevance result and the complete markets paradigm clearly do not apply in the “real” world, and have subsequently been questioned by the literature, such frameworks have been very useful in establishing some fundamental relationships. Adjustments correcting for specific deviations from these assumptions have been made. For example, the differential treatment of taxes on debt and equity can be accounted for by including the present value of tax shields (since interest payments are tax deductible) to the value of the firm (see Graham (2013) for a review on how taxes affect corporations’ financial decisions). Corrections can also be made to capture the effects of inflation: for example, the real interest rate, rather than the nominal rate, may need to be used.<sup>7</sup>

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<sup>5</sup> In most models, the pricing formula equates the expected rate of return on an asset in excess of the risk-free rate (its risk premium) to (the negative of) the covariance between that asset’s returns and the (stochastic) discount factor (the investor’s intertemporal rate of substitution). Hence, the more negative the covariance between an asset’s return and its discount factor, the higher its risk premium is (Campbell (2003), Cochrane (2006), and Campbell et al (2015)). In consumption-based asset pricing models, the discount factor is proportional to the covariance of the return on the asset’s cash flow with consumption growth, thus creating a link between real (macroeconomic) aggregates and asset prices (Cochrane (2000)). Ludvigson (2013) presents a review of the recent literature on consumption-based asset pricing models.

<sup>6</sup> Another set of implications relates to the predictability of asset prices and the absence of arbitrage opportunities. The notion that asset returns are impossible to predict if asset prices reflect all relevant information (“follow a random walk”) goes back a long time (Bachelier (1900)). Fama (1970), in his review of the existing literature, which included his own important empirical contributions (Fama (1963, 1965)), introduced the term “efficient market hypothesis” to capture this concept. He also provided a typology of possible empirical tests and related insights. See Fama (1991) for a review of the subsequent literature (up to the late 1980s).

<sup>7</sup> In addition, the time profile of the cash flows may matter as the maturity of the discount rate needs to match the profile of the cash flows. For example, the long-term interest rate, rather than the short-term rate, plays a major role for corporate investment, housing and the consumption of durable goods. The long-term interest rate is often a reflection of expected future short-term interest rates (the

For a long period of time, the Arrow-Debreu framework and the related Modigliani-Miller theorem greatly influenced the research agenda on macro-financial linkages (see Claessens and Kose (2017) for an overview of the evolution of this literature). Methodological advances in the 1970s contributed to this influence. Whereas money and credit featured prominently in earlier work, researchers focused increasingly on the real side of the economy and relied on the simplifying assumption that financial structures and intermediation did not matter for firm value or for the real economy in general. Although some empirical studies employing vector autoregressions (VARs), first proposed by Sims (1972), focused on the role of money as the key financial aggregate, until the early 1980s the literature considered mostly movements in real aggregates.

## Asset prices and activity

The standard models make clear predictions about how asset prices relate to individual agents' investment and consumption decisions. Implicit in most models is that asset prices, like any other prices, play an "allocative" role. This is clearly seen in corporations' investment and households' consumption decisions, ie the allocation of resources across different objectives, states of nature and time. This is probably best captured by Tobin's  $q$  theory, which posits that asset prices can be used to determine the market value of a firm's existing fixed capital stock. Tobin (1969) defines  $q$  as the market price of a firm, assuming that it is traded, relative to the replacement ("book") value of its assets. If  $q$  is high, new plants and equipment capital are cheap to add relative to the market value of the firm. The firm can then raise new equity and other external financing to expand its capital, or replace it, and thereby increase overall firm value. Value can be added in this way until  $q$  converges to its equilibrium level of one. Thus, the  $q$  theory establishes a natural link between asset prices and corporate investment.<sup>8</sup>

Models also show how asset prices influence households' consumption and saving decisions through wealth and substitution channels. In most such models, consumption decisions are based on households' lifetime wealth, including current and future income and current financial and physical assets. Changes in asset prices can then influence current consumption as they change individuals' financial and real wealth.<sup>9</sup> In addition, by altering the rate of substitution between consumption allocations over time (the intertemporal marginal rate of substitution), asset prices can affect households' saving behaviour.<sup>10</sup>

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expectations hypothesis). Textbooks, such as Brealey et al (2016), discuss many of the "corrections" employed. Even with corrections, however, the market value of a firm and of other asset prices can differ from the ones implied by the standard theoretical models. There has consequently been an extensive research programme analysing the various deviations from the benchmarks.

<sup>8</sup> There are conceptual complications associated with the links between asset prices and investment, even in the absence of financial frictions. An important one, pointed out by Hayashi (1982), is that it is the marginal  $q$  which matters, not the average  $q$ . Since only the average  $q$  is observable, not the marginal  $q$ , this requires further assumptions to allow for empirical tests. More importantly, though, the presence of financial frictions can affect the basic relationship between  $q$  and investment.

<sup>9</sup> Wealth effects on consumption relate to Ando-Modigliani's (1963) life-cycle/permanent income hypothesis (see Deaton (1992) for a detailed analysis). Given households' limited ability to borrow against future labour income and smooth consumption over their lifetime (ie in the presence of liquidity constraints), a form of market incompleteness or of financial friction, changes in asset prices can influence current consumption more than what is predicted by these models.

<sup>10</sup> Implications of changes in asset prices for household balance sheets have been an active area of research (see a recent review by Guiso and Sodini (2013)).

Another channel operates through the information that asset prices incorporate about future profitability and income growth. Private fixed investment depends on expected output growth. Financial markets can aggregate efficiently information about the state of the economy and future prospects into asset prices (see Allen (1993)). For example, when prospects of future corporate earnings improve, equity prices are expected to increase. To the extent that asset prices reflect fundamentals or provide information about future output (or sales) growth of a corporation or its competitors, the corporation will tend to respond to asset price changes by adjusting its investment (in terms of the selection of specific projects or their timing). At the aggregate level, changes in, say, expected productivity due to technological advances can lead to movements in asset prices. Similarly, households' consumption depends on expectations about future income. Movements in asset prices can provide information to households regarding current or future fundamentals, for example, by signalling faster or slower future income growth. This can lead households to adjust their consumption and saving behaviour.

## B. Empirical evidence

There is extensive empirical evidence supporting a number of mechanisms linking asset prices to microeconomic and macroeconomic outcomes. This section focuses on two major aspects of this evidence. First, asset prices are associated with changes in investment and consumption behaviour in manners predicted by the standard models. Second, the informational value of asset prices can play a signalling role as such prices tend to comove with activity and appear to help predict its future direction.<sup>11</sup>

### Asset prices, investment and consumption

Empirical evidence, both at the micro- and macroeconomic levels, suggests that asset prices appear to affect corporate investment decisions, as predicted by the basic models. Brainard and Tobin (1968) established an empirical relationship between Tobin's  $q$  and investment. Using firm-level data, Abel and Blanchard (1986) subsequently showed that firms' marginal  $q$  is positively related to their investment. At the aggregate level, various studies documented the links between asset prices and private investment. Based on evidence for 19 OECD countries, for example, Davis and Stone (2004) found a large elasticity, with a 1% change in equity prices being associated on average with a 1% change in long-run investment. However, others find minor or insignificant effects.<sup>12</sup>

A number of studies provide evidence that such links can arise because of other channels. Although most of these studies generally support the conclusion that equity prices are an important determinant of investment, notably in countries with more developed financial systems, some question this finding, in part due to the presence of channels arising from financial frictions. Such frictions can, for example, lead to a relationship between Tobin's  $q$  and investment independently of the investment adjustment and information channels outlined above. Chirinko (1997) and Gomes (2001) show that financial constraints, such as

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<sup>11</sup> Anecdotal evidence also indicates that the basic price determination models discussed here are widely used for the valuation of firms, projects and assets (Benninga (2008)).

<sup>12</sup> Caballero (1999) and Altissimo et al (2005) provide additional discussions. See also Davis (2010a, 2010b) for a review of empirical papers on the relationship between asset prices and consumption and investment as well as some specific regression results for 23 OECD countries. Estimating investment functions for the G7 countries, Ashworth and Davis (2001) show that Tobin's  $q$  only has a long-run effect on investment in Japan and France.

when the cost of external finance depends on leverage, are likely to be reflected in  $q$ , making that variable endogenous to firm choice. In a related paper, Erickson and Whited (2000) point out that measurement error in  $q$  can lead to a positive relationship between a firm's internal cash flow and its investment, even when there is no direct relation (which otherwise would suggest a deviation from the  $q$  model).

While results depend on methodology and data samples, empirical studies at the household level find significant wealth effects of asset prices on consumption. For the United States, estimates of the marginal propensity to consume (MPC) out of overall wealth (financial assets and illiquid assets, including housing) range between 4% and 7%. For financial wealth only, estimates for the United States suggest changes in consumption of the order of 0.03% to 0.07% for every 1% change in equity value.<sup>13</sup> Empirical estimates vary by country though. Bayoumi and Edison (2003) report that equity wealth effects are much weaker for countries other than the United States: for every 1% change in equity value, the change in consumption is 0.015% to 0.03% in Japan and 0.01% to 0.03% in various European countries. Others find long-run elasticities ranging from very small (or insignificant) to 0.35% on average for OECD countries (Catté et al (2004)).

The effects of asset prices also vary depending on financial market characteristics. In emerging market economies (EMEs), for example, wealth effects are small, possibly due to a limited and concentrated participation of households in capital markets. Slacalek (2009) reports an average wealth effect of 0.015% for a 1% change in equity value for 22 EMEs over 1985–2007. Funke (2004), in a study of 16 developing economies, reports that a 10% decline in annual real equity market return is associated with a reduction in real private consumption of about 0.2–0.4% on average.<sup>14</sup>

Linkages between asset prices and macroeconomic outcomes also tend to vary by type of asset. In theory, housing wealth could have a smaller effect on consumption than equity market wealth because it is less clearly connected with future increases in productive potential (Mishkin (2007)). Moreover, since housing services are a component of consumption, increases in house prices can negatively affect consumption. At the same time, real estate wealth tends to be a significant share of households' wealth and households can often borrow against this wealth and leverage the increase in house value for consumption purposes.

Both house and equity prices are much more volatile than output (Table 1A). House prices appear to be less volatile than equity prices, though, implying that changes in house prices are likely to be perceived more permanent than changes in equity prices (Cecchetti (2008)). Kishor (2007) reports that while 99% of the change in housing wealth is permanent, ie it remains after one quarter, only 46% of the change in equity wealth is. Housing also typically constitutes a larger share of total wealth, possibly making changes in house prices more important for household consumption decisions.<sup>15</sup>

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<sup>13</sup> For overall wealth estimates, see Gale et al (1999), Kiley (2000), Davis and Palumbo (2001), Barrell and Davis (2007a) and Case et al (2013). Using a broader definition of equity wealth (including both corporate equity and other types of security), the effect has been estimated at about 3 1/2 cents per dollar change in wealth (Ludvigson and Steindel (1999)).

<sup>14</sup> See Kim (2004) for Korea, Peltonen et al (2012) for 14 EMEs, and IMF (2008) for cross-country evidence.

<sup>15</sup> Lettau and Ludvigson (2004) also find that transitory shocks dominate variations in wealth in the United States while permanent shocks dominate variations in aggregate consumption, helping explain why little of the variation in household net worth relates to the variation in consumer spending. Kaplan et al (2014) find that households holding (illiquid) housing wealth behave like hand-to-mouth



Overall, the available evidence suggests that changes in house prices have a more pronounced impact on consumption than equity prices. For the United States, Carroll et al (2011) report that the propensity to consume from a \$1 increase in housing wealth ranges between two (short-run) and nine (long-run) cents, twice as large as that estimated for equity wealth (see also Case et al (2013)). Kim (2004) shows that in Korea the elasticity of consumption with respect to housing wealth is larger than with respect to equity market wealth between 1988 and 2003. Gan (2010) reports a significant impact in Hong Kong of housing wealth on consumption using a large panel data set of households. Case et al (2005), using annual data for 14 advanced economies, show that house prices are more important than stock prices in influencing consumption. These findings are consistent with the idea of a more permanent nature of house price changes and a larger share of housing in total wealth. Furthermore, changes in house prices also appear to have a differential impact on age groups, which is consistent with the relative importance of housing in overall financial wealth.<sup>16</sup> In addition, there is some evidence of asymmetric effects, with negative shocks to asset prices having a greater impact on consumption than positive shocks (Peltonen et al (2012)).

Recessions associated with asset price busts and recoveries accompanied by asset price booms tend to be more pronounced than those without such episodes. In particular, recessions associated with asset price busts are significantly longer than recessions without such disruptions (Claessens et al (2012), Drehmann et al (2012) and Muir (2017); Table 1B). They also result in significantly larger drops in output and correspondingly greater cumulative output losses. Given that about one third of recessions are accompanied by a house price bust, these results point again to the relevance of asset prices movements for economic activity.

### **Comovement between asset prices and macroeconomic outcomes**

Confirming the predictions of most general equilibrium-type models, asset prices tend to be correlated with current and future aggregate activity. Since they reflect current economic developments, both equity and house prices comove with business cycles (Table 1C). The contemporaneous correlations between house prices and output, however, tend to be higher than those between equity prices and output while the definitions of asset price cycles affect their correlations with the real sector.

Being forward-looking variables, equity prices provide the market's aggregated views of future economic prospects. Empirical evidence for advanced economies confirms that changes in equity prices tend to lead output growth by a few quarters (Table 1C). The channel appears to run through investment. Indeed, for a wide variety of countries, including EMEs, equity prices seem to be better leading indicators of investment than GDP or consumption (Aylward and Glen (2000)). However, linkages between asset prices and activity also depend on country- and market-specific features (for reviews focusing on the predictive power of asset prices, see Stock and Watson (2003) and Cochrane (2008)).

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consumers, implying that their consumption is quite sensitive to transitory shocks to income. Mian et al (2013) estimate the MPC out of housing wealth using US households data and find that more leveraged and poorer households suffer higher losses in consumption in response to changes in housing wealth. Some earlier studies also examine the interactions between house prices and the real economy across countries (Borio et al (1994), Kennedy and Anderson (1994) and Tsatsaronis and Zhu (2004)).

<sup>16</sup> Research documents that house prices have a stronger impact on the consumption of older, less indebted households (see Campbell and Cocco (2007), Calomiris et al (2013) and Attanasio et al (2011)).

House prices also display some predictive power for activity. There are several reasons for this (see Leamer (2007)). Housing market developments are sensitive to the same underlying factors affecting the overall economy (such as the level of interest rates and aggregate demand). As the economy expands or contracts, housing demand will change. This is highly relevant because the housing market is an important part of the overall economy. The housing market also exhibits long lags and is lumpy: it takes considerable time to start new housing projects, wealth effects associated with housing tend to operate with a lag and buying or selling of houses often involves large transactions costs. Together, these factors make various measures of housing sector activity, such as housing starts and prices, useful leading economic indicators. Although the predictive power of house prices for output growth is generally found to be somewhat weaker than that of equity prices, perhaps because housing is traded in relatively less liquid markets, changes in house prices have a greater power than equity prices in predicting future output gaps for some countries (IMF (2000)).

Equity and house prices are not only related to the overall business cycle but are also helpful in predicting cyclical turning points, albeit imperfectly. Recessions are often preceded by declines in equity prices or slowdowns in their growth (with the opposite for recoveries). For a large sample of countries for a period of almost 50 years, Claessens et al (2009) show that in the first year of a typical recession, equity prices decline on a year-to-year basis by roughly 35%. Anticipating the end of a recession, equity prices also often start registering positive growth after about three quarters into a recession (Figure 1). House price cycles generally lag business cycles, as reflected in the fact that house prices do not resume positive annual growth until at least 12 quarters after a recession has started whereas equity prices do after six to seven quarters.<sup>17</sup>

## C. Challenges to the standard models

The linkages between asset prices and activity differ from the predictions of standard models in a number of ways. First, asset prices are much more volatile than fundamentals would imply. They can at times deviate substantially, or at least appear to do so, from the predicted fundamentals-based values. Second, investment and consumption respond differently to asset prices than what standard models would predict, with a larger role for non-price factors in driving agents' behaviour and macroeconomic aggregates. Third, there are limits to the predictive ability of asset prices for real activity and the channels leading to the predictive power may be quite different from what the basic models would suggest. This sub-section discusses each of these issues in turn.

### Asset pricing puzzles

Asset prices are more volatile than what fundamentals suggest. An extensive literature, starting with Shiller (1979) for bond prices and Shiller (1981) for equity prices, has documented the “excess” volatility of asset prices. Shiller (1981) observed that if equity prices equal the expected sum of discounted dividends, then equity price volatility should face an upper limit determined by the volatility of what he called “ex-post rational” stock prices (defined as the sum of actual discounted dividends). However, he found that this was not born by the data. Studies using different approaches have also confirmed this finding (see

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<sup>17</sup> Bluedorn et al (2016) find that asset prices, especially equity prices, are helpful predictors of recessions in the G7 countries. Borio and Drehmann (2009) document that house prices, combined with credit, tend to predict financial crises.

Cochrane (2011b) for a review). In subsequent research, Campbell and Shiller (1987) showed that the excess volatility result remained even when the time series for prices and dividends were non-stationary (see LeRoy (2008)). Research has also shown that many other asset prices are much more volatile than the discounted value of the corresponding streams of dividend would suggest.<sup>18</sup>

Moreover, asset prices appear to move away at times from their predicted fundamentals-based values. This is not easy to confirm, however, because one does not know whether the mispricing represents a deviation from the “true” model or the use of a “mis-specified” model, including not knowing or using the “right” fundamentals. This can happen for individual assets (simply representing “arbitrage” opportunities) or for the market as a whole. Simple arbitrage opportunities are limited for most traded assets but markets may deviate at times from developments in fundamentals (Lo and MacKinlay (1999), Shiller (2000) and Akerlof and Shiller (2009, 2015)).

There is also ample evidence of stock price “bubbles”.<sup>19</sup> As an illustration, one can compare the aggregate price-earnings ratio, the dividend yield and the implied equity premium in 1999, just before the stock market peak in advanced economies, with their historical averages over the period 1980–99 (IMF (2000)). Such a comparison shows that, in the late 1990s, the valuations implied by equity prices were considerably higher than their historical averages in terms of price-earnings ratio but lower relative to dividend yields and implied equity risk premia. At the same time, real GDP growth was not very different from its historical average.<sup>20</sup> These comparisons suggest some overvaluation at the time, with markets indeed experiencing a major correction after mid-2000.

The high volatility of asset prices relative to their fundamental values appears to stem partly from the volatile nature of discount rates. Asset price volatility can be decomposed into two parts: the volatility of expected future cash flows (eg dividends) and the volatility of the discount rate applied to those cash flows. Campbell and Shiller (1988a, 1988b) developed a methodology for decomposing the variation in the dividend-to-price ratio into variations in expected dividends and discount rates. Their research and subsequent work suggest that the variation in expected dividends accounts for no more than one-fourth of stock market volatility whereas variation in the discount rate accounts for the bulk of volatility (Cochrane (2011b) for a review).

This relates to the finding that most asset pricing models, including the basic consumption-based model, cannot fully explain the magnitude of the risk premium actually

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<sup>18</sup> See Mankiw et al (1985, 1989), West (1988), Schwert (1989) and Barsky and De Long (1993).

<sup>19</sup> A bubble can be defined as: “...the part of a grossly upward asset price movement that is unexplainable based on fundamentals” (Garber (2000)). Patterns of exuberant increases in asset prices, often followed by crashes, figure prominently in many accounts of financial instability for all types of economy and going back centuries (Claessens and Kose (2014)). See Brunnermeier and Oehmke (2013), Scherbina and Schlusche (2014) and Williams (2013) for recent surveys on asset price bubbles. Some argue that fully irrational asset bubbles are not necessarily harmful and could even be beneficial (Kocherlakota (2009)).

<sup>20</sup> At the time, one explanation for the high level of stock prices was the strong labour productivity growth observed in the United States in the second half of the 1990s. This fuelled discussion of a “new economy” driven by information technology. However, later data revisions showed much lower labour productivity growth. The changes in (perceived or expected) productivity growth could well explain some of the run-up in prices and the following sharp corrections (Pastor and Veronesi (2006), Griffin et al (2011)). Lettau et al (2008) provide a summary of studies explaining persistently high stock market valuations, as observed in the late 1990s. They argue that a fall in macroeconomic risk or in economy-wide volatility can lead to such high stock prices.

observed for equities – the spread between the rate of return required for holding the market portfolio and the risk-free rate (for a discussion of the credit risk premium, see Amato and Remolona (2013)). Using the CCAPM, Grossman and Shiller (1981) were the first to show that the premium is much higher and more volatile over time than most plausible risk aversion parameters would suggest. The phenomenon was also noted by Shiller (1982) and Modigliani and Cohn (1979) but the literature truly emerged with the ground-breaking paper by Mehra and Prescott (1985).

Mehra and Prescott highlighted the difficulty that traditional models have in matching the observed excess return of stocks relative to a risk-free asset (with the degree of risk aversion viewed as realistic from a microeconomic perspective for a typical investor). The literature on the (excessive) equity risk premium in discount rates is large but inconclusive. The equity premium was subsequently refined by Epstein and Zin (1989) and Weil (1989), who developed models allowing preferences for risk and intertemporal substitution to be separated. Others explored the puzzle further, showing that one needs to distinguish between the intertemporal rate of substitution and the rate of risk aversion when trying to interpret the premium (see further Kocherlakota (1996), Mehra and Prescott (2003) and Rieger and Wang (2012)).

Higher asset price volatility can also arise if investors' risk aversion depends on macroeconomic volatility, as is the case, for example, in asset pricing models with habit formation (Campbell and Cochrane (1999)). Barro (2006) and Gabaix (2011) show that a standard model extended to allow for realistically calibrated rare-disaster probabilities can generate a high volatility of asset returns, high equity premia and low risk-free rates, which are all close to what is observed in practice.<sup>21</sup>

Apart from the overreaction of asset prices to swings in cash flows, the presence of various anomalies and other indications of “mispricing” also constitute a source of puzzles (see Schwert (2003) for a review). A number of possible answers to these puzzles have been proposed. For example, in some models, the rational expectations assumption that investors optimally use current information to forecast future dividend growth is relaxed. Instead, various market failures and forms of behavioural biases are introduced, such as investors' herding behaviour and sentiment (Barberis et al (1998)). Thaler (2005, 2015) presents a survey of the related behavioural finance literature (see also Shleifer (2000), Barberis and Thaler (2003), Barberis et al (2001) and Barberis (2013)).

Indications that investors tend to overestimate the persistence of variations in dividend growth – or, equivalently, to underprice risk – have motivated many studies (Barsky and De Long (1993)). Numerous reasons related to the functioning of markets – including limited market liquidity, “excessive” financial innovation, the perverse trading behaviour of large investors and the role of hedge funds – have also been mentioned as causes of the excessive volatility of asset prices (Bikhchandani and Sharma (2000)). Although this strand of research provides analytical models and some empirical evidence showing that asset prices are not simply determined by the present discounted value of future cash flows, it has not been able to identify definitive reasons driving the deviations from the basic models (Duffie (2010) reviews other examples of deviations).

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<sup>21</sup> For additional information, see also Campbell et al (2013), Chen et al (2012), Ju and Miao (2012), Albuquerque et al (2016) and Krueger et al (2016))

## Limits to the linkages between asset prices and activity

A number of empirical studies report that firm investment reacts less to asset prices than what standard models predict. Research casts some doubt about the role of asset prices, in general, and Tobin's  $q$ , in particular, in explaining investment. Blanchard et al (1993), for example, find a limited role for market valuation in explaining investment given fundamentals and current profits (see also Stein (2003) and Butzen et al (2003)). Other research finds that factors other than  $q$  or growth opportunities also drive investment (even though these may also be correlated with  $q$ ).<sup>22</sup> Some studies suggest that, consistent with the presence of financial frictions, an important channel operates through the quantity rather than the cost (as reflected in  $q$ ) of external financing.

The impact of asset price volatility on investment and other macroeconomic aggregates has been a fertile area of research. In theory, uncertainty associated with volatility has ambiguous effects on investment. On one hand, as Abel (1983) argues, uncertainty can increase the value of a marginal unit of capital and lead to more investment. On the other, as Dixit and Pindyck (1994) suggest, volatility may create incentives to delay investment, as more information about future payoffs becomes available over time, particularly given that investment may be irreversible (Bernanke (1983)). Households' response to high uncertainty can be similar to that of firms; they reduce their consumption of durable goods as they wait for uncertainty to abate. On the supply side, firms' hiring plans are also negatively affected by higher uncertainty because of the cost of adjusting personnel (Bentolila and Bertola (1990)).

Some recent empirical studies report that the macroeconomic uncertainty associated with volatile asset prices tends to lead to a decline in output. Evidence based on VAR models points to a significant negative impact of uncertainty shocks on output, investment and employment (Bloom (2009, 2014), Hirata et al (2012), Nakamura et al (2017) and Kose et al (2017b)). For example, a 1% increase in uncertainty is associated with a slightly larger than 1% decline in output in the first year (Figure 2). Using disaster data as instruments, Baker and Bloom (2013) offer evidence that causality runs from uncertainty to recessions and Bloom et al (2012) also report that (low) growth does not cause uncertainty. Predictions of theoretical models and findings from empirical studies collectively indicate that uncertainty, including that relating to asset prices, can play a dual role over the business cycle: it can be an impulse and a propagation mechanism (Gilchrist et al (2014) and Kose and Terrones (2012)).

Studies of household behaviour also suggest many deviations from the predictions of the standard models of consumption smoothing over the life cycle. Although the empirical linkages between financial wealth and household consumption are less contested, numerous puzzles remain. For example, household consumption depends as much on disposable income as on lifetime wealth. This is in large part due to financial "imperfections": households have limited ability to borrow against future labour income, leading to liquidity constraints. Zeldes (1989) presents a test of the permanent income hypothesis against the alternative hypothesis that consumers optimise subject to borrowing constraints. He finds supportive evidence from household data that an inability to borrow against future labour income affects the

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<sup>22</sup> For evidence and reviews, see Fazzari et al (1988), Hubbard (1998) and Davis (2010b). Another channel is between productivity and  $q$  (Gomes (2001) and Abel and Eberly (2011)). Cuthbertson and Gasparro (1995) show that the average  $q$  alone is not a sufficient statistic but that output, capital gearing and the average  $q$  jointly provide an adequate model for capturing aggregate manufacturing investment behaviour in the United Kingdom (see also Bolton et al (2013)).

consumption of a significant portion of the population (for reviews of this literature, see Carroll (2001), Meghir (2004) and Jappelli and Pistaferri (2010)).

Many studies also report that household consumption reacts more strongly to changes in asset prices, especially house prices, than consumption-smoothing models predict. This finding suggests that asset prices affect borrowing capacity, in large part because real estate can be used as collateral, with the relationship again arising from financial frictions. The value of housing does not represent net wealth for the aggregate household sector because an increase in house value is also an increase in the implicit rental cost of housing (see Buiter (2010)). Similar to other asset prices, the effects of changes in house prices on overall economic activity must therefore either be due to distributional factors (eg households with different MPCs are affected diversely by changes in house prices) or arise because of imperfections (such as limits to collateralised borrowing that affect in turn current consumption) or due to various types of bounded rationality, behavioral and informational issues.<sup>23</sup>

The links between asset prices and investment also vary across countries. The relationship between changes in equity prices and investment tends to be stronger in the United States than in France and Germany while changes in property prices appear to have a closer relationship to investment in continental Europe and Japan (IMF (2002)). Barrell and Davis (2007b) show that equity price declines have an impact on US output that is three times larger than on euro area output. This is consistent with a stronger role for equity finance for firms in the United States than in other, more bank-based financial systems. It is also consistent with the presence of financial frictions that vary by country and institutional environment.<sup>24</sup>

The reaction of investment and consumption to changes in asset prices also appears to depend in part on legal regimes and traditions. Empirical analysis by Claessens et al (2014b) suggests that the responses of investment to changes in  $q$  are faster in countries with better corporate governance and information systems. They interpret this as evidence of fewer financial frictions in such countries. The effects of house price changes on household consumption can also depend on a country's financial system and institutional environment in ways that suggest the presence of certain financial frictions.

### Limits to the predictive power of asset prices

There are limits to the predictive value of asset prices. Such limits appear to vary by type of asset and financial system. The standard theory implies that asset prices should be good proxies for expected growth (at both microeconomic and macroeconomic levels) because they are forward-looking. Equity prices, however, with their low signal-to-noise ratio and their (excess) volatility, do not have a good record of forecasting general economic developments. While equity prices have some predictive ability for investment, they do not generally increase the out-of-sample forecasting ability of GDP when compared with other economic variables (see Aylward and Glen (2000)). This observation is succinctly described by the well-known

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<sup>23</sup> For reviews of these issues, see Davis and Van Nieuwerburgh (2015), Iacoviello (2004) and Piazzesi and Schneider (2016).

<sup>24</sup> Barrell and Davis (2005) analyse 13 European Union countries and the United States, and find a stronger association between equity prices and output in market-based than in bank-based financial systems. Using data for 16 OECD countries, Ludwig and Slok (2004) show that the long-run responsiveness of consumption to permanent changes in stock prices is higher for market-based than for bank-based systems.

saying that: “*The equity market has forecasted nine of the past five recessions.*”<sup>25</sup> Indeed, the leading indicator property of asset prices appears to be limited to certain classes of asset and depends on the depth of markets. In their review, Stock and Watson (2003) conclude that: “*Some asset prices have been useful predictors of inflation and/or output growth in some countries in some periods.*” (page 822).<sup>26</sup>

The nature and direction of causality is also unclear. Some interpret the linkages between asset prices and future economic activity as evidence that financial markets correctly anticipate future earnings growth and other fundamentals while others argue that asset prices affect output because of some form of amplification mechanism, such as the “financial accelerator”. In the first view, asset prices relate to current consumption and investment decisions because they are leading indicators of changes in activity. This suggests, however, no causal relationship and only an informational link between current prices and future output. In the other view, changes in asset prices have an impact on access to finance, partly because of frictions, and thereby influence current consumption and investment and thus help predict GDP growth (see Estrella and Mishkin (1998), Stock and Watson (2003) and Diebold et al (2006)).

Both effects are likely to be at play but their relative importance is hard to disentangle. The discussion above shows that linkages between asset price changes and output growth are complex and that the exact direction and source of causality can be difficult to identify. Some studies document a long-run and two-way causal linkage between stock market performance and consumption, in which stock prices act, on the one hand, as leading indicators of consumption, and, on the other hand, are explained by consumption and real economic activity. More generally, though, the direction and source of causality between changes in asset prices and activity are not entirely clear.

### 3. International dimensions of asset prices

Any discussion of the linkages between asset prices and macroeconomic outcomes has to take into account the international dimensions of these linkages given the highly integrated nature of the real economy and financial markets. Like their closed economy counterparts, many of the international asset pricing models are based on partial equilibrium constructions that often imply relatively weak linkages between real and financial variables. Moreover, a number of puzzles remain with respect to the predictions that could be derived regarding the international dimensions of asset prices. This section first presents a short review of the theoretical approaches to asset price determination in open economy models. It then briefly

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<sup>25</sup> One caveat is that most studies have only considered aggregate stock price indices. There is evidence (Di Mauro et al (2011)) that considering information about the return and volatility of individual equity prices, in addition to aggregate financial market information, can lead to significant improvements in the forecasting of business cycle developments in major economic areas (eurozone, Japan, the United Kingdom and the United States) at various horizons.

<sup>26</sup> One reason why equity prices, or asset prices more generally, could be weak predictors is that they are themselves influenced by shocks that do not have a clear impact on real activity and by shocks that do. If the only shock were a persistent total factor productivity shock, for example, then current equity prices and future economic activity could be tightly linked. However, there are many other types of shock and some affect real activity but not asset prices while some operate *vice versa*. This means that simply observing asset prices is not sufficient to predict real activity. This does not necessarily represent a failure of the underlying model. It could also stem from an incomplete specification of the environment when conducting reduced-form data analysis.

examines the empirical evidence and concludes with a summary of the main challenges faced by international asset pricing models.

## A. Determination of asset prices in open economy models

Both domestic and international factors affect asset prices in open economy models. Early models (Solnik (1974), Stulz (1981) and Adler and Dumas (1983)) extended the domestic asset pricing models (mostly the CAPM) to an international context. These models suggest that the determination of (relative) asset prices is based on a trade-off between exchange rate risk and the diversification benefits of global investment, in addition to the domestic factors discussed earlier. Accordingly, the required rate of return is derived from global benchmarks, such as the correlations of domestic asset returns with those of world market portfolios.

As is the case with many closed economy models, international asset pricing models tend to be based on partial equilibrium frameworks (see Dumas (1994) for an early review). Typically, cash flow processes are assumed to be predetermined and little attention is devoted to whether changes in the domestic supply of securities and asset prices are consistent with actual cross-border portfolio holdings. Uppal (1993) and Engel (1994) are early exceptions: they develop general equilibrium models that take into account holdings of international assets and liabilities in the determination of asset prices. Engel and Matsumoto (2009) revive this class of models while Devereux and Sutherland (2009) extend them to dynamic settings with incomplete asset markets. However, these general equilibrium models continue to face difficulty in matching some of the basic statistical moments, such as variance and persistence of asset prices, including exchange rates (see Coeurdacier and Rey (2013) for a review).

A strand of the literature has focused on the implications of various barriers to cross-border investment and of home bias, ie the tendency of investors to invest close to their base. Although many models in this literature are simple extensions of the standard closed economy setup – and assume perfectly integrated financial markets – some have devoted greater attention to the effects of market segmentation, eg when some financial markets are only accessible to resident investors or when no outward investment is allowed. These and other types of (indirect) barrier, such as ownership restrictions, have been shown to alter the determination of asset prices. This in turn leads to “deviations” from the predictions of standard models since an identical asset can be priced differently in two different markets.<sup>27</sup> Another branch of this research considers how changes over time and differences across markets, including the degree of financial openness, can affect the determination of asset prices and portfolio allocation and can lead to home bias (see Karolyi and Stulz (2003) and Bekaert et al (2016) for reviews and Sa (2013) for recent evidence on bilateral financial linkages).

## B. Empirical evidence

Consistent with theoretical predictions, global factors play an increasingly important role in determining asset prices. Cross-country correlations of asset prices are well documented, especially the high and growing correlations between equity prices (Figure 3). Over the past two decades, asset price movements (and output) have been explained increasingly by common factors (Figure 4). Correlations have increased not only among advanced economies

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<sup>27</sup> For a detailed discussion of such deviations, see Black (1974), Stulz (1981), Errunza and Losq (1985) and Eun and Janakiraman (1986).



and EMEs but also between these two groups of country (Ehrmann et al (2011), Rey (2015), Passari and Rey (2015) and Miranda-Agrippino and Rey (2015)). This was to be expected. Owing to technological advances and liberalisation, financial markets have become ever more closely integrated and gross international financial flows have increased sharply. Evidence shows that increases in comovements between assets are due to both *de jure* capital account liberalisation (as stock return correlations and market betas increase after liberalisation) and actual increases in international capital flows.<sup>28</sup>

In addition to financial integration, financial development, the liquidity and depth of equity markets and real economic integration (including trade intensity) have been shown to affect the comovement of asset prices across countries. Forbes and Chinn (2004) and Beine and Candelon (2011) show that bilateral financial and trade intensity drive stock market synchronisation. Dellas and Hess (2005) show how the liquidity and depth of equity markets can determine the synchronisation of equity returns. The adoption of a single currency (Walti (2011)), lower real exchange rate volatility and asymmetry in output growth (Tavares (2009)) also increase correlations. In addition, there is an extensive literature on the importance of financial linkages for international spillovers (see Diebold and Yilmaz (2009, 2015), Hirata et al (2012) and Helbling et al (2011)).

Prices of non-traded assets, such as houses, also tend to move together across countries.<sup>29</sup> While there are limited fundamental linkages between housing markets – housing being the quintessential non-traded good – house prices move together considerably across countries and have become more synchronised over time (Figure 3). Hirata et al (2012) report that the degree of concordance of housing cycles has increased from 51% during the period between Q1 1971 and Q4 1984 to more than 63% during the period between Q1 1985 and Q3 2011. The fraction of the variance of house prices explained by a global house price factor has increased from about 20% to 35% over the two periods (Figure 4). In addition, downturns in house prices tend to be synchronised across countries and overlap more frequently than recessions do, especially so during the most recent cycle (Figure 5).

As is the case for other asset prices, the comovement of house prices is driven by real and financial global factors. Examples of global factors include the global business cycle, commodity prices and a measure of the “world” rate of interest (Hirata et al (2012)). The fact that house prices appear to be partly determined by current and past income growth (and real interest rates or some other proxy for mortgage costs) is not surprising. As the supply of land is fixed and that of residential dwellings and offices can only increase slowly, property prices tend to be largely demand-determined in the very short run. Over the business cycle, though, supply catches up with house prices, as prices and investment are driven by similar factors. And, indeed, prior to the GFC, countries that experienced housing price booms in 2000–06 also saw substantial growth in residential investment (Figure 6, upper panel). However, this trend reversed over the 2007–08 period (Figure 6, lower panel).

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<sup>28</sup> See Bekaert and Harvey (2000), Goetzmann et al (2005) and Quinn and Voth (2010). Conversely, growing financial integration has reduced the cost of capital for firms in integrating countries. Chari and Henry (2004) find that liberalisation reduces systematic risk, thereby lowering the cost of capital for individual firms. The effects are quantitatively important since the covariance of the median “investible” (ie with no barriers to ownership) firm’s stock return with the local market is 30 times larger than its covariance with the world market. At the same time, increased financial integration means that there might be smaller diversification gains for investors (Kose et al (2009) and Bekaert et al (2016)).

<sup>29</sup> See BIS (1993), Borio et al (1994), Sutton (2002), Borio and McGuire (2004), Claessens et al (2011), Cesa-Bianchi et al (2015), Harding and Pagan (2016) and Miles (2017).

In addition, the common factor that captures cross-country house price movements is related across advanced economies to mortgage-to-GDP ratios (reflecting the depth of mortgage markets) and home ownership ratios (reflecting institutional structures and policies aimed at fostering home ownership). The impact of global factors on house prices consequently varies across individual countries, depending in part on the development of local mortgage markets, income growth and structural and policy factors, such as tax and subsidies (Terrones (2004)).

In related research, Vansteenkiste and Hiebert (2011) show that spillovers from country-specific house price shocks are relatively low in the euro area. Some studies document the coincidence of global recessions with sharp downturns in global house and equity prices (Kose and Terrones (2015); Figures 7A and 7B). Collectively, these findings underscore the importance of the international dimensions of real and financial linkages in driving asset prices. That said, some puzzles remain.

### C. International dimensions of asset pricing puzzles

Similar to the domestic context, there are a number of puzzles relating to the international dimensions of asset prices. For example, cross-country correlations of equity prices tend to be higher than those implied by fundamentals. Similar to the weak link between equity prices and firms' fundamentals within a country, comovements in asset prices appear to not (just) reflect the commonality of cash flow streams as would arise from synchronised business cycles. This delinking is partially attributed to comovements in risk premia because investors in one market are likely to be exposed to other markets as well, triggering common price adjustments. Indeed, Engle and Susmel (1993) show that the high correlation of price volatility across countries is related to the degree of international financial integration.

Financial integration may also increase herding behaviour among investors, which can then lead to more volatile capital flows and cause asset prices to move significantly in one direction or the other, again amplifying correlations beyond what fundamentals-based models would suggest. Goodhart (1999) argues that a key factor for the high correlations of second moments is asymmetric and incomplete information. The high correlations observed across asset prices and the large volatility of capital flows suggest that various other channels of transmission are at play, including contagion. However, those channels require further study.<sup>30</sup>

The so-called home bias – ie the limited extent of international portfolio diversification – has been hard to reconcile with the predictions of most asset pricing models. Models that include barriers to cross-border investment, both direct, such as capital controls and ownership restrictions, and indirect, such as information asymmetries, are not very good at explaining the limited degree of actual cross-border asset holdings (they tend to underestimate home bias) and the behaviour of the rates of return (which are highly correlated). Furthermore while restrictions on international capital flows may have been a viable explanation for the home bias thirty years ago, they no longer do so today.

With barriers diminishing over time, the bias should have fallen. In fact, until the late 1990s the home bias among advanced countries changed little.<sup>31</sup> While there is some evidence

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<sup>30</sup> For research on these channels and related work, see Dornbusch et al (2000), Karolyi (2004), Pritsker (2011), Forbes (2012) and Cesa-Bianchi et al (forthcoming).

<sup>31</sup> See Lewis (1999, 2011), Karolyi and Stulz (2003) and Sercu and Vanpee (2007) for reviews of the literature on home bias. Research points to the importance of indirect barriers, such as those related

of a decline in the bias in more recent years (see Sorensen et al (2007)), international holdings still appear to be far below the levels determined by portfolio models, with correspondingly lower risk-adjusted rates of return (see also Sercu and Vanpée (2007) and Kho et al (2009) for evidence on the home bias in equity holdings).

Related to the home bias, prices of internationally-traded assets continue to depend on local risk factors. Firm-level equity prices, for example, depend significantly on domestic equity risks factors, such as value, size and market returns, even when conditioned on global equity counterparts (see Lewis (2011) for a review of global asset pricing models and the associated empirical evidence). Similarly, bond prices depend more than expected on local factors. These patterns suggest that there is still *de facto* segmentation, even though legal and other formal barriers among equity markets have largely been removed, at least for advanced countries. The predictable deviations from interest rate parity also suggest other failures of the standard international asset pricing model. Factors other than formal barriers, such as heterogeneous information and other asymmetries, may be behind these anomalies (Engel (2014)). Coeurdacier and Rey (2013) present a review of models focusing on home bias and its macroeconomic implications.

## 4. Exchange rates and macroeconomic outcomes

A rich research programme has analysed the determinants of exchange rate movements and their implications for macroeconomic outcomes. However, providing models that can satisfactorily explain the multiple linkages between macroeconomic and financial variables while accounting for the role of the exchange rate as the relative price of both domestic goods to foreign goods and domestic assets to foreign assets, has been a challenge. This section provides an overview of the literature on the linkages between exchange rates and macroeconomic outcomes. It begins by presenting a summary of the basic theoretical mechanisms regarding the determination of exchange rates and their impact on macroeconomic aggregates and financial variables. Next, it reviews empirical findings regarding the linkages between real exchange rates and activity. It concludes with a discussion of a number of puzzles regarding the dynamics of exchange rates and their relationships with macroeconomic and financial variables.<sup>32</sup>

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to differences in corporate governance, ownership structures and information asymmetries, which may lead to home bias (see Stulz (2005)). These factors, however, would also suggest a reduction in home bias as countries have tended to converge in these dimensions. Berriel and Bhattarai (2013) emphasise the importance of government spending in explaining the home bias puzzle. For discussions of international diversification, see Baxter and Jermann (1997), Coeurdacier and Guibaud (2011) and Heathcote and Perri (2013, 2014).

<sup>32</sup> The discussion here touches upon the main puzzles only. We discuss the role of financial frictions in Claessens and Kose (2017). For a discussion of abrupt movements in exchange rates associated with financial crises, see Claessens and Kose (2014).

## A. The basic mechanisms

### Determinants of exchange rates

A large body of literature seeks to understand the determinants of exchange rates.<sup>33</sup> The basic building blocks used in this literature include two parity conditions: i) purchasing power parity (PPP), which posits a relationship between exchange rates, on one hand, and local and foreign goods prices, on the other; and ii) interest rate parity (covered or uncovered), which stipulates the existence of arbitrage conditions between the exchange rate, on one side, and the interest rates on domestic and foreign assets, on the other.

To analyse exchange rate movements, early studies often employed extensions of closed economy models. For example, the Mundell-Fleming model, set forth (independently) by Mundell (1963) and Fleming (1962), is the open economy extension of the traditional IS-LM model. The model shows that an economy cannot simultaneously maintain a fixed exchange rate, free capital movement and an independent monetary policy (so called “the impossible trinity”; see Obstfeld et al (2005) for a review). Under a flexible exchange rate regime, shocks to money or goods markets can lead to capital flows through an equalisation of the local interest rate with the global rate, resulting in changes to the exchange rate and trade flows. Under a fixed exchange rate regime, the money supply adjusts to external or domestic shocks affecting the balance-of-payments. The model thus shows in a simple way the roles played by real and nominal variables in exchange rate determination.

The exchange rate can also play an important role in the transmission of monetary policy in small open economies. In early models, such as the monetary model of Frenkel and Johnson (1978), the nominal exchange rate simply reflects the relative demand for and supply of money in different countries. Changes in the quantity of domestic money then immediately affect the exchange rate. In these and other models, a lowering of the policy rate leads to a decline in the return on domestic assets relative to that on foreign assets. Consequently, the currency depreciates, leading to expenditure switching and a rise in net exports and aggregate demand.

The more recent literature, often under the rubric of “new open economy macroeconomics”, incorporates advances in the domestic macroeconomic literature to help explain the main features of exchange rate movements. This literature has employed dynamic stochastic general equilibrium (DSGE) models to analyse the role played by nominal rigidities in environments featuring imperfect competition and rational optimising agents. Much of this literature is based on the canonical model developed by Obstfeld and Rogoff (1995a, 1995b). Like earlier models, such models try to predict the dynamics of exchange rates, including the possibility of overshooting. They are also used to analyse the dynamics of the current account, (net) debt, the exchange rate and the impact of exchange rate uncertainty on international transactions (see further Obstfeld and Rogoff (2000a)).<sup>34</sup>

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<sup>33</sup> For more detailed discussions of the linkages between exchange rates and macroeconomic and financial variables, see Obstfeld and Rogoff (1996), Mark (2001) and Sarno and Taylor (2003). Engel (2014, 2016) present a discussion of the theoretical and empirical exchange rate literature, with a focus on interest rate parity and other financial arbitrage conditions.

<sup>34</sup> See Corsetti (2008) for a review of DSGE models. See also Woodford (2010b) and Christiano et al (2011a) for an open economy model incorporating financial frictions.

## Exchange rates and activity

Many models examine the linkages between fluctuations in exchange rates and macroeconomic fundamentals. When focused on the real side, such models detail how changes in exchange rates endogenously relate to consumption, investment, exports and imports, both in terms of volumes and prices. Research has also looked at how these relationships are affected by a variety of factors, including the heterogeneity of economic sectors, economies of scale, imperfect competition, type of exchange rate regime, country-specific elements and time horizons (see Lane (2001) for a review).<sup>35</sup>

In theory, some of the linkages between real exchange rates and macroeconomic outcomes are ambiguous. For example, a depreciation can lead to an increase in investment as the marginal profit from an additional unit of capital is likely to go up as future foreign sales rise. However, the higher price of imported capital and inputs can reduce profits and, in turn, lower investment. The overall impact of exchange rate changes on investment hinges then on which of these forces dominates (see Landon and Smith (2009)).

The theoretical literature on the effects of exchange rate devaluations on output is similarly inconclusive. On the one hand, devaluation can lead to an increase in the production of tradable goods and be associated with an expansion of output. On the other hand, it can have a contractionary impact on the non-tradable goods sector and translate into a decline in overall output. Related to these inconclusive findings are the financial effects of exchange rate changes, including those operating through adjustments in balance sheets, which are reviewed below. There is also an extensive theoretical literature looking at how linkages between exchange rates and output can depend on exchange rate regimes (see Uribe (1997) and Mendoza and Uribe (1996)).<sup>36</sup>

## Exchange rates and financial variables

Most of the early models sidestepped financial variables or resorted to simplifying assumptions, such as perfect financial markets. They only considered “real” environments, focusing on the role of the (real) exchange rate as the price that cleared goods markets in open economies. Although some models attempted to incorporate financial markets, this was typically under restrictive assumptions. The standard uncovered interest rate parity (UIP) condition, for example, requires at a minimum the joint presence of rational expectations and risk neutrality, which are strong assumptions already. Early models rarely considered the role of financial intermediation or market imperfections and assumed instead perfect financial markets (ie perfect substitutability between assets and no financial frictions or defaults).<sup>37</sup> While later models took into account the links existing between the exchange rate and other asset prices, this was largely through arbitrage conditions, notably with short-term interest rates linking the forward exchange rate to the current exchange rate and local and foreign interest rates.

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<sup>35</sup> See, among others, chapters in Volume 3 of the *Handbook for International Economics* (Grossman and Rogoff (eds) (1995)) and Volume 4 (Gopinath et al (eds) (2014)).

<sup>36</sup> Dornbusch (1981) provides a review of the early literature on the macroeconomic implications of devaluations and Marston (1995) presents a review of exchange rate policies in open economies.

<sup>37</sup> For example, some models (eg Stockman (1980) and Lucas (1982)) use cash in advance constraints, but this is a short cut to introduce money rather than a proper model of financial intermediation. Others (eg Branson and Henderson (1985)) use portfolio balance models to consider the trade-offs involved in the holding of various assets but do not include financial market imperfections, such as information asymmetries or principal-agent issues.

More recently, researchers have studied how the role of the exchange rate in macroeconomic adjustment is affected by financial variables during “normal” times.<sup>38</sup> In particular, models have been developed to see how real linkages are impacted by capital flows and stocks and balance sheets valuation effects. These models (Tille (2008), Benigno (2009), Coeurdacier et al (2010) and Tille and van Wincoop (2014b)) allow for the exchange rate to influence the adjustment of current and capital accounts through two financial channels: (i) capital gains and losses on external assets and liabilities due to exchange rate movements; and (ii) portfolio adjustments (trading in securities).

These models still employ rather restrictive assumptions and continue to face difficulties in explaining the behaviour of exchange rates. They often assume endowment economies, perfect foresight and exogenously-determined initial asset positions. Moreover, the types of asset considered are often limited and the possibility of investing in equity and bonds is ruled out. Notably, the current account has little role to play in intertemporal dynamics. In many models based on the framework of Obstfeld and Rogoff (1995a), the current account follows basically a random walk (as does the economy’s net foreign asset position). These models are essentially “modern versions” of the monetary model (of Frenkel and Johnson (1978), for example) in that the exchange rate is determined by relative money supplies. Although more recent general equilibrium models provide richer environments, their basic predictions do not seem to square with the empirical evidence (Corsetti and Pesenti (2001) and Cavallo and Ghironi (2002)). In particular, the forward risk premium has been hard to incorporate, except in environments allowing unrealistically high rates of substitution and risk aversion (Obstfeld (2008)).

Recent classes of general equilibrium models with valuation effects and liquidity preference appear more promising. Such models have been harder to calibrate but they obtain simulated results that are more consistent with those of empirical studies. For example, the model by Gourinchas and Rey (2007) allows for international financial adjustments to affect the exchange rate. It highlights the role that valuation effects on the US net foreign asset position might have had in relaxing the country’s external constraint.<sup>39</sup>

Others study how capital gains and losses on external portfolios can affect exchange rate and current account dynamics in general equilibrium settings (Devereux and Sutherland (2010) and Pavlova and Rigobon (2012)). Some of these models allow for international equity trading in a two-country DSGE model with production under monopolistic competition, and separate asset prices and quantities to account for capital gains and losses and portfolio adjustments (Ghironi et al (2015)). These models appear to deliver more realistic findings. Limited participation models have also had some success in explaining the behaviour of exchange rates. For example, Alvarez et al (2009) build a two-country model in which the fraction of agents that participate in financial markets varies over time due to transaction costs across assets. The exchange rate in their model is much more volatile than consumption – something difficult to achieve in models with complete markets but more consistent with real-world observations.

Some recent models examine the impact of learning on the linkages between exchange rates and fundamentals. The literature reviewed above clearly suggests that there is no

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<sup>38</sup> The behaviour of exchange rates during financial crises and their role in macroeconomic adjustment and activity is discussed in Claessens and Kose (2014).

<sup>39</sup> See Gourinchas and Rey (2014) and Coeurdacier and Rey (2013) for extensive reviews of such models. Gabaix and Maggiori (2016) present a model in which exchange rates are driven by capital flows in imperfect financial markets. For research on the effects of “ambiguity aversion” or “taste for robustness” in the determination of exchange rates, see Ilut (2012) and Djeutem (2014).

consensus on a specific model that fully captures the relationships between exchange rates and macroeconomic and financial variables (Ca’ Zorzi et al (2017) and Eichenbaum et al (2017)). A reasonable assumption consequently is that agents do not know the true model or at least do not know the true parameters linking exchange rates to economic and financial fundamentals. Therefore, they need time to learn about the structure of the economy. Bacchetta and van Wincoop (2004, 2006, 2013) and Bacchetta et al (2010) show how, if structural parameters are unknown (or imperfectly known) and time-varying, market participants can change the weight they give to certain fundamentals. Hence, their models provide a framework that allows for a disconnect between observed macroeconomic fundamentals and exchange rates in the short- to medium-run but still exhibit a close relationship in the long-run (Hassan et al (2016)).

## B. Empirical evidence

### Tests of models of exchange rate determination

Although there is broad acceptance of the basic building blocks of exchange rate models, there remains a large gap between the predictions of such models and empirical regularities. Each successive generation of models has provided new insights into the determination of exchange rates and empirical testing has much improved. But the more complete models that have emerged have met with limited empirical success (Frankel and Rose (1995)). As Meese and Rogoff (1983a, 1983b), initially, and Cheung et al (2005), later, have shown, models do not necessarily work consistently well across time and different countries.

The purchasing power parity (PPP) hypothesis provides a useful framework for thinking about the relevance of exchange rate models. PPP was initially found to have little explanatory value, especially when considering very short periods (Taylor and Taylor (2004)).<sup>40</sup> However, when considering longer time periods, the evidence relating to PPP is more favourable (Flood and Taylor (1996)). Furthermore, although there may be little response of the exchange rate to deviations from PPP when the exchange rate is close to parity, even in the short- to medium-run, there can be a rapid response when the rate is far away from it (see Sarno and Taylor (2002)). More generally, it has been found that there can be non-linear dynamics in exchange rate adjustment, with “bands of inaction” around the PPP rate and faster adjustment as the rate moves further away from the level consistent with PPP (see further Taylor et al (2001) and Taylor and Taylor (2004)).

There is also some empirical support for the monetary approach to exchange rate determination. Early studies provided evidence for the flexible-price monetary model (Frenkel (1976) and Balassa (1978)) but later studies were less supportive. Notably, Meese and Rogoff (1983b) showed that monetary models fit poorly out of sample.<sup>41</sup> In a related paper, Eichenbaum and Evans (1995) showed how, in response to a monetary shock, expected exchange rates displayed a hump-shaped pattern rather than the sharp depreciation implied by the overshooting model of Dornbusch (1976). Mark and Sul (2001), using exchange rate

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<sup>40</sup> Ghironi and Melitz (2005) also find this effect with a micro-founded model allowing for heterogeneous firms and productivity shocks.

<sup>41</sup> Meese and Rogoff (1983b) and most of the subsequent literature use the root mean square error (RMSE) as the main criterion for judging models. Since the RMSE values under- and over-predictions equally, it is not necessarily a good yardstick for examining the profitability of trading strategies because trading depends on the quality of the directional forecast (“buy or sell”). See further Elliott and Ito (1999) and Abhyankar et al (2005).

data for 17 industrialised countries to implement a panel version of the test developed by Mark (1995), found that monetary fundamentals outperform a random walk (as well as PPP fundamentals) at short and long horizons. Rapach and Wohar (2002), using long historical series for 14 advanced economies, documented some support for a simple form of the long-run monetary model. Cerra and Saxena (2010) also provided evidence supporting the monetary approach.<sup>42</sup>

Some studies confirm the Balassa-Samuelson hypothesis of a link between productivity and exchange rates, especially over the long run (Balassa (1964) and Samuelson (1964)). However, the channels that generate this effect appear to be more complex than the traditional view suggests (Chong et al (2012) and Bordo et al (2017)). In particular, while higher labour productivity tends to lead to real exchange rate appreciation, which is consistent with the traditional view that richer countries have stronger exchange rates, the productivity effect is transmitted through relative prices between tradable goods rather than through the relative prices of tradable and non-tradable goods (Lee and Tang (2007) and Ricci et al (2013)). Other evidence regarding the effect of productivity on the real exchange rate is more ambiguous. Chinn and Johnston (1999) and Fitzgerald (2003), for example, find little evidence of a long-term relationship between real exchange rates and productivity differentials (see further Froot and Rogoff (1995), Tica and Druzic (2006) and Bordo et al (2017)).

The literature also considers the roles played by many other “fundamentals” in explaining the (real) exchange rate. For example, several papers have studied the effects of fiscal spending and deficits on the real exchange rate (Bouakez and Eyquem (2015) and Alves da Silva et al (2015)). Following work by Monacelli and Perotti (2011), Ravn et al (2012) find that increases in government spending can lead to a depreciation of the real exchange rate in some advanced economies. However, this finding contradicts the predictions of many traditional models (see Kim and Roubini (2008) for a review and estimates for the United States).

## Exchange rates, prices and activity

There is a vast empirical literature on the linkages between exchange rates, prices and macroeconomic outcomes (including the current account and external adjustment), with the major caveat that many of these relationships are endogenous and simultaneous. Moreover, a number of empirical puzzles involving those linkages remain, as discussed further in the next sub-section.

***Exchange rates and prices.*** Empirical evidence supports some of the basic channels through which exchange rates affect export and import prices (Burstein and Gopinath (2014)). Understanding the quantitative importance of linkages between exchange rates and prices is an important step since these linkages are influential in shaping how fluctuations in exchange rates may subsequently affect macroeconomic aggregates. While deviations from the law of one price remain one of the most fundamental puzzles, exchange rates have been found to have a quantitatively significant impact on both import and export prices, especially in the long run. For example, in advanced countries about 64% of the change in exchange rates is estimated to be transmitted to import prices after one year (IMF (2007) and Choudhri and Hakura (2015)).

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<sup>42</sup> The hump-shaped behaviour documented by Eichenbaum and Evans (1995) has been shown by Steinsson (2008) to be consistent in the context of a two-country sticky-price business cycle model. See Engel et al (2008) for a view suggesting that exchange rate models do not perform as poorly as commonly thought.



However, the extent of pass-through (ie the impact of exchange rate movements on prices) varies over time and across countries (Forbes et al (2017)). Reflecting differences in market size and sectoral composition of imports (the lack of which in earlier estimations was part of the reason for the limited estimated impact on aggregate prices), pass-through coefficients have been found to vary greatly across sectors: they are higher for commodities and lower for highly differentiated manufacturing products (Amiti et al (2014) and Chen and Juvenal (2016)). They also vary across countries. An important determinant of pass-through is the currency of invoice, which is often the US dollar. The United States has a low pass-through of 0.4, for example, while smaller, more open economies have coefficients estimated to be closer to one (Gopinath (2015) and Casas et al (2017)).<sup>43</sup>

***Exchange rates and macroeconomic aggregates.*** Exchange rates, real and nominal, are much more volatile than output (see Burstein et al (2007)). For example, the real effective exchange rate for advanced economies in the post-Bretton Woods era is on average more than two times more volatile than output (Table 2A). At the same time, the contemporaneous correlations (as well as the lead and lag relations) between real and nominal exchange rates and output are very low for advanced economies (Table 2B).

A large research programme analyses the direct linkages between movements in exchange rates and macroeconomic aggregates (Cordella and Gupta (2015)). Most studies show that currency depreciations (appreciations) are associated with a contraction (expansion) of investment (see Landon and Smith (2009), Goldberg (1993) and Campa and Goldberg (1999)). The strength of this relationship, however, varies across sectors, countries and time horizon. Some other studies consider the impact of real exchange rate volatility on investment and international trade (see Darby et al (1999), McKenzie (1999), Chowdhury (1993), Caballero and Corbo (1989) and Grier and Smallwood (2013)). Others, such as Harchaoui et al (2005), find ambiguous results of exchange rate volatility on investment, which is consistent with theoretical models. Habib et al (2017) find that a real appreciation (depreciation) is associated with significantly lower (higher) GDP growth but only for developing and currency-pegging countries.

Although standard models of international risk sharing with complete asset markets predict a positive association between relative consumption growth and real exchange rate depreciation, empirical studies investigating this relationship do not report conclusive results (Backus and Smith (1993) and Obstfeld (2007)). One strand of the literature considers the effects of exchange rate devaluations. In many cases, real depreciations are contractionary, which is not consistent with the predictions of basic models for which a positive output effect results from an increase in net exports (see Burstein et al (2005) and Kearns and Patel (2016)). Other studies, though, suggest that any contractionary impact of devaluations tends to disappear in the longer run (IMF (1999, 2005)).

***Exchange rates and the current account.*** Although the empirical linkages between exchange rates, trade volumes and current accounts are weak in the short run, they reappear in the longer run (IMF (2015)). Because of limited pass-through, low short-run elasticities

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<sup>43</sup> This difference relates to the stronger domestic competition for imported goods in the United States and the international use of the US dollar in the invoicing of exports and imports (Goldberg and Tille (2008)). Another factor here is the role of vertical specialisation. Chinn (2010) shows that, combined with changing tariff rates and transportation costs, it can account for the high-income elasticities typically found for trade. A number of studies analyse the extent of pass-through, see Campa and Goldberg (2005), Hellerstein et al (2006), Thomas and Marquez (2009), Frankel et al (2010) and IMF (2006). Campa and Goldberg (2005) also document that import prices in local currencies reflect 60% of exchange rate fluctuations in the short run, with this fraction increasing to 80% in the long run.

and the presence of imported intermediate goods, the expenditure-switching effect of exchange rate changes on trade volumes is muted in the short run (Engel (2010)). Fratzscher et al (2010) show that shocks to the real exchange rate explain less than 7% of the movements in the US trade balance.

However, the impact of exchange rate changes on the current account materialises over time. Many studies (eg McKinnon (1990)) test the empirical relevance of the well-known J-curve effect, which describes how the current account worsens immediately after a depreciation and improves only with a time lag. While studies often report mixed findings on short-run effects (see Bahmani-Oskooee and Ratha (2004) for a review), the terms of trade and the flows of exports and imports seem to relate to the real exchange rate in expected ways in the longer run, although with a different quantitative impact across countries (Hooper and Marquez (1995)).

Exchange rates can play a supportive role in reversing current account imbalances, albeit with a lag. Many studies argue, for example, that the large US current account deficit of the 2000s could not be reduced without a significant depreciation of the real exchange rate (Blanchard et al (2005), Obstfeld and Rogoff (2000b, 2007) and Blanchard and Milesi-Ferretti (2012)). The role of the exchange rate in facilitating external adjustment is reported for a wide range of countries (Calvo (2005), IMF (2007), Gervais et al (2016) and Martin (2016)).<sup>44</sup>

## Exchange rates and financial variables

As noted earlier, the exchange rate has been identified as one of the transmission channels through which monetary policy affects the real economy. The potency of this channel depends on three main factors. First, of course, the exchange rate regime matters in this relationship.<sup>45</sup> Second, the sensitivity of the exchange rate to the interest rate appears to vary across models. Early models found the sensitivity to be small, even though theoretical models that imposed UIP suggested a large role for this channel (Boivin et al (2011)). More recent models, however, explicitly acknowledge the tenuous and complex empirical links between monetary policy and the exchange rate (see Walsh (2010) and Engel (2017) for reviews; and see also Bruno and Shin (2015)).

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<sup>44</sup> The quantitative importance of exchange rates in reducing (global) imbalances has been a hotly debated issue (Blanchard and Milesi-Ferretti (2012) and Claessens et al (2010)). Exchange rates are strongly related to capital flows and external financing during financial crises (Claessens and Kose (2014)). Fluctuations in exchange rates can also have a strong impact on the allocation of resources in small open economies, especially during crises (Calvo (2005)).

<sup>45</sup> Countries vary greatly in the exchange rate regime they pursue. Moreover, regimes can also change over time with their choice mattering for macroeconomic developments, including for growth and inflation. Aizenman et al (2011) find that, controlling for other factors, greater monetary independence – as captured by greater exchange rate flexibility – is associated with lower output volatility while exchange rate stability implies more output volatility. Ghosh et al (2010) show that pegged exchange rate regimes tend to provide a useful nominal anchor and deliver lower inflation without compromising growth. Floating rate regimes, however, are associated with a lower susceptibility to financial crises and faster and smoother external adjustment than other regimes. Chinn and Wei (2013) question whether a flexible regime facilitates current account adjustment. Similarly, Engel (2010) concludes that exchange rate adjustment may have only a modest effect on current account imbalances in the short run. Klein and Shambaugh (2010) also analyse exchange rate regimes and Rose (2011) surveys the literature on the incidence, causes and consequences of a country's choice of exchange rate regime (see also Gagnon (2011)).

Third, as one would expect, this channel is more pronounced for small open economies. Devereux et al (2006) illustrate that the effectiveness of this channel depends on the degree of exchange rate pass-through. Indeed, for small open EMEs, especially those targeting inflation, the exchange rate appears in practice to play an important role in monetary policy frameworks, much more so than is the case for advanced economies (Mishkin (2008)). This appears to reflect, among others, concerns about second-round effects, notably of exchange rate depreciations on inflation expectations.

Research supports the expected links between exchange rates and interest rates but with some caveats. Until the GFC, covered interest rate parity (CIP) was the norm in normal times as few arbitrage opportunities emerged. Akram et al (2008), for example, showed that deviations dissipated in a matter of minutes. However, the GFC was a notable exception. Heightened counterparty risk (and other risks) led to significant deviations from CIP (see Baba et al (2008), Baba and Packer (2009), Coffey et al (2009) and Griffoli and Ranaldo (2010)). Since then, deviations have declined but not disappeared.<sup>46</sup>

Evidence also suggests that, while there can be substantial deviations from UIP in the short-to-medium term (leading to “carry-trade”, as discussed below), local interest rates are affected by global rates in the longer run, especially for countries with fixed or pegged exchange rates (see Engel (1986) for an earlier survey).<sup>47</sup> Chinn and Meredith (2004) show that the UIP hypothesis obtains empirical support when interest rates on longer-maturity bonds of G7 countries are used, which is consistent with models where “fundamentals” drive exchange rates over longer periods. Chinn (2006), using data for major advanced economies and EMEs, shows that the evidence against UIP in the current floating rate era is not as strong as is commonly thought (see also Ismailov and Rossi (2017)).<sup>48</sup> Based on a new measure of sovereign credit risk, “the local currency credit spread”, defined as the spread of local currency bonds over a synthetic local currency risk-free rate based on cross-currency swaps, Du and Schreger (2016) find that local currency credit spreads are positive and sizeable. However, they are lower than credit spreads on foreign currency-denominated debt as well as less correlated across countries and less sensitive to global risk factors.

Fluctuations in equity and other asset prices have also been found to relate to exchange rates. Individual firms are affected by exposures to exchange rates in expected ways, with inter alia firm size, multinational status, foreign sales, international assets and competitiveness found to matter (see Dominguez and Tesar (2006)). Moreover, the direction of exposure depends on the evolution of the exchange rate vis-à-vis other countries as firms dynamically adjust their operational behaviour in response to exchange rate risk. With the usual caveats about endogeneity and causality, aggregate and individual stock prices in

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<sup>46</sup> See, among others, Borio et al (2016), Sushko et al (2016), Avdjiev et al (2017), Du et al (2017), Rime et al (2017) and papers presented at the conference “CIP – RIP?” and Levich (2017) for a review of the general literature on CIP deviations.

<sup>47</sup> Flood and Rose (2002) found that UIP worked better on average in the 1990s than in previous eras as the slope coefficient from a regression of exchange rate changes on interest rate differentials was positive. Moreover, UIP worked systematically better for fixed and flexible exchange rate countries, less so for countries experiencing financial crises. And there was no statistically significant difference between rich and poor countries.

<sup>48</sup> In general, the relationship between interest rates and exchange rates can be complex. For example, Hnatkovska et al (2013) argue that higher interest rates have three distinct effects: raise the fiscal burden, reduce output (due to a higher cost of capital) and raise the demand for domestic currency assets. The first two effects act to depreciate the currency while the last one tends to appreciate it. The net effect depends on the relative strength of these opposing forces.

advanced economies as well as in many EMEs have also been found to be affected by exchange rates in ways that were expected (Phylaktis and Ravazzolo (2005), Jorion (1990, 1991) and Cenedese et al (2016)).

### C. Exchange rate puzzles

There are a number of puzzles associated with the behaviour of exchange rates. Indeed, some of the six puzzles of international macroeconomics identified by Obstfeld and Rogoff (2000c) are intimately related to exchange rates: McCallum's home bias in trade puzzle; the Feldstein-Horioka saving-investment puzzle; the French-Poterba equity home bias puzzle; the Backus-Kehoe-Kydland consumption correlation puzzle; the PPP puzzle; and what they call the exchange rate disconnect puzzle.<sup>49</sup>

The key puzzle is the disconnect between exchange rate movements and macroeconomic aggregates. This is reflected in the limited success of models relating exchange rates to underlying short-run fundamentals. As highlighted by Obstfeld and Rogoff (2000c), this disconnect can be considered as an umbrella of puzzles that all refer to *“the remarkably weak short-term feedback links between the exchange rate and the rest of the economy.”*

Some of these “disconnect puzzles” are closely related. By explicitly introducing costs in international trade (including transport costs, tariffs, non-tariff barriers and other trade costs), Obstfeld and Rogoff (2000c) argue that they can explain several puzzles, including the PPP puzzle and the exchange rate disconnect puzzle. Some of the puzzles also relate to the widespread use of linear models in empirical exchange rate economics, which leaves no room for transaction costs.<sup>50</sup> Engel (2011) points out how another set of puzzles comes into play: any successful model of the exchange rate must simultaneously explain why high interest rate currencies tend to earn excess returns (the forward premium puzzle) and why high real interest rate currencies tend to be stronger than what their fundamental values would imply (the discounted rationally expected future real interest differentials). The joint observation of these puzzles means, in turn, that if there is an exchange risk premium, it should tend to shrink as real interest rates rise.

### Exchange rates and fundamentals

Many exchange rate puzzles mimic those reported in the literature on other asset prices in that the ability of models to explain and predict exchange rates using fundamentals remains limited. First, exchange rates can be modelled as the present value of expected fundamentals (Frenkel (1981)). Relative to fundamentals, however, exchange rates appear to exhibit much higher volatility. This is similar to the excess volatility of stock prices relative to underlying dividend streams (Shiller (1981)), raising the puzzle of “excess volatility” (see Baxter and Stockman (1989) and Flood and Rose (1995)).<sup>51</sup> Second, macroeconomic and financial news

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<sup>49</sup> The latter includes both the Meese-Rogoff exchange rate forecasting puzzle and the Baxter-Stockman neutrality of exchange rate regime puzzle. See Engel and Zhu (2017) and Eaton et al (2016) for recent reviews and empirical work on the major puzzles.

<sup>50</sup> The incorporation of transaction costs creates an intrinsically non-linear relationship. This means that in the presence of such costs, the estimation of linear models is inappropriate. A true empirical test of the validity of the hypothesis must be based on non-linear models.

<sup>51</sup> See Killeen et al (2006), Hau (1998) and Jeanne and Rose (2002) for discussions on the sources of excess volatility in exchange rates.

appear to affect exchange rates “too much”, which is also similar to how bond and other asset prices overreact to news.<sup>52</sup>

Importantly, the forward exchange rate is not an unbiased predictor of the future exchange rate. Much work has rejected the speculative efficiency hypothesis (which posits that the forward rate is the expected spot rate without a risk premium). Rejection can be due to a departure from rationality and/or to risk premia (Froot and Frankel (1989)). Empirically, the recent literature is converging towards the view that the forward bias and the resulting profitability of carry trades are driven by a foreign exchange risk premium that is non-zero on average and varies over time according to global factors (Menkhoff et al (2012), Lustig et al (2011) and Burnside et al (2011b) review the literature on carry trade). This is akin to the presence of an equity premium that appears to be excessively high for most asset pricing models (see Fama (1984), Mehra and Prescott (1985) and the review by Mehra and Prescott (2003)).

One of the enduring puzzles involves the difficulty of forecasting exchange rates out of sample. Meese and Rogoff (1983b) were the first to show that asset market-based models do not outperform a simple random walk in predicting exchange rates. Although there is some evidence that models perform better than a random walk at longer horizons (Mark (1995)), in part due to the changing weight of fundamentals, the success of such models remains limited for predictive purposes (Sarno and Valente (2009)).<sup>53</sup> Cheung et al (2017) assess the success of exchange rate predictions using a wide variety of models (interest rate parity, productivity-based, a composite specification, PPP and the sticky-price monetary model) and find that a model that works well in one period may not necessarily work well in another, or for all countries or all horizons.<sup>54</sup> This suggests that, while each model has merits, none is able to capture completely the determinants of exchange rates.<sup>55</sup>

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<sup>52</sup> For recent studies on excess sensitivity to news, see Jaimovich and Rebelo (2008), Bacchetta and van Wincoop (2006) and Ehrmann and Fratzscher (2005). For early evidence, see Goodhart (1999) and Goodhart and Figliuoli (1991). For an examination of the impact of news in explaining the relationship between exchange rates and consumption using general equilibrium models, see Lambrias (2016), Opazo (2006) and Nam and Wang (2010).

<sup>53</sup> Three exchange rate models often used in practice are: i) the macroeconomic balance approach, which builds on Obstfeld and Rogoff (1996) and focuses on flows (ie current account equilibrium) over the medium term; ii) the equilibrium real exchange rate (ERER) approach, which looks for consistency of the real effective exchange rate (REER) with trend fundamentals (including the stock of net foreign assets (NFAs)) over the medium term (see Rogoff (1996) for a survey); iii) and the external sustainability approach, which checks for stock-flow consistency and budget constraint (see Lee et al (2008) for the application of these types of model and their forecasting power).

<sup>54</sup> Sarno and Valente (2009) report that: (i) the weak out-of-sample predictive ability of exchange rate models is caused by a poor performance of model selection criteria rather than a lack of information content of the fundamentals; and that (ii) the difficulty of selecting the best predictive model is largely due to frequent shifts in the set of fundamentals driving exchange rates, including swings in market expectations (see also Della Corte et al (2016a) and Menkhoff et al (2017)).

<sup>55</sup> Rossi (2013) provides a comprehensive review of the literature on the predictability of exchange rates and concludes that: *“Overall, our analysis of the literature and the data suggests that the answer to the question: “Are exchange rates predictable?” is, “It depends” on the choice of predictor, forecast horizon, sample period, model, and forecast evaluation method. Predictability is most apparent when one or more of the following hold: the predictors are Taylor rule or net foreign assets, the model is linear, and a small number of parameters are estimated. The toughest benchmark is the random walk without drift.”*

Some studies show, though, that exchange rates and fundamentals are connected in a way that is broadly consistent with asset pricing models. As Frankel and Meese (1987) noted early on, empirical tests of the “excess volatility” of exchange rates are hard to implement. In a world with sticky prices (Dornbusch (1976)), for example, the exchange rate can be volatile because of overshooting but this does not necessarily imply excess volatility relative to what the fundamental determinants of exchange rates would predict. Engel and West (2005) show that if fundamentals are integrated of “factor one” and the factor for discounting future fundamentals is near one, then the exchange rate exhibits a behaviour that approximates a random walk. Sarno and Sojli (2009) empirically confirm the assumption of near unity of the discount factor. The results by Engel and West (2005) thus help explain the exchange rate disconnect puzzle since they imply that fundamental variables (such as relative money supplies, output, inflation and interest rates) offer little help in explaining changes in exchange rates.

Conversely, exchange rate movements can help predict changes in fundamentals. Standard present-value models suggest that exchange rates are driven by expected fundamentals. Sarno and Schmeling (2014) test the implication that exchange rates contain information about future fundamentals. Employing a variety of tests in a sample of 35 currency pairs ranging from 1900 to 2009, they find that exchange rates have strong and significant predictive power for nominal fundamentals (inflation, money balances and nominal GDP). They also find that the predictability of real fundamentals and risk premia is much weaker and largely confined to the post-Bretton Woods era.<sup>56</sup>

## Exchange rates and financial factors

Some studies have had partial success in incorporating financial variables into exchange rate models. Since financial conditions play a significant role in affecting expectations, they have been found to be helpful in predicting exchange rates, even though the underlying mechanisms are not entirely clear. For instance, recent research reports that out-of-sample exchange rate forecasting can be improved by incorporating monetary policy reaction functions (Taylor rules) into standard models.<sup>57</sup>

Combining monetary fundamentals and policy reaction functions with yield curve factors reflecting expectations and risk premia further helps to explain exchange rate movements and excess currency returns one month to two years ahead, outperforming the random walk (Chen and Tsang (2013)). Conversely, as Engel and West (2005) show, exchange rates are useful in forecasting future monetary policy, consistent with the idea that they reflect market expectations of policy. These findings suggest that excess currency returns reflect both real (business cycle) and financial factors.

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<sup>56</sup> A related study is Chen et al (2010) who show that the exchange rates of commodity-exporting countries can help predict commodity prices but conversely that commodity prices do not help predict exchange rates (Ferraro et al (2015)). They attribute this asymmetry to the forward-looking nature of exchange rates. Hassan (2013) shows that a large fraction of currency returns is explained by differences in the size of economies.

<sup>57</sup> For example, Molodtsova et al (2008) and Molodtsova and Papell (2009) find that incorporating Taylor rule variables improves short-term predictability more than conventional interest rate, purchasing power parity or monetary models. See also Benigno (2004), Engel and West (2006), Mark (2009), Corsetti et al (2011) and Engel et al (2010) for models and empirical evidence relating to monetary policy rules that can, among others, generate some of the observed persistence in real exchange rates.

The literature has also established linkages between movements in exchange rates and order flows in foreign exchange markets. In the very short run, order flow – the volume of buy and sell requests and the related willingness of dealers to trade at certain prices – affects exchange rate behaviour over periods varying from minutes to a couple of months (see Lyons (1995, 2001) and Sarno and Taylor (2002) for reviews). This link seems to reflect in part the micro market structure of trading as well as the information gleaned by traders from the positions of other market participants. It also appears to be related to the information contained by order flows about the underlying macroeconomic factors and parameters of exchange rate processes.

In particular, traders respond to economic news in deciding what currencies to buy and sell, and that order flow is a powerful predictor of future exchange rates (Breedon et al (2016) and Menkhoff et al (2016)). Rime et al (2010) argue that taken together the two results imply that economic variables are indeed linked to exchange rates but that the link is likely to be partly indirect in the sense that it is established via the trading decisions of dealers rather than via the macroeconomic channel posited by standard rational expectations models. On a related note, Evans (2010) presents evidence that order flow information reaching dealers provides signals concerning the slowly evolving state of the macroeconomy (see also Evans (2011) for a review of this and the associated literature).

Another possible channel is that the order flow provides information about the (true or perceived) parameters of the exchange rate process – information, which, in turn, affects exchange rate behaviour. Consistent with this hypothesis, Chinn and Moore (2011) show that combining a standard monetary model with order flow information can improve out-of-sample exchange rate forecasting. Furthermore, Fratzscher et al (2015) find that a large fraction of the variation and directional change in exchange rates can be explained by a combination of order flow and survey data on the relative importance attributed by traders to various fundamental factors. This supports the “scapegoat” theory of exchange rates (Bacchetta and van Wincoop (2004), Bacchetta et al (2010) and Tille and van Wincoop (2014a)).

Exchange rate behaviour could also be linked to the level of financial development and to global saving-investment dynamics. Caballero et al (2008) argue that the lack of well-developed financial systems leads developing economies to run persistent current account surpluses with countries that can generate “sound” or liquid financial assets (such as the United States). In addition, they show that shifts in growth rates, in the presence of home bias in consumption and portfolio holdings, can lead to changes in exchange rates. In their model, the exchange rate moves in response to financial shocks rather than to the current account balance. Using this model, they explain how the GFC exacerbated the shortage of liquid assets and induced a rush to dollar assets (see also Della Corte et al (2016b)).

There is also evidence suggesting that the safe haven function of some currencies allows them to enjoy a privileged cost of capital and liquidity. The United States, for example, appears to pay less on its external liabilities than it earns on comparable external assets, correcting for exchange rate movements (Gourinchas et al (2010)). The relatively sharp appreciation of the US dollar following the GFC appears to be related to this role.<sup>58</sup> Curcuru et al (2013), however, find that the hypothesis of an exorbitant privilege – insofar as portfolio claims are concerned – suffers from a number of weaknesses, including measurement problems and statistical insignificance, and can largely be explained by differences in the relative

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<sup>58</sup> Gourinchas and Rey (2014) review the literature on the so-called “exorbitant privilege” enjoyed by the United States (see also Gorton (2017) for a review of the general literature on safe assets and Cohen et al (2017) for a review of the literature on global liquidity). McCauley and McGuire (2009) for their part focus on bank behaviour in the context of the US dollar’s appreciation after the GFC.

composition of asset holdings between US residents and non-residents (see Rogoff and Tashiro (2015) for a discussion of the safe haven privilege in the context of Japan).

Another phenomenon that needs more work is how a shortage of dollar liquidity in Europe and other markets seems to have created upward pressure on the dollar during the GFC (Engel and West (2010)). Why the safe haven and liquidity roles of a currency arise and why they do not apply equally to various major currencies (eg the euro) is still unclear. One possible reason is that lender of last resort facilities have traditionally been limited to local commercial banks and have not been available to foreign banks in other markets. Since lending in dollars is large outside the United States, including in EMEs with extensive liability dollarisation, in times of stress there is a large demand for US dollars (Obstfeld (2004), Engel and West (2010) and Rajan and Tokatlidis (2005)).

Many studies find evidence of the importance of balance sheet variables and related valuation effects (Gourinchas and Rey (2014) review the literature). Balance sheet and valuation effects appear to be important in driving exchange rates and, in turn, real variables (as first formally documented by Gourinchas and Rey (2007), followed by Lane and Milesi-Ferretti (2009)). Gourinchas and Rey (2007) find that the effects of exchange rate changes on financial variables have contributed to about 30% of US external adjustment since the 1950s. This is not to deny that exchange rates affect real variables, net exports in the case of their work, thereby aiding adjustment; rather, this financial adjustment channel results in a high degree of predictability of the exchange rate over a two- to four-year horizon.<sup>59</sup>

The results of the model developed by Gourinchas and Rey have been examined in various studies. Using aggregate data, Alquist and Chinn (2008) compare the relative predictive power of the sticky-price monetary model, UIP and the Gourinchas and Rey model and find some support for the latter model but only at short horizons for bilateral exchange rates. Moreover, they find that no model outperforms a random walk. The Gourinchas and Rey model also predicts that cyclical external imbalances in the United States are linked to future movements in the dollar. Della Corte et al (2012) test this prediction and find a negative correlation between nominal exchange rate returns and lagged measures of bilateral external imbalances. Specifically, using exchange rates, data on valuation effects and the ratio of net exports to net foreign assets, they show that a model using cyclical external imbalances provides substantial economic value to a risk-averse investor when compared to a random walk.

The carry trade puzzle illustrates that the literature is still struggling to integrate a number of financial factors. One can clearly exploit interest differentials in the short run, as exchange rates do not satisfy UIP. The carry trade, however, appears to be a more persistent phenomenon – even though risk-adjusted UIP should preclude this over the longer term.<sup>60</sup> Carry trade is likely to be behind some of the increase in cross-border holdings of assets although this is hard to confirm given data limitations (see Galati et al (2007)). Since the

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<sup>59</sup> Despite its empirical importance, the source of this financial adjustment channel effect remains unclear. Gourinchas and Rey (2007) argue that the effect is consistent with a home bias in asset holdings.

<sup>60</sup> For evidence, see Jordà and Taylor (2012) and Brunnermeier et al (2009). Clarida et al (2009) show that the forward rate bias disappears during periods of high volatility. Burnside et al (2011a) show that rare disasters (or “peso” problems) can be significant in explaining returns on carry trades. Hassan and Mano (2014) show that carry trade has little to do with the forward premium puzzle: carry trade exploits persistent differences in interest rate differentials across currencies while the premium puzzle seems to be driven by the interest rate movements of all currencies against the dollar.



profitability of carry trade is the flip side of the forward premium bias coin, any explanation must be consistent with risk premium patterns (Engel (2011) and Cenedese et al (2014)).<sup>61</sup>

One such possible risk premium is a reward for assuming global foreign exchange volatility risk. Indeed, Menkhoff et al (2012) show that a global premium can explain more than 90% of cross-sectional excess returns on five carry trade currencies with high interest rates. While liquidity risk also matters, volatility risk appears to be more important.<sup>62</sup> They document that there is a clear connection between global foreign exchange volatility “innovations” and portfolio returns on carry trades. They also report that when volatility innovations are high, carry trades perform poorly, implying that low interest rate currencies perform better than high interest rate currencies.

## 5. Interest rates and macroeconomic outcomes

This section surveys the interactions between interest rates and economic activity. It begins with a summary of the basic mechanisms that relate changes in interest rates to fluctuations in output in standard models. Next, it reviews the empirical evidence supporting these mechanisms. It concludes with a brief discussion of arguments challenging the mechanisms.

### A. Basic mechanisms

The main channel of monetary policy transmission is the so-called interest rate channel. Conceptually, by adjusting the policy rate, such as the fed funds rate in the United States, the central bank affects the nominal short-term rate at which banks and financial intermediaries borrow.<sup>63</sup> A change in nominal interest rates alters the real interest rate given some degree of price stickiness, ie the price level does not adjust fully in the short run.

When the short-term interest rate changes because of monetary policy decisions, long-term interest rates can also be affected. Long-term interest rates are directly linked to short-term rates by expectations and arbitrage relationships, at least in the standard models. However, the degree to which a central bank can affect long-term rates depends, among others, on the monetary policy regime, the credibility of the central bank, the structure of

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<sup>61</sup> One “fundamentals-based” explanation could be the presence of disaster risk. Farhi et al (2009) show that, for a large set of advanced economies over the 1996–2008 period, disaster risk premia accounted for about 25% of excess returns on carry trades (see also Farhi and Gabaix (2016)).

<sup>62</sup> Adrian et al (2015) provide evidence that the funding liquidity aggregates of US financial intermediaries forecast dollar exchange rate returns – at weekly, monthly and quarterly horizons – both in-sample and out-of-sample and against a large set of currencies. They attribute the association to time-varying risk premia.

<sup>63</sup> See Mishkin (1995), Smets (1995), Borio (1997) and Boivin et al (2011) for reviews of monetary policy transmission channels. Our presentation is a highly stylised summary of how the direct interest rate channel of monetary policy operates. In reality, in the case of the United States, the fed funds rate, which is the interest rate prevailing in the overnight interbank market, is not controlled by the Federal Reserve, ie it is not a set rate. Instead, the Federal Reserve sets a target for that rate and tries to ensure that the actual rate remains close to the target by buying and selling securities in the open market. Similar mechanisms operate in other countries. For a detailed review, see Woodford (2003).

financial markets and various external factors (Walsh (2010), Duffee (2013) and Vavra (2014)).<sup>64</sup>

The real interest rate affects the user cost of capital and thereby economic activity. Standard neoclassical models of investment, such as Tobin's  $q$  model (reviewed above), imply that the user cost of capital is one of the factors that determine the demand for investment and durable goods, including housing and consumer durables. In response to changes in the real cost of capital, corporations adjust their decisions with respect to production and investment. A decline in interest rates, for example, leads to a rise in investment as the user cost of capital falls relative to the return on investment. Interest rates also affect household spending on durable goods and saving and investment decisions. In turn, through these mechanisms, real activity responds to changes in interest rates.

Such mechanisms are found in a wide variety of models, including the textbook IS-LM model and the new Keynesian (NK) models. The latter group of models starts from the standard real business cycle (RBC) framework but adds monopolistic competition in the goods market and rigidities in nominal price-setting. Christiano et al (2005) and Smets and Wouters (2007) provide NK models that include features, such as a sluggish response of prices and a large and delayed response of real variables. Similar mechanisms are also at play in recent DSGE models (see Blanchard (2009), Walsh (2010) and Christiano et al (2011b) for reviews). In many of these models, however, financial intermediation is largely irrelevant because there are no financial frictions. This means, in turn, that important channels by which interest rate changes could affect the real economy are left out. While this deficiency has been widely acknowledged following the GFC (see Hall (2010), Woodford (2010a), Ohanian (2010), Caballero (2010) and Blanchard (2017b)), progress with modelling has been slow (see further Claessens and Kose (2017)).

Recent developments, notably the UMPs under which interest rates were brought at or near the zero lower bound (ZLB) in many advanced economies have raised many questions because the standard transmission channels are no longer effective. At the ZLB, a central bank loses its conventional policy instrument, the short-term rate (Woodford (2012b), IMF (2013), Borio and Zabai (2016), Farmer and Zabczyk (2016), Gourinchas and Rey (2016) and Rogoff (2017)). It can then try to target real long-term yields and inflation expectations directly through forward guidance and purchases of government bonds and other assets.

Forward guidance can convince markets that rates will remain low for longer than what is consistent with the usual policy rule.<sup>65</sup> If successful, this can impart downward pressure on expected nominal and real rates (ie flatten the yield curve) and stimulate current spending. Since forward guidance poses a time consistency problem, in order to be effective it needs to be employed by a central bank with a solid reputation. Given the extraordinary nature of these policies, however, more research is required to gain a better understanding of their effects on the real economy.<sup>66</sup>

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<sup>64</sup> This discussion, as most text-books do, ignores the possibility of default on domestic public debt, which is not uncommon (see Reinhart and Rogoff (2011) and Claessens and Kose (2014)).

<sup>65</sup> See Eggertsson and Woodford (2003), Gertler and Karadi (2011), Del Negro et al (2017) and McKay et al (2016).

<sup>66</sup> Pre-announced thresholds for the timing and pace of the interest rate “lift-off” from the ZLB and purchases of long-term assets are thought to help enhancing the credibility of this policy. Other solutions have been proposed involving policy rules, such as price-level or nominal GDP-level targeting that allow for temporarily higher inflation. Woodford (2012a) reviews this literature with a focus on the implications for the conduct of US monetary policy (see also Gust et al (2017)).

## B. Empirical evidence

Short- and long-term interest rates, both nominal and real, display considerable variation in advanced economies (Table 3A). While, as expected, nominal long-term rates have been less volatile than short-term rates, real long-term rates have been as volatile as short-term rates, at least in advanced economies. That said, the volatility of interest rates has declined since the mid-1980s. Consistent with the expectation hypothesis, evidence indicates that monetary policy shocks affect, albeit not necessarily at all times, the whole yield curve (eg Estrella and Hardouvelis (1991) and Evans and Marshall (2007) for the United States and Estrella and Mishkin (1997) for a panel of European economies).<sup>67</sup>

Many studies provide evidence that is consistent with the theoretical mechanisms described above. Early work found large effects of short-term interest rate movements on output through changes in consumption and investment (see Taylor (1995) for a summary). Romer and Romer (1994) document that changes in the fed funds rate are negatively correlated with US output fluctuations. Christiano et al (1999) provide evidence suggesting that, following an unexpected change in the interest rate, prices respond sluggishly, leading to movements in the real rate and hence activity. Uhlig (2005), on the other hand, shows with a less restrictive identification strategy that, although prices still move sluggishly, one cannot reject neutrality (ie real variables do not display a significant response).

Other evidence also supports the relevance of the interest rate channel. For example, results for the euro area suggest that the interest rate channel completely (or substantially) characterises the direct transmission of monetary policy in most countries (BIS (1995) and Angeloni et al (2003)). The traditional channel of monetary transmission is also embedded in most “policy” models. Indeed, a number of large-scale macroeconometric models used by central banks and other policy institutions exhibit a negative interest rate elasticity of investment.<sup>68</sup> Coenen et al (2012) present a review of seven structural models commonly used by policymaking institutions.

The interest rate channel operates with lags and can have asymmetric effects on output. Nominal short-term rates tend to have a higher correlation with output than other interest rates (Table 3B). Consistent with policy operating with a lag, nominal rates lead the business cycle, that is, rates rise (decline) slightly before output growth goes down (up) (see Cooley and Hansen (1995), Stock and Watson (1999) and Aruoba (2011)). Albeit reflecting various mechanisms (not only the direct interest rate channel), a typical finding for the United States is that a 1 percentage point decrease in the federal funds rate is associated with an increase in quarterly output growth over the following two years of about 0.5 percentage points. There are asymmetries, however: a 1 percentage point increase in the federal funds rate, for example, is associated with a reduction in quarterly output growth over the following two years of about 1.2 percentage points, more than double the effect of a similar decrease (see Angeloni et al (2003) and Boivin et al (2011)).

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<sup>67</sup> Deviations from the simple arbitrage-free model and other conundrums exist. For example, the period of low long-term US interest rates between 2004 and 2006 could not easily be explained by existing term structure models (with residuals amounting to some 40–50 basis points) and was attributed at the time by some to a “global savings glut” and globalisation more generally (see Rudebusch (2010)). Since the GFC, there have been many studies on the drivers of the natural interest rate (eg Laubach and Williams (2016) and Holston et al (2016)).

<sup>68</sup> For reviews of the various DSGE models employed by central banks, see Smets and Wouters (2003) for the euro area; Edge et al (2008) and Chung et al (2010) for the United States; and Dorich et al (2013) for Canada).

Empirical studies also report high cross-country correlations of nominal interest rates and significant correlations of real interest rates. These correlations have risen over the past 25 years (Figures 8 and 9), due in part to greater financial market integration but also to the adoption of more similar monetary policies (see King (2012) who reviews the experience with inflation targeting). Henriksen et al (2013), in a model that replicates the high degree of comovement of interest rates, argue that, in response to cross-border spillovers of technology shocks, central banks' reactions can lead to highly correlated interest rate movements (see further Rey (2016) regarding the international comovements of interest rates and the global transmission of US monetary policy shocks).

The spread between long- and short-term interest rates appears to help predict the timing of recessions.<sup>69</sup> Estrella and Mishkin (1998) document that term structure models based on the three-month and ten-year US Treasury rates provide a reasonable combination of accuracy and robustness in predicting US recessions. A number of studies have since documented that the slope of the yield curve or the term spread – the difference between the long- and the short-term rate – has significant power in predicting economic slowdowns (Estrella and Trubin (2006), Rudebusch and Williams (2009) and Croushore and Marsten (2016)).<sup>70</sup> Indeed, Figures 10A and 10B show how the difference between the 10-year Treasury bond yield and the three-month Treasury-bill rate can be useful in predicting recessions in the United States. The slope also helps predict changes in certain components of real economic activity, including consumption and investment (see Estrella and Hardouvelis (1991) and Ang et al (2006)).<sup>71</sup>

Evidence on the effects of UMP measures is somewhat limited. A rigorous assessment of the effects of asset purchases and forward guidance on aggregate demand is difficult, in part because it requires establishing a counterfactual scenario and elucidating an unstable transmission channel.<sup>72</sup> With this caveat in mind, the literature generally finds that central bank statements affect not only current interest rates but also their future path. Campbell et al (2012), for example, performing event studies over narrow time windows, find that 90% of the variation in the expected federal funds rate four quarters-ahead can be attributed to factors related to surprises in the timing of changes to the policy target. It also appears that

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<sup>69</sup> If the market expects economic activity in the longer term to be stronger than what it is today, then the short-term real interest rate should be higher in the future relative to today because the central bank would be expected to increase its target rate to avoid an increase in inflation. An expected increase in the short-term rate would, in turn, increase the long rate today through a no-arbitrage relation. This would lead to a higher slope of the yield curve today. By contrast, a negative slope of the yield curve would signal expectations of a recession (see also Smets and Tsatsaronis (1997)).

<sup>70</sup> Analysing different spreads, Bernanke (1990) shows that the spread between US commercial paper and Treasury bill rates is the best predictor. Also for the United States, Boulier and Stekler (2000) show that the spread between the 10-year Treasury bond yield and the 90-day Treasury bill rate is positively associated with real growth rates. For the euro area, Moneta (2005) finds the spread between the ten-year government bond yield and the three-month interbank rate to be the best in predicting recessions. The slope of the yield curve has a greater predictive power than an index of leading indicators, real short-term interest rates, lagged growth in economic activity and lagged rates of inflation (see Wheelock and Wohar (2009) and Duffee (2013) for recent reviews). Gilchrist and Zakrajsek (2012) document the predictive ability of credit spreads for economic activity in the United States.

<sup>71</sup> Mehl (2009) reviews the literature on the predictive ability of the yield curve in EMEs and shows that, depending on the extent of market liquidity, it has informational value for future inflation and growth.

<sup>72</sup> See IMF (2013), Krishnamurthy and Vissing-Jorgensen (2013), Baumeister and Benati (2013), Gust et al (2017) and Arteta et al (2015, 2016) for reviews.

there are temporary effects of UMPs on output and inflation. Evidence also suggests that asset purchases can significantly reduce long-term yields, especially during times of financial market turmoil (see also Krishnamurthy and Vissing-Jorgensen (2012) and Hancock and Passmore (2011)).

### **C. Challenges to the standard models**

While much research supports the basic transmission channels, evidence suggesting that other factors play a role is accumulating. First, the quantitative importance of the direct interest rate channel has been questioned. While results are not necessarily inconsistent with other evidence that the direct channel exists, they do suggest the need to consider firm, household and financial system heterogeneity and variations over time in the transmission of policy. Second, there is intense debate about the causal factors underlying the predictive value of interest rates and the slope of the yield curve for economic activity. These findings suggest collectively that other elements, possibly associated with financial frictions, could be quite significant for transmission.

#### **Strength of the interest rate channel**

A number of studies reveal that the direct impact of interest rate changes on economic activity tends to be weak. Hall (1988) and Yogo (2004) find the effects of interest rates on aggregate consumption not to be significantly different from zero (Elmendorf (1996) and Islamaj and Kose (2016)). Other studies using micro data also fail to find strong evidence of a direct interest rate impact on investment (Chirinko (1993)). This result appears to be related to heterogeneity among firms. Since corporations engage in both saving and borrowing decisions, the effects of interest rate changes depend on the structure of balance sheets, including the maturity of assets and liabilities (Riddick and Whited (2009)). This could explain in part why the empirical macroeconomic literature finds a weaker effect for the direct interest rate channel.

Other studies find that the impact of interest rates varies according to individual household characteristics. Some studies find a weak effect for (financially) constrained households and a stronger impact for non-constrained ones. Vissing-Jørgensen (2002), for example, reports the elasticity of intertemporal substitution to be close to zero for agents that do not hold stocks and bonds but about 0.3–0.4 for stockholders and around 0.8–1.0 for bondholders. Changes in interest rates would therefore rarely matter for agents that do not participate in asset markets (Wong (2016)).

The potency of the direct interest rate channel also depends on the state of the economy and the financial sector. In a weak economy, or one with an undercapitalised financial system, interest rate changes tend to have a smaller impact on activity. In particular, in recessions and periods of financial stress, pass-through from the policy rate to the cost of borrowing gets smaller as more firms and households are excluded from credit markets. Moreover, even when they do not face borrowing constraints, corporations and households could well be more constrained during recessions for many other reasons and could change their investment and consumption decisions for other reasons than interest rate changes (see Borio and Hofmann (2017) for the non-linearity of interest rate effects).

The direct interest rate channel can depend especially on the capitalisation of banks. When banks try to restore profitability in the face of recession-impaired balance sheets, a change in the policy rate may only be passed through partially to lending rates. This would act to limit the lending response to a lower policy rate in the short run (see Woodford (2003),

Eggertsson and Woodford (2004) and Bernanke et al (2004)). Conversely, low interest rates can lead to more risk-taking when bank balance sheets are stronger. De Nicolò et al (2010) show theoretically that when the policy rate is low, high-charter value (well capitalised) banks may increase risk-taking and low-charter value (poorly capitalised) banks may do the opposite (see further Dell’Ariccia and Marquez (2013) for a discussion of the theoretical literature on the links between interest rates, bank capitalisation and risk-taking).

Suggestive of market imperfections and financial frictions, many studies document that the indirect effects of interest rates on activity can be quite large. Those studies, notably Bernanke and Gertler (1995), argue that additional factors related to financial imperfections can amplify and propagate the quantitative effect of the conventional direct interest rate transmission channel. Using aggregate time series data for the United States, Bernanke and Gertler (1995) show that because of frictions in financial intermediation, the transmission of monetary policy largely operates through the financial system and depends on the balance sheets of firms and households.

The quantitative importance of different mechanisms also depends on country-specific financial and institutional environments. In bank-based financial systems, where retail deposits typically play an important role in funding and a large share of investment is financed by banks, the direct interest channel can be expected to be more influential in transmitting the effects of interest rates (see Allen and Gale (2000)). Indeed, while the overall quantitative impact of changes in interest rates in the euro area is comparable to that reported for the United States, there is a larger direct effect on investment (relative to consumption) in the euro area. Angeloni et al (2003), for example, find that the interest rate channel characterises monetary policy transmission in some euro area countries.<sup>73</sup> By contrast, in the United States, complementary channels through which interest rates affect consumption and investment are more important (see Boivin et al 2011)).

### **Limits to the predictive power of the yield curve**

Some interpret the predictive power of the slope of the yield curve for economic activity as evidence of other channels. While many argue that the slope reflects expectations about the monetary policy stance, and its relationship to economic activity, others question the analytical foundations of this channel (Stock and Watson (2003)). Some give more credence to the view that the slope of the yield curve affects intertemporal consumption choices that lead to sales or purchases of assets in anticipation of changes in income (Campbell (1986)).

Others point out that the direction of influence can be from activity to the yield curve. In a dynamic model with rational expectations, Estrella (2005) shows that the term spread contains information about expectations of future activity and is affected by current monetary policy, which is, in turn, influenced by current activity. Using a state-space model that comprises yield curve and macroeconomic factors, Diebold et al (2006) document that the two sets of factor interact in both directions: macroeconomic variables affect the yield curve (perhaps through the central bank’s reaction function) and the yield curve influences macroeconomic variables.

Furthermore, in the finance literature, movements in the term structure are thought to reflect changes in (inflation) risk premia rather than (just) real activity. Advanced term structure models, which employ data on interest rates at different maturities, explain the

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<sup>73</sup> For the eurozone, see Kok Sørensen and Werner (2006) and van Leuvensteijn et al (2011). See also Mojon (2000) for an analysis of differences in financial structures across euro area countries and their implications for the interest rate channel.

predictive power by allowing for time-varying risk premia. For example, changes in the term structure largely reflect changes in risk premia in the canonical affine no-arbitrage term structure models augmented with macroeconomic variables. This is related in part to shifts in the perception of inflation risk, with risk premia guiding, albeit imperfectly, macroeconomic and financial developments (Gürkaynak and Wright (2012)).<sup>74</sup>

Some studies report that risk premia are affected by macroeconomic factors. Using a dynamic term structure model, Joslin et al (2014) find that macroeconomic variables have significant predictive power over and above the level, slope and curvature of the yield curve. Specifically, they report that macroeconomic risks that cannot be hedged by financial variables (so called “unspanned risks”) explain a substantial portion of the variation of the forward term premium, with unspanned real economic growth being the key driving factor.<sup>75</sup> Baele et al (2010) show that macroeconomic factors are important in explaining bond return volatility. This research suggests that macroeconomic factors affect not only the level of short-term interest rates but also the term structure and other moments of the yield curve.

There are also limits to the predictive ability of the yield curve, which depend on the time horizon, country-specific circumstances and external factors. In particular, predictive ability is largely relevant for up to one year in advance, especially in forecasting the timing of recessions. The predictive value also varies across time periods (Bordo and Haubrich (2004)), with its power possibly having declined over time (Stock and Watson (2003)). In related research, Mody and Taylor (2003) find evidence of predictive power in the 1970s and 1980s in the United States, possibly due to high and volatile inflation but not in the 1990s and 1960s. Chinn and Kucko (2015) report that predictive power has deteriorated in the United States and in some European countries in recent years. Bonser-Neal and Morley (1997) find that the yield spread explains 30% to 50% of future real economic activity in Canada, Germany and the US, and less than 10% in Switzerland and Japan.

Predictive power also seems to depend on global financial market conditions. The close relationship between the risk premium in swap markets and real activity, for example, breaks down around the year 2000 and during the 2006–07 period (Joslin et al (2014)). Since these were periods of elevated financial stress, it suggests that predictive ability results from developments in the financial system rather than from the direct effects of changes in interest rates on activity (see also Adrian (2017) for a review).

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<sup>74</sup> For empirical evidence, see Diebold et al (2005, 2006) and Rudebusch and Wu (2008). Affine models are a special class of arbitrage-free term structure models, in which bond yields are affine (constant plus-linear) functions of some (vector of) state variables (see further Rudebusch (2010)). Campbell et al (2014, 2017), Christiansen and Rinaldo (2007), David and Veronesi (2013), Guidolin and Timmermann (2007) and Viceira (2011) further examine the drivers of bond returns. For additional reviews of the literature on the linkages between the nominal and real term structures of interest rates and macroeconomic outcomes, see Dai and Singleton (2003), Gürkaynak and Wright (2012), Duffee (2013) and Adrian (2017).

<sup>75</sup> In addition to the models that add macroeconomic variables to the canonical arbitrage-free term structure model, Rudebusch (2010) identifies two additional strands: those that examine the financial implications of bond pricing in DSGE models and those that use the Arbitrage-Free Nelson-Siegel (AFNS) model. The first strand augments the standard RBC model with habit or recursive preferences (Epstein and Zin (1989) and Hansen and Sargent (2008)) but has difficulty in replicating the size and volatility of bond premia. Furthermore, the financial sector in these models remains very rudimentary in terms of frictions and intermediation. The second class, AFNS-models, lacks theoretical foundations but can be easily estimated and often exhibits a superior forecasting record. These models are extensively used by policy institutions.

## 6. Conclusions

The GFC of 2007–09 revived an old debate in the economics profession about the importance of macro-financial linkages. Some argue that the crisis was a painful reminder of our limited knowledge of such linkages. Others claim that the profession has already made substantial progress in understanding them but that there is too much emphasis on certain approaches and modelling choices.<sup>76</sup>

At the centre of the macro-financial nexus lies the relationship between asset prices and macroeconomic outcomes. A long-held view among some academics, market participants and policymakers is that asset prices are set in an efficient manner by market forces, which helps guide the allocation of resources among competing projects. However, the apparent disconnect between asset prices, fundamentals, market volatility and other phenomena, on the one hand, and the predictions of standard models, on the other, has led many to question the “efficient markets” framework, especially after the GFC. A broad review of “*what we know*” and “*what we do not know*” about the linkages between asset prices and macroeconomic outcomes is thus called for.

This paper provides a survey of the literature on the linkages between asset prices and macroeconomic outcomes, which is the natural starting point for an analysis of macro-financial relationships. Since the literature covers a wide array of topics, there are many caveats associated with a survey like ours. In light of these caveats, our survey focuses on a small set of specific questions. First, what are the basic theoretical linkages between asset prices and macroeconomic outcomes? Second, what is the empirical evidence supporting these linkages? Third, what are the main challenges to the theoretical and empirical findings? We analyse these questions in the context of the following asset price categories: equity prices, house prices, exchange rates and interest rates. In this section, we first summarise our answers to these three questions. We then offer pointers about promising avenues for future research.

### What are the main takeaways?

***Basic theoretical mechanisms.*** A broad lesson of the survey is that standard models provide elegant benchmarks that allow the main mechanisms between asset prices and macroeconomic variables to be analysed. Asset prices play a significant role in determining the allocation of real and financial resources. They influence consumption, saving and investment decisions

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<sup>76</sup> We presented some quotes reflecting the tenor of the debate at the beginning of the survey. Krugman (2009a) criticises the macroeconomics literature because of its failure to recognise the strong relationship between the financial sector and the real economy while Cochrane (2011a) provides a critical response to Krugman’s views. Kocherlakota (2010), Caballero (2010), Romer (2016) and Reis (2017) assess the state of research on macroeconomics, but arrive at different conclusions. Blanchard (2017a) looks at the state of macroeconomics, focusing on the need to include distortions other than nominal price rigidities, including financial frictions. For perspective, Blanchard (2000, 2009) and Mankiw (2006) provide general reviews of the state of macroeconomics before the GFC. Many others, including Bernanke (2010), Blanchard et al (2010, 2013), Woodford (2010a), Taylor (2011), Turner (2012), Borio (2014), Claessens et al (2014a), Kose and Terrones (2015) and Blanchard and Summers (2017) and several papers in the Fall 2010 issue of the *Journal of Economic Perspectives* look at how the GFC may have influenced research. These and other reviews cover a broader set of issues than macro-financial linkages and the intersection between macroeconomics and finance (see for example Gopinath (2017) who provides a review of the recent macroeconomic policy-related work in international economics). In addition, contributions have taken a broader perspective on how economic policies have been reassessed (Blanchard et al (2012, 2016) and Akerlof et al (2014)).



through wealth and substitution effects. Through the information they carry about future profitability and income growth, they also affect activity at both micro- and macroeconomic levels. Moreover, the linkages between asset prices and macroeconomic outcomes play critical roles in the cross-border spillovers of real and financial shocks.

The linkages between exchange rates and macroeconomic outcomes are also multidimensional. Many models look at how exchange rates are endogenously related to macroeconomic variables and how these relationships are affected by a variety of factors, including the heterogeneity of economic sectors, economies of scale, imperfect competition, the type of exchange rate regime, country-specific elements and time horizons. Recent theoretical models employ richer environments, including a consideration of the role of financial variables and valuation effects in developing a better understanding of the linkages between exchange rates and real and financial aggregates. However, some of the links between exchange rates and macroeconomic outcomes remain ambiguous, including with respect to the effects of devaluations on investment and output.

The short-term interest rate is a special asset price since it is the main tool of monetary policy. One of the key channels of monetary transmission, the direct interest rate channel, focuses on the impact of interest rates on economic activity. In standard models, changes in real interest rates lead to movements in the cost of capital and these, in turn, affect business and household investment and consumption decisions.

***Empirical evidence.*** Empirical studies provide evidence supporting some of the basic mechanisms linking asset prices and activity. For example, there is evidence indicating that asset prices affect corporate investment. Research also suggests that linkages arise through a wide range of channels, with their impact depending on the characteristics of financial markets and the types of asset under consideration. Moreover, consistent with the predictions of most models, asset prices tend to be correlated with current and future aggregate activity. And global factors play an increasingly important role in driving variations in asset prices.

The empirical literature documents economically meaningful long-run relationships between exchange rates and economic activity. The strength of these relationships, however, varies across sectors, countries and time horizons. While empirical studies have been inconclusive about the link between exchange rate depreciation and consumption growth, there appears to be stronger long-run links between changes in exchange rates, volume of trade and current account. A number of studies emphasize that exchange rates can play supportive roles in facilitating reversals of current account imbalances. The exchange rate can also affect aggregate activity (as a transmission mechanism of monetary policy), especially in small open economies. In addition, there is a large empirical literature analysing the interaction between exchange rates, financial variables and macroeconomic outcomes.

The role of interest rates in shaping macroeconomic outcomes has also been extensively documented. A number of empirical studies show that interest rates affect investment, consumption and overall activity. The interest rate channel of monetary policy operates with lags and can have asymmetric effects on output. Moreover, certain characteristics of the yield curve can help in explaining the behaviour of various macroeconomic aggregates and can help in predicting the timing of recessions.

***Challenges to theoretical and empirical findings.*** The links between asset prices and activity differ from the predictions of standard models in a number of ways. First, asset prices are much more volatile than fundamentals would imply and can at times deviate, or at least appear to do so, from their predicted fundamental values. The term structure of interest rates is not fully consistent with the simple expectation hypothesis. Although exchange rates can be modelled as the present value of expected fundamentals, they appear to be overly volatile,

as is the case between equity prices and their underlying dividend streams (the puzzle of “excess volatility”). Moreover, macroeconomic and financial news seem to have an exaggerated effect on asset prices: equities, bonds and currencies overreact to news about cash flows and other fundamentals.

Second, investment and consumption respond differently to asset prices from what standard models would suggest, with a larger role for “non-price factors” in driving agents’ behaviour and macroeconomic aggregates. Firm investment reacts less strongly to asset prices than predicted by models while household consumption reacts more vigorously to changes in asset prices, especially house prices, than consumption-smoothing models would suggest. In addition, the links between asset prices and macroeconomic outcomes appear to vary across countries depending on financial, institutional and legal structures. Research also questions the strength of the direct impact of interest rate changes on activity and highlights its dependence on the state of the economy and the financial sector, and institutional arrangements. Recent studies emphasize the importance of uncertainty (measured among others by the volatility of asset prices) in explaining macroeconomic outcomes.

Third, there are limits to the predictive ability of asset prices for real activity. The basic theory implies that asset prices should be good proxies for expected growth as they are forward-looking variables. Equity prices, however, with their low signal-to-noise ratio and their (excess) volatility, have a mixed record in forecasting activity. There are also limits to the predictive ability of the yield curve, which depends on the time horizon, country-specific circumstances and external factors. Although this remains a topic of intense research, recent studies suggest that movements in exchange rates help only to a limited degree in predicting changes in fundamentals.

Fourth, similar to the domestic context, there are many puzzles involving the international dimensions of asset prices. As is the case for the weak link between equity prices and firms’ fundamentals within a country, comovements in asset prices appear to not (just) reflect commonality in cash flow streams. The observed high correlations across asset prices suggest other channels of transmission, including contagion, as suggested by the high volatility of capital flows. The limited international diversification of investment, the so-called home bias, has been hard to reconcile with the predictions of most asset pricing models.

Fifth, recent research emphasises the important role played by financial imperfections in explaining the linkages between asset prices and macroeconomic outcomes. Such imperfections appear to curtail households’ ability to borrow against future labour income, leading to liquidity constraints. Similarly, asset prices affect firm behaviour, including their willingness and ability to issue new equity, in ways suggestive of financial frictions. Imperfections also appear to amplify and propagate movements in asset prices (including through changes in agents’ balance sheets). Moreover, financial factors and imperfections seem to influence the linkages between exchange rates and macroeconomic outcomes.

## **Possible avenues for future research**

Our survey suggests that the profession has made substantial progress in advancing its understanding of the linkages between asset prices and macroeconomic outcomes. For example, the standard models have been useful for studying the fundamental determinants of these linkages. There is also a wealth of empirical evidence supporting some of the channels posited by these models. However, there are still many qualitative and quantitative differences between the predictions of the models and data. In addition, empirical evidence points to a range of puzzles that require exploration. Hence, there is need for additional work to further our understanding of the linkages. We briefly discuss three promising areas for future research.

**Data issues.** There are large data gaps. The shortage (or outright lack) of data on important financial and macroeconomic variables has been a severe limitation. For example, comprehensive cross-country databases on public debt, fiscal space, and business and financial cycles are only of recent construction (see Kose et al (2017a) for a discussion of the literature on fiscal space). Although the prices of equities, bonds and other tradable assets are widely available, obtaining higher frequency and more comparable series on house prices and measures of credit remains a challenge. More granular data on the balance sheets of firms, banks and other financial intermediaries would be required to be able to explore the causal links between finance and the real economy and the systemic risks that can arise from these links.<sup>77</sup>

Data deficiencies are especially large at the international level. There is a dearth of granular information, including on the bilateral exposures of financial intermediaries, and on the cross-border activities of banks, institutional investors, hedge funds and other market participants (see further Cerutti et al (2014)). Moreover, data are often not comparable because they are compiled under different statistical frameworks. While some recent data collection efforts have been fruitful, such as under the G20 Data Gap Initiative (FSB-IMF (2016)), progress in this area has been slow. Obtaining detailed data on the world’s largest financial institutions, the so-called global systemically important financial institutions (G-SIFIs), remains a challenge.

**New generation of models.** The survey documented a number of puzzles in the context of asset prices. Some of these puzzles may simply have stemmed historically from a lack of data to properly test for the predictions of models. However, many puzzles likely reflect the inability of underlying theoretical models to account for certain features that potentially lead to macro-financial linkages. The literature has been cognizant of the various factors that could drive these puzzles (such as financial market imperfections). However, it has not always been able to relate the puzzles to specific analytical deficiencies or convincingly demonstrate the role played by particular channels. It is therefore critical to develop models that can better account for the heterogeneous behaviour of agents, financial imperfections, differences in financial and institutional structures across countries, and global linkages and spillovers (see further Blanchard (2017a)). Such models also need to take into account demand- and supply-driven linkages between asset price movements and macroeconomic aggregates. Potential research avenues that would take into account financial imperfections are discussed in detail in Claessens and Kose (2017).

It is also necessary to develop a better understanding of the roles played by quantities in driving linkages between asset prices and activity. Most models feature mechanisms that work through prices, yet quantities appear to matter as well for the behaviour and volatility of macroeconomic outcomes. For example, the interactions between house prices and lending appear to affect how house prices relate to macroeconomic outcomes. The impact of interest rates on activity also varies depending on the state of household and corporate balance sheets. In addition, exchange rates appear to depend not only on interest rate differentials but also on (changes in) balance sheets, order flows and valuation effects.

**Design of policies.** The GFC has highlighted the need for a better integration of “core” research and operational aspects of policy. Many current policy questions focus on macro-financial linkages. These include the implications of UMPs for the real economy and financial markets, including overall financial stability. A better assessment of the role played by monetary policy during a liquidity trap and the implications of UMPs on activity are of

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<sup>77</sup> See the papers collected in Brunnermeier and Krishnamurthy (2014) on the general data needs for research and policy work on macro-financial linkages.

essential interest. In addition, the role of the exchange rate as a monetary policy target (possibly in addition to the inflation rate) needs further investigation, especially for the design of policies in small open economies and EMEs. Some recent studies have attempted to advance the collective understanding of these topics but more work is warranted.

Table 1A. House prices, equity prices and output: stylised facts  
(in percent)

	Mean	Volatility	Maximum	Minimum
<b>House Prices</b>				
1971:1-2016:4	2.17	7.64	59.80	-21.77
1971:1-1984:4	1.24***	8.92***	59.80	-21.32
1985:1-2016:4	2.57	6.96	36.74	-21.77
<b>Equity Prices</b>				
1971:1-2016:4	4.96	23.73	149.64	-65.21
1971:1-1984:4	-0.07***	23.85	138.50	-63.54
1985:1-2016:4	7.16	23.34	149.64	-65.21
<b>Output</b>				
1971:1-2016:4	2.30	2.61	28.08	-9.26
1971:1-1984:4	2.60***	2.62	10.76	-4.10
1985:1-2016:4	2.24	2.61	28.08	-9.26

Note: Mean indicates the average year-over-year growth rate. Volatility is the standard deviation of the growth rate. Maximum (minimum) is the maximum (minimum) growth rate. The sample consists of 18 advanced economies. \*\*\* indicates that the results for the period Q1 1971 to Q4 1984 are statistically different from those for the period Q1 1985 to Q4 2016 at the 1% level.

Table 1B. Business cycles, asset price busts and booms

Recessions associated with Financial Disruptions	Output				
	Number of		Amplitude	Cumulative	
	Events	Duration		Loss	Slope
A. Recessions without House Price Busts	95	3.38	-1.96	-3.08	-0.60
Recessions with House Price Busts	46	4.74***	-2.76**	-7.29***	-0.62
Recessions with Severe House Price Busts	26	5.04**	-2.76**	-5.86***	-0.78
B. Recessions without Equity Price Busts	144	3.55	-2.15	-3.41	-0.57
Recessions with Equity Price Busts	76	4.21**	-3.85***	-6.85***	-0.98***
Recessions with Severe Equity Price Busts	38	4.47**	-5.17***	-9.73***	-1.27***

Recoveries associated with Financial Booms	Output			
	Number of		Amplitude	Slope
	Events	Duration		
A. Recoveries without House Price Booms	126	4.76	2.89	0.75
Recoveries with House Price Booms	14	2.29***	6.14***	1.35***
Recoveries with Strong House Price Booms	9	2.44***	6.65***	1.59**
B. Recoveries without Equity Price Booms	161	4.89	3.96	1.11
Recoveries with Equity Price Booms	55	4.69	4.36	1.13
Recoveries with Strong Equity Price Booms	30	5.18	4.46	1.21

Note: All statistics, except “Duration,” correspond to sample medians and are in percent. For “Duration,” sample means are reported. Duration for recessions is the number of quarters between peak and trough. Duration for recoveries is the number of quarters it takes to attain the previous peak level of output. The amplitude of recessions is defined as the decline in output from peak to trough. The amplitude for recoveries is the one year change in output after trough. Cumulative loss combines information about duration and amplitude to measure the overall cost of a recession and is expressed in percent. The slope of a recession is the amplitude from peak to trough divided by duration. The slope of a recovery is the amplitude from trough to the period when output reached its last peak, divided by duration. Booms correspond to the observations in the top 25% of upturns calculated by amplitude. Busts correspond to the observations in the worst 25% of downturns calculated by amplitude. Recessions, recoveries, equity prices and housing busts and booms are identified following Claessens et al (2012). The sample consists of 21 advanced economies for the period Q1 1960 to Q4 2011. \*\*\* and \*\* denote that recessions (recoveries) with asset price busts (booms) are significantly different from those without asset price busts (booms) at the 1% and 5% levels, respectively.

Table 1C. Correlations between asset prices and output  
(*correlation coefficient*)

	Lags				Leads		
	-3	-2	-1	0	1	2	3
<b>Equity Prices</b>							
1971:1-2016:4	0.44	0.49	0.47	0.37	0.22	0.07	-0.05
1971:1-1984:4	0.47	0.49	0.44	0.26**	0.05***	-0.17***	-0.32***
1985:1-2016:4	0.44	0.50	0.50	0.41	0.27	0.12	0.01
<b>House Prices</b>							
1971:1-2016:3	0.34	0.41	0.46	0.47	0.44	0.39	0.35
1971:1-1984:4	0.06***	0.17***	0.27*	0.37	0.37	0.35	0.30
1985:1-2016:3	0.39	0.45	0.48	0.47	0.44	0.39	0.35

Note: The average within-country correlation between the year-over-year growth rates of asset prices and output is presented. The sample consists of 18 advanced economies. Lags (leads) indicate that output is shifted one or more quarters forward (backward) relative to asset prices. \*\*\*, \*\* and \* indicate that the average correlations for the period Q1 1971 to Q4 1984 are statistically different from those for the period Q1 1985 to Q4 2016 (or Q3 2016) at the 1%, 5% and 10% levels, respectively.

**Table 2A. Changes in exchange rates: stylised facts**  
(in percent)

	Mean	Volatility	Maximum	Minimum
<b>Real effective exchange rate</b>				
1971:1-2016:3	0.22	6.11	47.80	-22.66
1971:1-1984:4	0.62*	6.50***	47.80	-15.39
1985:1-2016:3	0.10	5.99	39.02	-22.66
<b>Nominal effective exchange rate</b>				
1971:1-2016:3	0.30	6.42	43.50	-23.70
1971:1-1984:4	-0.32***	6.91***	31.92	-20.53
1985:1-2016:3	0.58	6.18	43.50	-23.70
<b>Output</b>				
1971:1-2016:4	2.30	2.61	28.08	-9.26
1971:1-1984:4	2.60***	2.62	10.76	-4.10
1985:1-2016:4	2.24	2.61	28.08	-9.26

Note: The mean indicates the average year-over-year growth rate. Volatility is the standard deviation of the growth rate. Maximum (minimum) is the maximum (minimum) growth rate. The sample consists of 18 advanced economies. \*\*\* and \* indicate that the results for the period Q1 1971 to Q4 1984 are statistically different from those for the period Q1 1985 to Q4 2016 (or Q3 2016) period at the 1% and 10% levels, respectively.

**Table 2B. Correlations between exchange rates and output**  
(correlation coefficient)

	Lags				Leads		
	-3	-2	-1	0	1	2	3
<b>Real effective exchange rate</b>							
1971:1-2016:3	-0.11	-0.10	-0.08	-0.04	0.01	0.05	0.08
1971:1-1984:4	-0.18	-0.21	-0.15	-0.09	-0.05	-0.03	-0.04
1985:1-2016:3	-0.10	-0.08	-0.06	-0.03	0.02	0.06	0.09
<b>Nominal effective exchange rate</b>							
1971:1-2016:3	-0.07	-0.06	-0.04	-0.01	0.02	0.04	0.06
1971:1-1984:4	-0.06	-0.05	-0.01	0.03	0.06	0.06	0.02
1985:1-2016:3	-0.07	-0.05	-0.03	0.00	0.03	0.06	0.07

Note: The average within-country correlation between the year-over-year growth rates of exchange rates and output is presented. The sample consists of 18 advanced economies. Lags (leads) indicate that output is shifted one or more quarters forward (backward) relative to exchange rates.



**Table 3A. Interest rates and output: stylised facts**  
(in percent)

	Mean	Volatility	Maximum	Minimum
<b>Nominal short-term interest rate</b>				
1971:1-2016:4	-0.18	2.13	13.86	-17.50
1971:1-1984:4	0.21***	2.84***	12.28	-11.53
1985:1-2016:4	-0.35	1.70	13.86	-17.50
<b>Nominal long-term interest rate</b>				
1971:1-2016:4	-0.10	1.33	11.59	-13.19
1971:1-1984:4	0.27***	1.51***	6.15	-6.88
1985:1-2016:4	-0.26	1.21	11.59	-13.19
<b>Real short-term interest rate</b>				
1971:1-2016:4	-0.07	2.32	14.82	-16.19
1971:1-1984:4	0.15***	3.25***	12.37	-10.04
1985:1-2016:4	-0.16	1.76	14.82	-16.19
<b>Real long-term interest rate</b>				
1971:1-2016:4	0.00	2.17	12.83	-10.65
1971:1-1984:4	0.21***	2.95***	11.76	-10.65
1985:1-2016:4	-0.09	1.72	12.83	-9.53
<b>Output</b>				
1971:1-2016:4	2.30	2.61	28.08	-9.26
1971:1-1984:4	2.60***	2.62	10.76	-4.10
1985:1-2016:4	2.24	2.61	28.08	-9.26

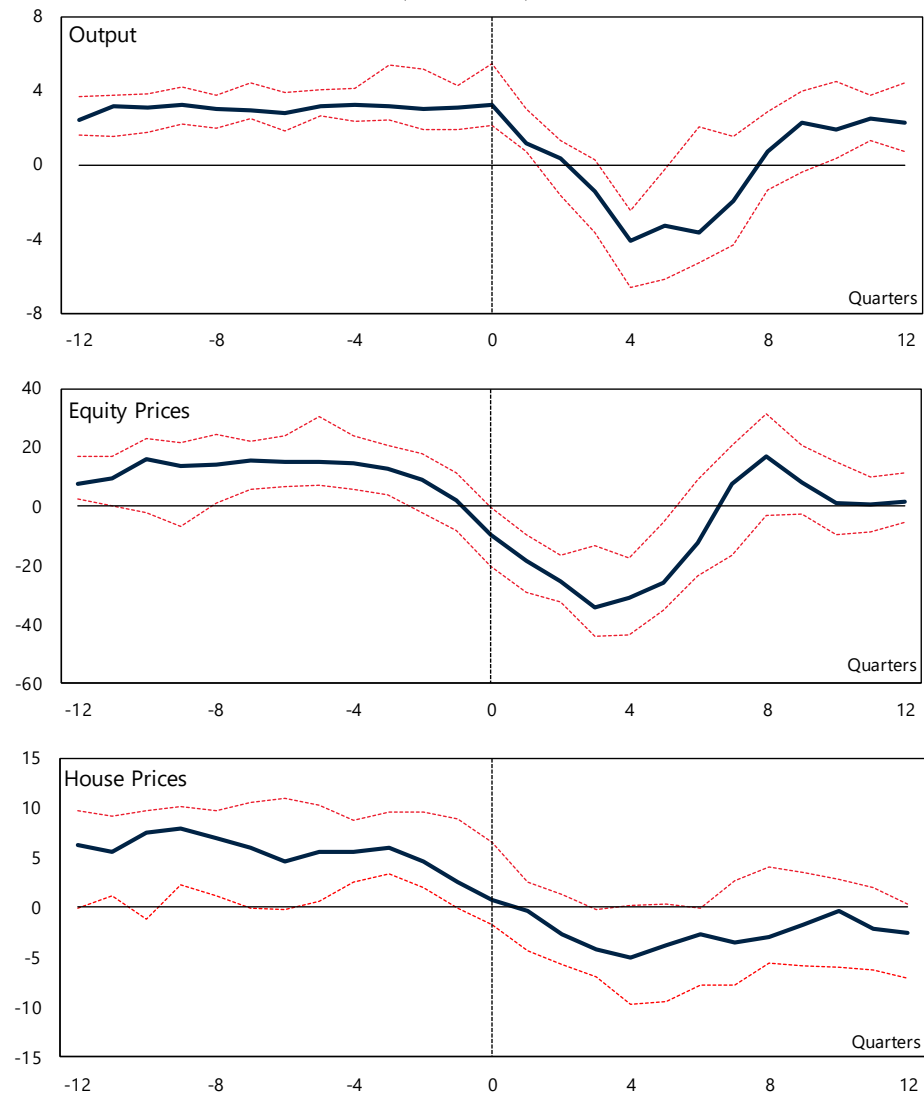
Note: Mean indicates the average year-over-year change (growth rate) in interest rates (output). Volatility is the standard deviation of the change in interest rates (growth rate of output). Maximum (minimum) is the maximum (minimum) change in each interest rate (growth rate of output). The sample consists of 18 advanced economies. \*\*\* indicates that the results for the period Q1 1971 to Q4 1984 are statistically different from those for the period Q1 1985 to Q4 2016 at the 1% level.

**Table 3B. Correlations between interest rates and output**  
(*correlation coefficient*)

	Lags			0	Leads		
	-3	-2	-1		1	2	3
Nominal short-term interest rate							
1971:1-2016:4	-0.10	0.04	0.21	0.35	0.42	0.42	0.36
1971:1-1984:4	-0.23**	-0.11***	0.08**	0.22	0.26	0.28	0.21
1985:1-2016:4	0.00	0.13	0.28	0.40	0.46	0.44	0.37
Nominal long-term interest rate							
1971:1-2016:4	-0.17	-0.06	0.06	0.17	0.21	0.20	0.15
1971:1-1984:4	-0.44***	-0.30***	-0.13***	0.09	0.25	0.29	0.24
1985:1-2016:4	-0.08	0.02	0.12	0.20	0.21	0.18	0.12
Real short-term interest rate							
1971:1-2016:4	0.05	0.08	0.11	0.12	0.09	0.06	0.01
1971:1-1984:4	0.03	0.08	0.19	0.24	0.16	0.07	-0.07
1985:1-2016:4	0.05	0.05	0.07	0.08	0.08	0.07	0.06
Real long-term interest rate							
1971:1-2016:4	0.04	0.00	-0.05	-0.12	-0.18	-0.23	-0.24
1971:1-1984:4	0.02	0.03	0.05*	0.05**	-0.02*	-0.13	-0.25
1985:1-2016:4	0.00	-0.06	-0.11	-0.17	-0.21	-0.22	-0.20

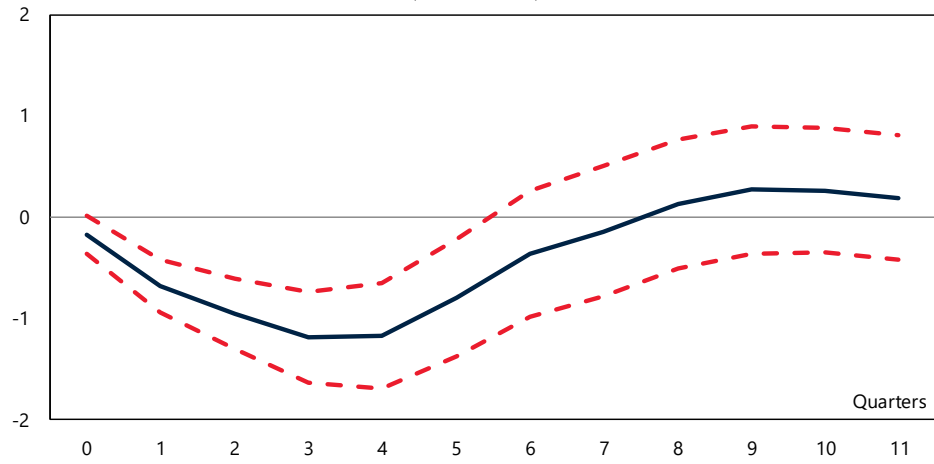
Note: The average within-country correlation between the year-over-year interest rate changes and output growth is presented. The sample consists of 18 advanced economies. Lags (leads) indicate that output is shifted one or more quarters forward (backward) relative to interest rates. \*\*\*, \*\* and \* indicate that the average correlations for the period Q1 1971 to Q4 1984 are statistically different from those for the period Q1 1985 to Q4 2016 at the 1%, 5% and 10% levels, respectively.

**Figure 1. Output and asset prices over the business cycle**  
(in percent)



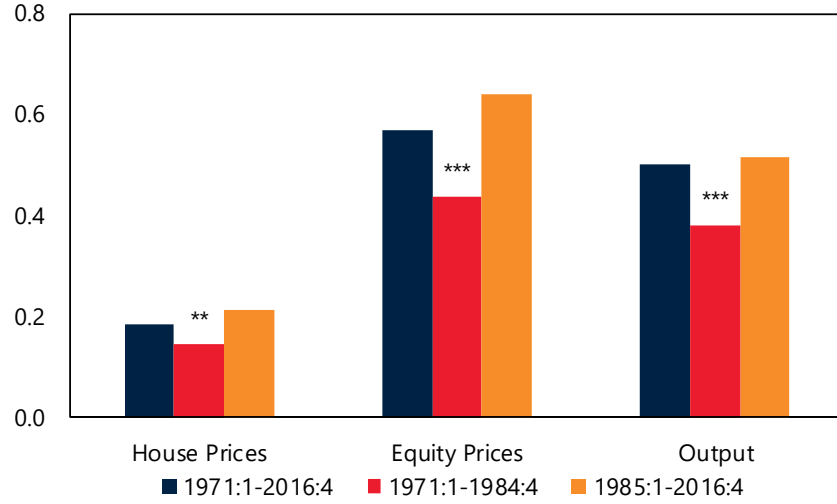
Note: In each panel, the solid line denotes the median year-over-year growth rate of the indicated variable during recessions while dotted lines correspond to the upper and lower quartiles. Zero is the quarter during which each recession begins. The data sample consists of 18 countries and covers the period Q1 1971 to Q3 2011.

**Figure 2. Impulse response of output to an uncertainty shock**  
(in percent)



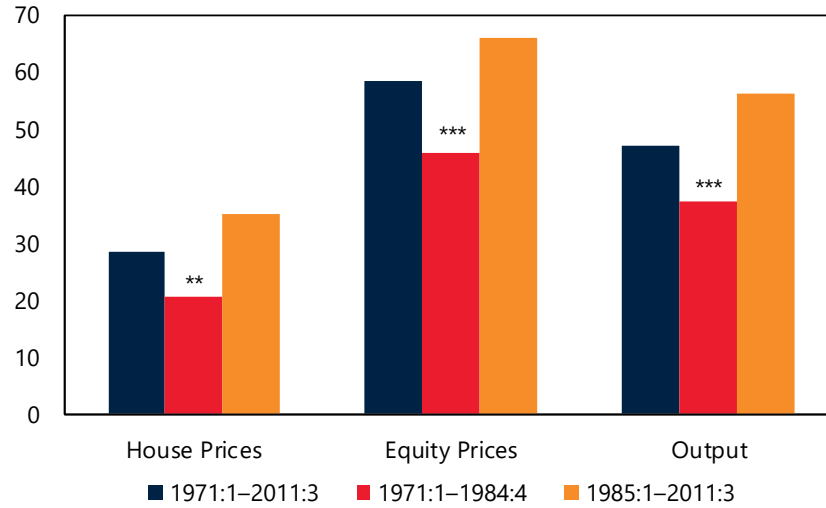
Note: The graph shows the cumulative impulse response of global output to a global uncertainty shock. The solid line represents the median estimate and the dotted lines denote the 16% and 84% error bands. This impulse response is based on a FAVAR model that includes equity prices, uncertainty, interest rates, house prices and output. Shocks are identified using a recursive identification strategy. Uncertainty is constructed using the volatility of daily equity prices for G7 countries. The data sample consists of 18 countries and covers the period Q1 1971 to Q3 2011.

**Figure 3. Cross-country correlations: asset prices and output**  
(correlation coefficient)



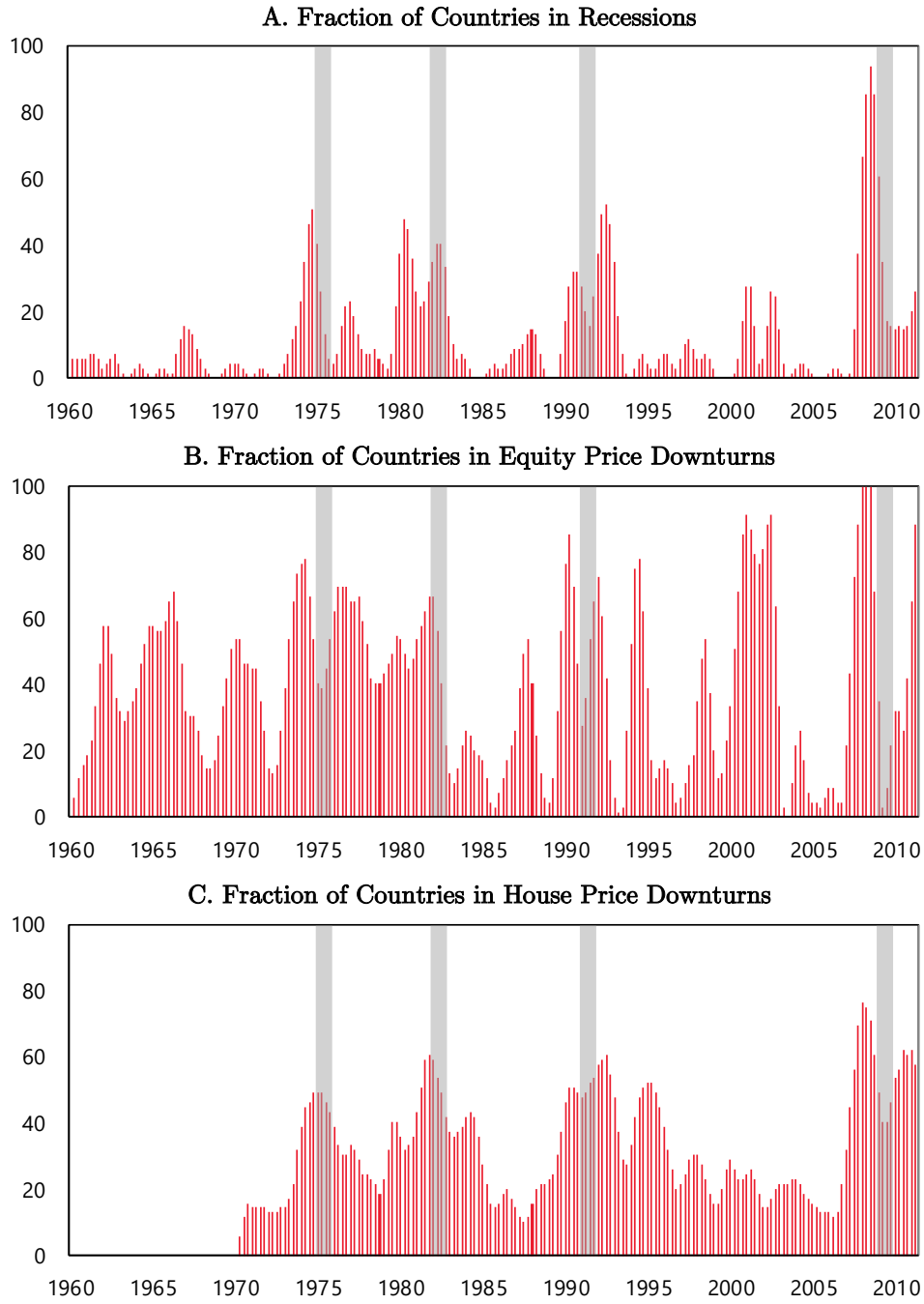
Note: The average cross-country correlation for each variable in the respective periods is presented. The sample consists of 18 advanced economies. \*\*\* and \*\* indicate that average correlations for the period Q1 1971 to Q4 1984 are statistically different from those for the period Q1 1985 to Q4 2016 at the 1% and 5% levels, respectively.

**Figure 4. Variance due to the global factor: asset prices and output**  
(in percent)



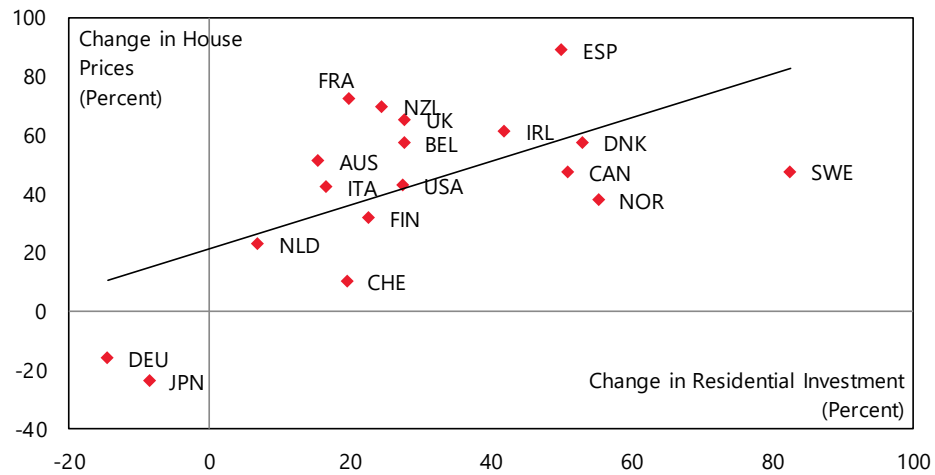
Note: The average fraction of the variance explained by the global factor is presented. The sample consists of 18 advanced economies. \*\*\* and \*\* indicate that variance explained by the global factors for the period Q1 1971 to Q4 1984 is significantly different from that for the period Q1 1985 to Q3 2011 at the 1% and 5% levels, respectively.

**Figure 5. Synchronisation of recessions and financial downturns**  
(in percent)

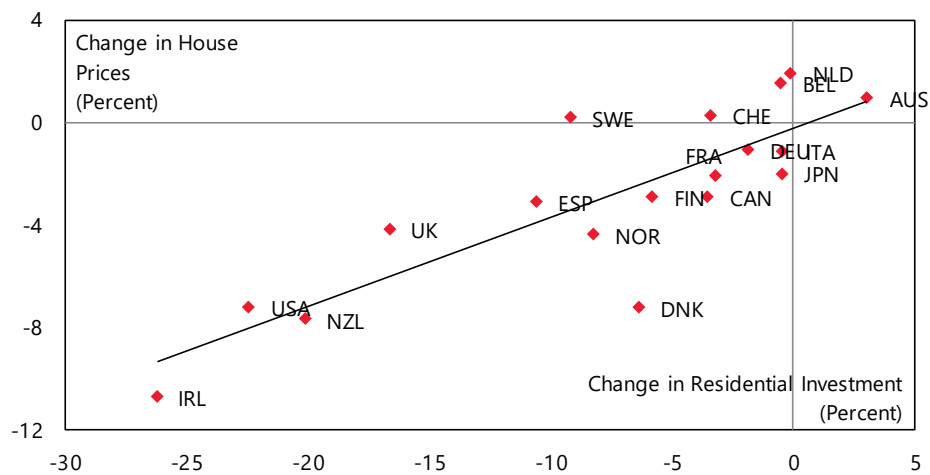


Note: Each bar represents the share of countries experiencing recessions or respective financial downturns. The figures include complete as well as ongoing episodes. The sample contains the quarterly data for advanced economies. Global recession years (1975, 1982, 1991 and 2009) are shaded in gray. House price data start in 1970.

**Figure 6. House prices and residential investment**  
(in percent)  
2000–2006

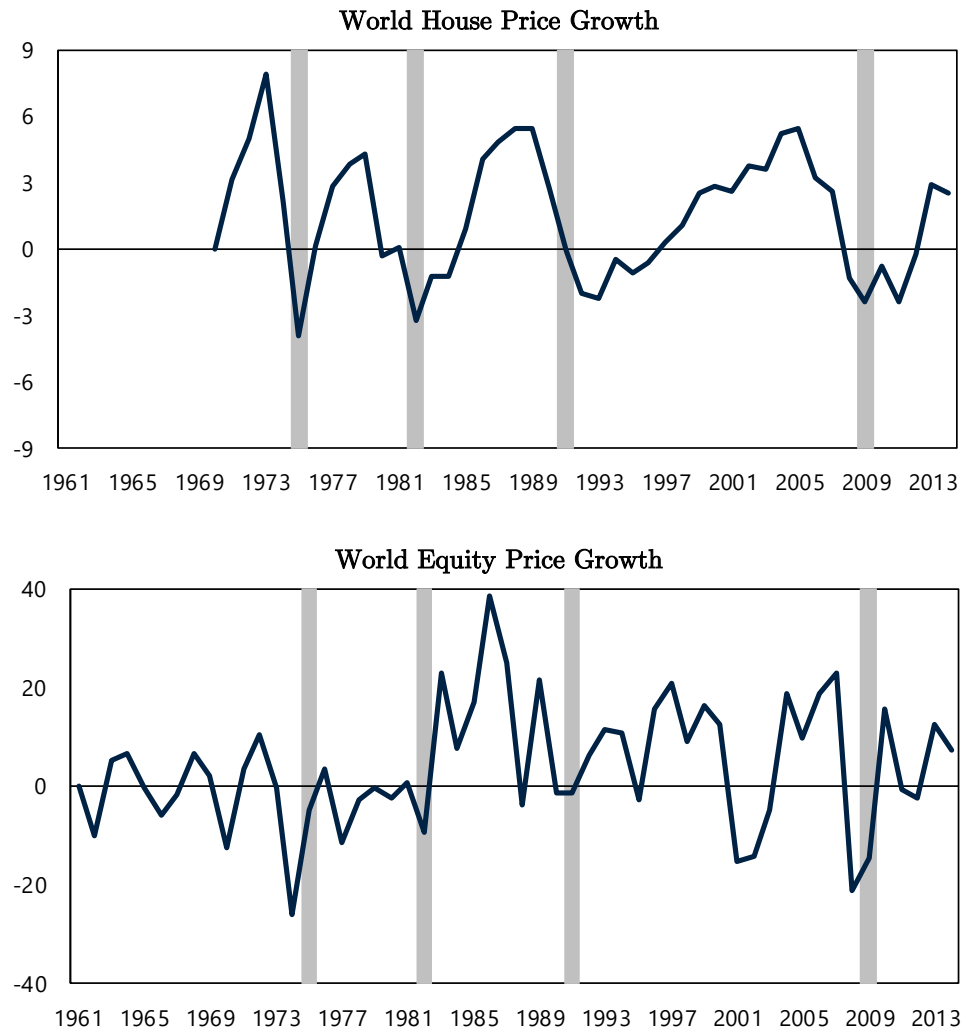


2007–2008



Note: Each figure plots the percent changes in house prices and residential investment during the respective periods. The sample consists of 18 advanced economies.

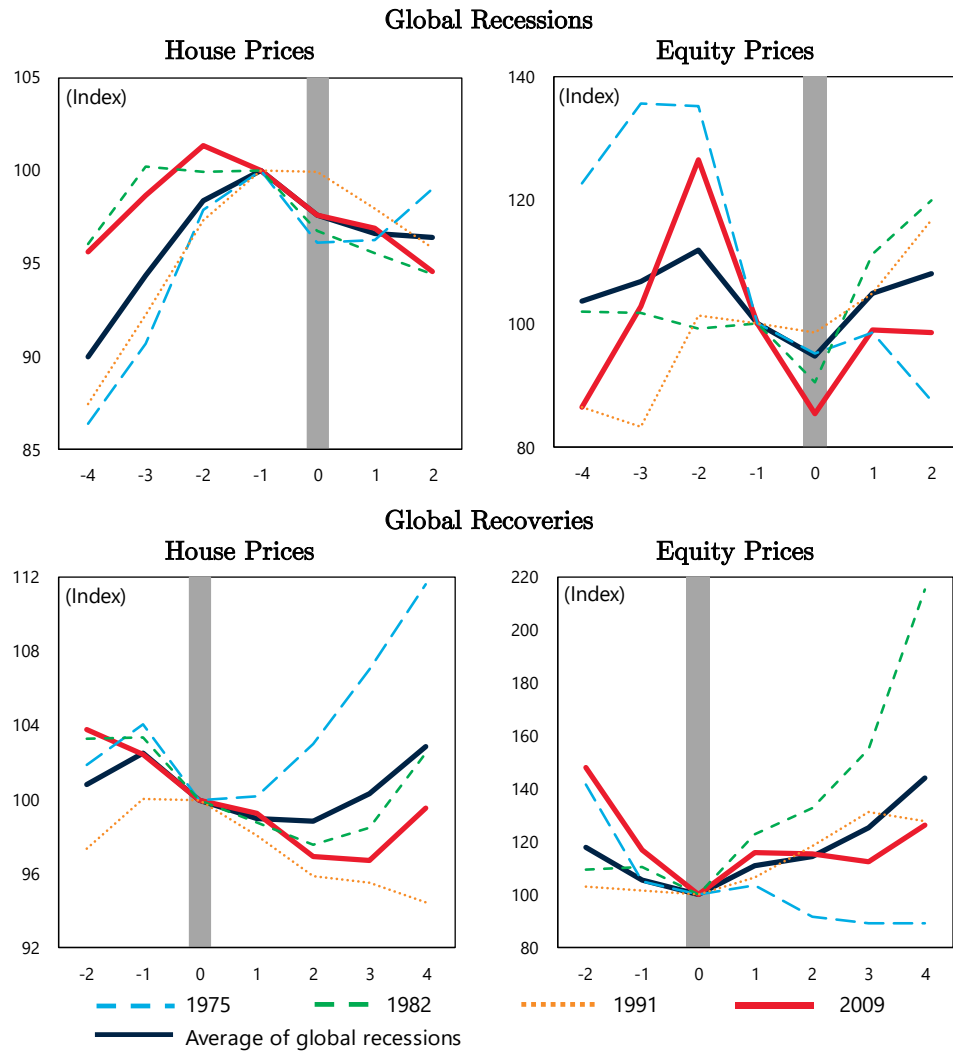
**Figure 7A. Evolution of world house and equity prices**  
(in percent)



Note: Each panel shows the four-quarter average of market-weighted growth rates of the respective variables for advanced and emerging market economies. All variables are in real terms. House price data start in 1970. Growth in world equity prices starts in 1962; the market-weights are three-year rolling averages. Shaded bars indicate global recessions. The last observation is for 2014.

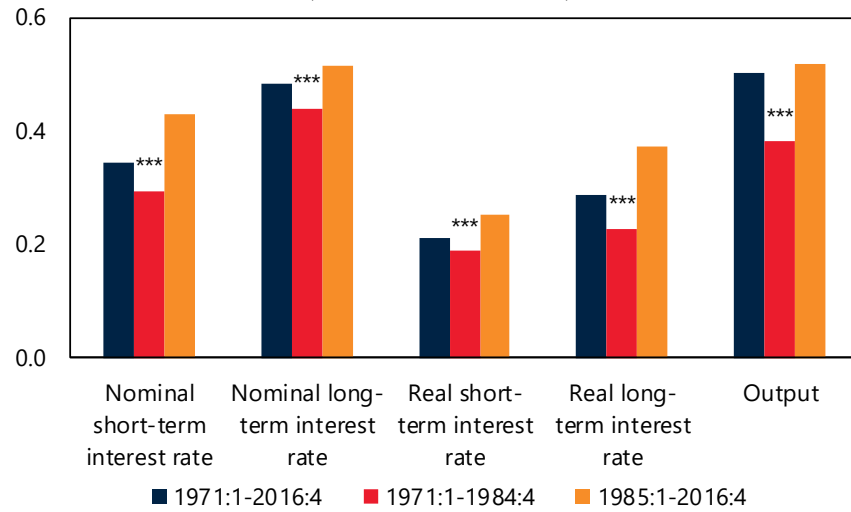


Figure 7B. Asset prices during global recessions and recoveries  
(index)



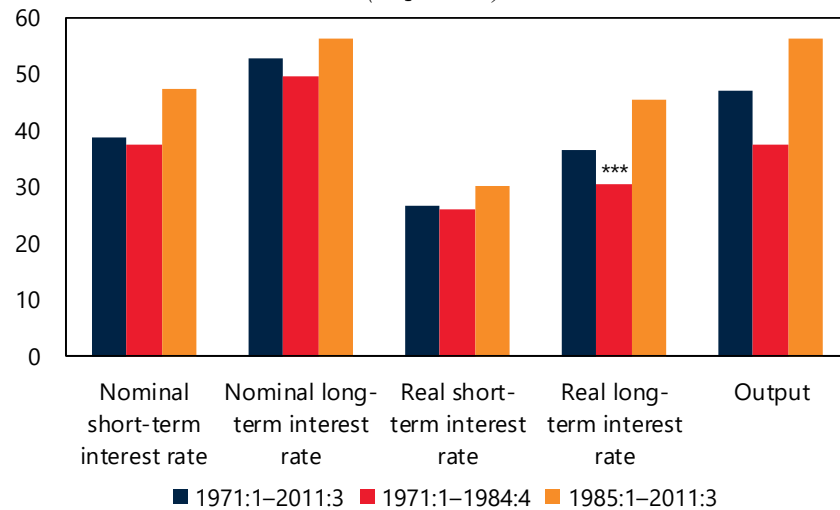
Note: Time 0 denotes the year of a global recession (shaded in gray). All variables are at annual frequency. All variables are market-weighted by gross domestic product in US dollars, including all advanced and emerging market economies. Panels on global recessions are index numbers equal to 100 one period before the global recession year. Panels on global recoveries are index numbers equal to 100 in the global recession year.

**Figure 8. Cross-country correlations: interest rates and output**  
(correlation coefficient)



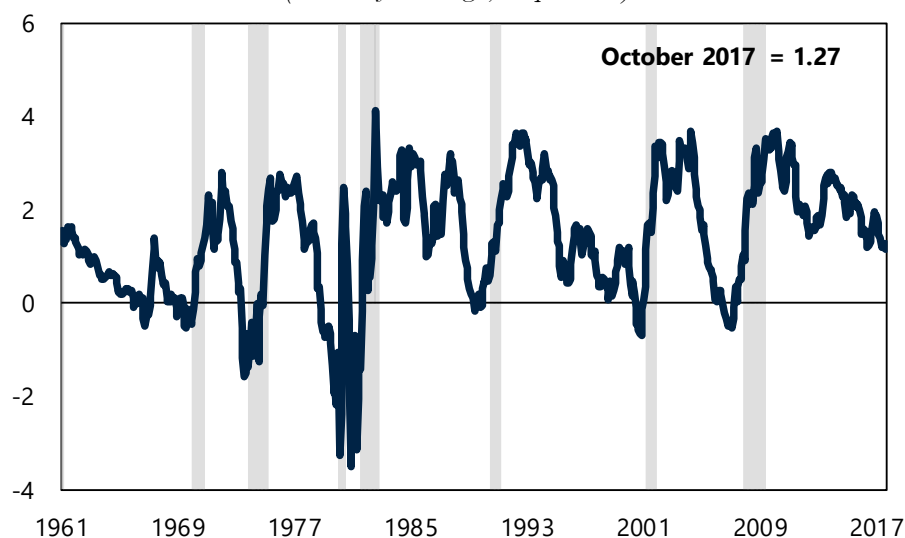
Note: The average of cross-country correlations for each variable in the respective periods is presented. The sample consists of 18 advanced economies. \*\*\* indicates that average correlations for the period Q1 1971 to Q4 1984 are statistically different from those for the period Q1 1985 to Q4 2016 at the 1% level.

**Figure 9. Variance due to the global factor: interest rates and output**  
(in percent)



Note: The average percent of the variance explained by the global factor is presented. The sample consists of 18 advanced economies. \*\*\* indicates that variance explained by the global factors for the period Q1 1971 to Q4 1984 is significantly different from that for the period Q1 1985 to Q3 2011 at the 1% level.

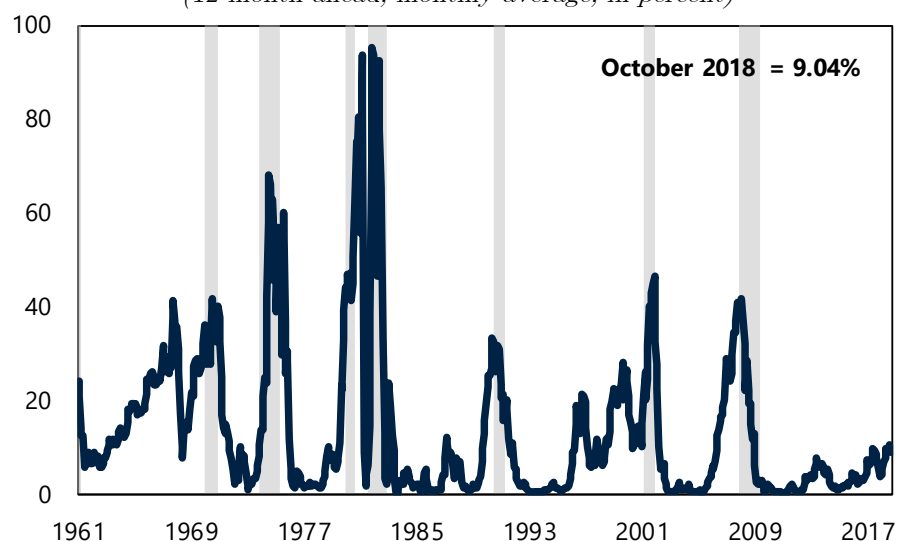
**Figure 10A. Treasury spread: 10-year Treasury bond yield minus  
3-month Treasury bill rate**  
*(monthly average, in percent)*



Source: Federal Reserve Bank of New York.

Note: This figure shows the US Treasury spread, which is calculated as the difference between 10-year Treasury bond yield and the three-month Treasury bill rate. The gray areas show recessions in the United States.

**Figure 10B. Probability of US recession predicted by treasury spread**  
*(12-month ahead, monthly average, in percent)*



Source: Federal Reserve Bank of New York.

Note: This figure shows the probability of a US recession predicted by the Treasury spread. This prediction is based on a model estimated using data from January 1959 to December 2009. Recession probabilities are predicted using data through October 2017. The gray areas show recessions in the United States.

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