Credit and bubbles

SUMMARY

Following the financial crisis, many have argued that monetary policy should lean against asset price increases and that deviations of credit and asset prices from trend can be used to capture financial imbalances. We study quarterly data spanning 1986–2008 for a sample of 18 countries and argue that such measures contain little information useful for forecasting the future economic conditions. This casts doubts on the leaning-against-the-wind view. We also argue that tightening monetary policy in response to such imbalances are likely to depress real growth substantially. That finding, however, is sensitive to the Lucas critique.

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Monetary policy and financial imbalances: facts and fiction

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1. INTRODUCTION

The current financial crisis raises yet again the issue of whether and how central banks should react if they perceive an asset-price bubble to be forming.[1] With the benefit of hindsight, it seems self-evident that they should have constrained the rise in asset prices, the expansion of credit and the increase of leverage of the financial system in the years before the crisis erupted. Moreover, there is broad agreement that tighter regulatory policies would have been desirable. Such policies should aim to ensure that market participants perform the required risk analysis, limit the complexity and opaqueness of the financial system, remove conflicts of interests such as those faced by rating agencies and align managers' private incentives to take risks

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[1] The notion of an 'asset-price bubble' has two meanings in the literature. In the policy literature it is best thought of as a usually large and protracted increase in asset prices that is poorly understood by observers. By contrast, in the formal literature on rational bubbles it refers to a situation in which there is a known deviation between the fundamental value and actual price of the asset, which is expected to grow sufficiently quickly to make it rational to hold the asset despite the known overvaluation and risk of a crash. See Blanchard and Watson (1982).

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with the social costs that they entail. Moreover, such policies should broaden the scope of the regulatory umbrella to cover all systemically important institutions, irrespectively of whether they are banks or not.

What remains more controversial is whether and how central banks *in their role of monetary policy-makers* should have reacted to the build-up of the bubble. Since rapid credit extension typically plays a key enabling role in episodes of rising asset prices, many have argued that central banks should have raised interest rates, thereby increasing the cost of credit and reducing the demand for assets. But there is little agreement whether such a policy was desirable and whether it would have been feasible. There are two sides to the debate.

A growing number of observers have argued that central banks should take an *activist approach* and react to, or lean against, signs of financial imbalances when setting monetary policy. Central banks operating with explicit or implicit inflation targets react to all developments – including rapid credit growth and asset-price increases that are the defining characteristics of an asset-price bubble – that influence aggregate demand and impact on the outlook for inflation. But the activist view goes further than this in arguing that monetary policy-makers should react to financial imbalances *over and beyond* what they imply for inflation at the 2- to 3-year policy horizon that central banks typically employ. Raising interest rates to slow asset-price increases is warranted, it is argued, because a bursting asset-price bubble can have large effects on inflation and economic activity at time horizons beyond those that central banks normally consider when setting interest rates.

The activist view relies on four empirical propositions being true.[2] First, central banks can determine in real time what constitutes an asset-price bubble by looking for signs of *financial imbalances* that are supposedly easily identifiable. Second, such imbalances contain information that is useful for forecasting the future path of inflation and output, also beyond the 2- to 3-year horizon. Third, monetary policy can be used to influence asset prices. Furthermore, there is no risk of 'nonlinearities' in the sense that a small increase in interest rates might lead to a collapse in asset prices and trigger a deep recession. Fourth, the improvement in economic performance resulting from a tightening of monetary policy to forestall an asset-price bubble exceeds the short-run costs of inflation falling below target and economic activity being weaker than it otherwise would have been.

The competing view, which we call the *wait-and-see approach*, is that central banks have insufficient information to conduct policy in this way.[3] Instead, they should focus on the outlook for inflation and output when setting interest rates and not react to hypothetical future collapses in asset values. However, if asset prices were to decline abruptly, central banks should be quick to reduce interest rates and to

[2] See also the discussion in Kohn (2006).

[3] See Kohn (2006, 2008).

take whatever other measures are necessary to forestall a recession and inflation falling below the desired level.

These polar opposite views of the nexus between monetary policy, financial imbalances and macroeconomic performance arise as a consequence of radically different assessments of how easy it is to diagnose such imbalances and of the effects of monetary policy on asset prices and macroeconomic conditions. In the hope of distinguishing between what is fact and what is fiction, in this paper we explore some key elements of the activist view. The paper is organized as follows.

In the second section we review some of the relevant literature, focusing on four testable propositions. Many proponents of the activist view maintain that financial imbalances and the likelihood that an asset-price bubble is forming can be assessed in real time by looking at deviations of credit and asset prices from trend. Following this suggestion, we construct indicators of financial imbalances and explore four propositions that we believe arise from the activist view. First, such imbalances contain information about future inflation and output, particularly at time horizons beyond those typically used by central banks in setting monetary policy. Second, this information is especially useful when trying to predict the occurrence of highly adverse macroeconomic outcomes (which we define below). Third, monetary policy has predictable effects on asset prices. Fourth, these effects are large relative to the effects monetary policy has on real economic activity and inflation, implying that central banks can tighten monetary policy in order to slow asset-price increases without depressing real economic activity and inflation excessively.

In Section 3 we discuss the data, which are quarterly, span the period 1986 to 2009 and stem from 18 countries. To measure financial imbalances, we follow the existing literature and compute property-price, equity-price and credit 'gaps' that are defined by the deviations of asset prices and credit from one-sided trends. The current crisis demonstrates that the burst of a financial bubble may cause a severe recession and even deflation. We therefore define indicators that measure whether 'adverse macroeconomic conditions' (AMCs) have prevailed. These are defined as (a) an average output gap of less than -1% for at least four quarters; or (b) annual inflation being either negative or declining by more than two percentage points in a time span of four quarters.

Section 4 reviews the information content of asset prices and credit for, first, output and inflation and, second, the indicators of AMCs. To predict output and inflation we estimate forecasting models on data ending, for the first set of forecasts, in 1999 and use these to provide out-of-sample forecasts for the period 2000 to the second quarter of 2009, recursively updating the model before making each new set of forecasts. When predicting AMCs we pool the data and estimate panel probit models since such events are rare. To ensure that there are a sufficient number of adverse events in the forecast-evaluation period, we first use a sample ending 1994 and compute out-of-sample forecasts for the period 1995 to the second quarter of 2009 before updating the model and computing a new set of forecasts.

We first consider a forecasting model that contains the output gap, inflation and the interest rate, which are the variables that central banks monitor as a matter of course. We think of this as our benchmark model. Then, we add the deviations of credit and asset prices from trend, the 'gaps', in various combinations as regressors to this model and investigate whether the forecasting precision for output and inflation improves. Since the activist hypothesis suggests that large and positive financial imbalances can raise serious macroeconomic risks, but 'small' imbalances and situations in which credit and asset prices are below trend do not, we interact the credit and asset-price gaps with an indicator variable that is unity when the gaps exceed a certain threshold, and zero otherwise.

We draw two main conclusions in this section. First, credit and asset-price gaps do not contain much information about future inflation and output gaps beyond that already included in the current output gap, inflation rate and interest rate. Though the results improve if one considers the growth rate of credit and asset prices instead of the gaps, the forecast models are only useful for predicting output at most four quarters into the future. This finding, which conflicts with the assumptions underlying the activist hypothesis, supports the findings in other studies (see e.g. Stock and Watson, 2003). Second, when focusing on predicting AMCs we find that the models are indeed able to provide useful predictions of adverse output states up to a horizon of 9–12 quarters. During that horizon, however, the benchmark model performs best. For inflation, the benchmark model also generates the best forecasts up to a horizon of less than 12 quarters. Thereafter, models including the credit gap are sometimes able to outperform the benchmark model. While this finding is supportive of the activist hypothesis, the models also predict a large number of adverse events that in fact did not occur. Credit and asset prices are therefore unlikely to provide useful guidance for monetary policy-makers.

Section 5 investigates whether monetary policy influences asset prices and what the consequences for output and inflation would be of doing so. To address this question we estimate panel VARs that allow the coefficients to vary depending on whether financial imbalances are present or not and study whether the responses to monetary policy shocks differ during periods when a bubble is forming. Our results show that while monetary policy does have important effects on asset prices, those effects are not particularly large relative to those it has on inflation and output. This suggests that attempts to lean against asset-price increases by using interest-rate policy are likely to put considerable downward pressures on real economic activity and inflation. Moreover, the effects of monetary policy shocks during boom periods do not appear to be fundamentally different from those in ordinary times. Overall, monetary policy seems to be a too blunt tool to deal with financial imbalances.

Of course, these results are sensitive to the Lucas critique and one could argue that an announcement that monetary policy in the future would lean against financial imbalances would change the behaviour of households and financial institutions and reduce the frequency of bubbles. In fact, we interpret our empirical results as suggesting that a leaning against the wind policy will *only* be successful if it elicits such behavioural changes. While such changes are possible, they are by no means guaranteed.

Finally, Section 6 concludes that our findings provide little support for the idea that financial imbalances contain information about future inflation and economic activity and that small changes in monetary policy can be used to prevent financial imbalances from developing at little cost to real output foregone. Overall, the notion that using monetary policy to lean against the wind is an effective way to ensure financial stability seems to be based less on fact and more on fiction.

2. RELATED LITERATURE

The literature on monetary policy and asset prices is large and is developing rapidly. We here review a selection of papers that consider whether central banks should respond to asset prices over and beyond what these imply for expected inflation at the standard 2- to 3-year horizon. Finally, we discuss the empirical evidence on the impact of monetary policy on output, inflation and asset prices.

2.1. The 'wait-and-see' versus the 'activist' approach

In an influential paper, Bernanke and Gertler (1999) study whether central banks should gear monetary policy to asset prices. Since the answer to this question depends on the structure of the economy and the nature of the shocks hitting it, the analysis is conducted using a version of the financial accelerator model proposed by Bernanke *et al.* (1999), which is modified to allow for non-fundamental movements in asset prices that in turn may influence economic activity. The authors consider the stabilizing effects of several different monetary policy regimes. The main findings are that responding aggressively to expected inflation – including any expected deflation arising from a bursting asset-price bubble – stabilizes the economy effectively. Furthermore, directly responding to asset prices brings no extra benefits. One reason for this perhaps surprising finding is that asset-price bubbles expand aggregate demand in the model and thus raise inflation pressures which the central bank already responds to.

Similar conclusions are drawn by Gilchrist and Leahy (2002), who also simulate a version of the Bernanke *et al.* (1999) model, and who consider shocks to future economic conditions and net worth.[4] Importantly, the authors find that interest

[4] Other papers that are sceptical about the desirability of the central bank responding to equity prices include Tetlow (2006) and Gilchrist and Saito (2006).

rates are more stable when monetary policy reacts aggressively to expected inflation, since agents' expectations of future policy reflect the monetary policy regime in force. This finding underscores the importance of credibility in setting monetary policy.

Arguably the most cogent arguments for why central banks should attach some weight to asset prices when setting monetary policy is put forth by Cecchetti *et al.* (2000). The authors also simulate a version of the model of Bernanke *et al.* (1999), but conclude that a policy of reacting to equity prices is in fact superior to one that entails solely reacting aggressively to expected inflation. They also argue that public awareness that the central bank is leaning against asset-price bubbles would reduce the likelihood that they develop, increasing the desirability of such a policy. Loisel *et al.* (2009) advance a similar argument, and show that in the presence of uncertainty about the productivity of a new technology, the central bank can discourage herd behaviour and increase welfare by responding to asset prices.

Cecchetti *et al.* (2000) also consider the frequent claim that it is difficult for central banks to know when equity markets are seriously overvalued. They note that dealing with unobservables, such as the equilibrium level of equity prices, is unavoidable in monetary policy and conclude that there is no inherent reason why central banks would have greater difficulties estimating the extent to which asset prices are misaligned than the likely size of the output gap or the deviation of unemployment from the NAIRU.

Bordo and Jeanne (2002, 2004) also consider the potential usefulness of leaning against asset-price bubbles that are caused by episodes of excessive optimism and show that optimal policy is highly non-linear. Thus, when asset-price bubbles are small, the central bank should not react to asset prices since the unwinding of a 'small' bubble is not likely to cause a credit crunch. Similarly, when asset-price bubbles are large, tightening monetary policy risks triggering a credit crunch and macroeconomic weakness, suggesting that it is not desirable to react by monetary policy. Instead, the central bank should wait for the uncertainty to be resolved and relax monetary policy if the bubble bursts. In an intermediate range, however, proactive monetary policy is useful in reducing the risk that a large bubble, and a large crash, will occur.

A more recent literature argues that as interest rates decline, banks and other financial institutions become more prone to take risks.[5] This suggests that if weak growth and low inflation were to require central banks to adopt an extremely expansionary stance of monetary policy for an extended period, as happened after the burst of the 'dot-com' bubble in 2001, the result could be a sharp increase in level of risk in the financial system. However, the appropriate way to avoid such a

[5] See Rajan (2005) for an early and particularly clear discussion. Jiménez *et al.* (2007), Altunbas *et al.* (2009) and Maddaloni and Peydró (2009) provide supporting empirical evidence.

development would presumably be to tighten the regulation and supervision of financial institutions in periods when interest rates are unusually low and risk-taking increases, rather than to tighten monetary policy, which has too blunt an effect on the economy.

Overall, we interpret the theoretical literature as suggesting that there is little benefit from responding mechanically with monetary policy to the level of asset prices, but that more elaborate strategies may be desirable. However, these are much more demanding from an information perspective and may be difficult to implement in practice.

2.2. Financial imbalances and future economic conditions

Bernanke and Gertler (2001) discuss the difference between their finding and those of Cecchetti *et al.* (2000) which are obtained using the same model. They argue that while they assume that the central bank did not know the shocks hitting the economy, Cecchetti *et al.* (2000) implicitly assume that the central bank knows that a bubble has formed and that it will necessarily burst within a given period. This suggests that the desirability of leaning against asset prices depends crucially on the central bank's ability to diagnose asset-price bubbles in real time and to assess their longevity.

While Cecchetti *et al.* (2000) argue that this is not an impossible task, they do not propose how this can be done in practice. In a widely cited paper, Borio and Lowe (2002) claim that cumulative deviations of credit and equity prices from real-time (one-sided) trends that exceed a pre-specified threshold can be used to diagnose financial imbalances and argue that the empirical evidence indicates that they help predict future banking crises. However, their analysis leaves important questions unanswered. For instance, and most obviously, the authors do not explore the hypothesis that these correlations arise only because some obviously important variables, such as short-term interest rates and output gaps, have incorrectly been omitted from the analysis.

Similarly, the association of credit growth and property-price changes they observe does not imply that credit growth predicts future property-price developments. While the analyses reviewed above only considered equity prices, movements in property prices are generally recognized to play a more important role in boom-bust cycles and episodes of financial instability. Gerlach and Peng (2005) investigate data from Hong Kong, which has undergone extreme swings in property prices and bank lending in the last three decades, and demonstrate that while property prices contain information about future bank lending, the reverse is not true. The results in the cross-country study of Hofmann (2003) suggest that this finding is general.

Furthermore, the statistical methodology used by Borio and Lowe (2002), which is due to Kaminsky and Reinhart (1999), does not allow for formal hypothesis testing. It is therefore difficult to know what significance should be attached to the findings in the paper. Furthermore, their research methodology does not permit them to assess whether asset prices are essential for setting monetary policy since any information they contain may already be embedded in standard monetary policy indicators.

2.3. Financial imbalances and monetary policy

Several papers have demonstrated that the severity of asset-price declines and their macroeconomic effects depend on the extent to which asset prices rose before the bubble burst (e.g. International Monetary Fund [IMF], 2003). This finding has been interpreted as indicating that financial imbalances and asset-price bubbles build up during economic expansions and that the longer this process continues, the larger the expected unwinding when the bubble finally bursts. As a consequence, it is argued, it makes sense for central banks to lean against the wind by tightening monetary policy when asset prices rise in order to insure against a particularly severe future recession (European Central Bank, 2005).

However, these studies do not address the question of what consequences responding with monetary policy might have for output and inflation. In particular, while a leaning-against-the-wind policy might reduce the risk of a sudden and large collapse of asset prices, it would also reduce current real economic activity. Assenmacher-Wesche and Gerlach (2008a, b, c) present panel VAR estimates for 17 countries suggesting that the output losses of this policy could be dramatic. If so, the wait-and-see approach appears more appropriate. As we discuss below, these estimates do not capture the possibility that the adoption of a leaning-against-the-wind policy will change the behaviour of economic actors, which in turn may reduce the likelihood that an asset-market bubble develops. Nevertheless, the estimated impact on real gross domestic product (GDP) is so large that even if the size of asset-market bubbles were considerably reduced by the adoption of a different policy, the point remains valid.

Furthermore, as suggested by the analysis in Bordo and Jeanne (2002, 2004) and the experiences of the United States in 1929 and Japan in 1989–90, there is a risk that leaning against a 'large' bubble may trigger a collapse in asset prices. Unless monetary policy is exceptionally nimble, this risks leading to a large recession and many years of poor economic growth.

Finally, there is always the possibility that an asset-price bubble may burst on its own before the effect of monetary policy on asset prices has materialized. If so, a tightening of monetary policy in response to financial imbalances could coincide with the contractionary effects of an imploding bubble. Rather than reducing macroeconomic volatility, monetary policy activism could instead tend to destabilize the economy.

Overall, in addition to studying to what extent measures of financial imbalances predict future economic conditions, it is of interest to investigate how monetary policy impacts on asset prices.

3. CREDIT GAPS AND FINANCIAL IMBALANCES

As noted above, the activist view holds that financial imbalances can be diagnosed in real time by looking at deviations of credit and asset prices from a one-sided trend.[6] We follow this literature and in this section compute credit gaps, property-price gaps and equity-price gaps. The definition of these gaps leaves many choices to the analyst, such as how to compute the trend and the choice of the thresholds, which potentially can affect the conclusions. In the following section we therefore check the robustness of our results by varying the thresholds and also using growth rates of the credit-to-GDP ratio, property prices and equity prices instead of their deviations from trend.

Our empirical work relies on quarterly data spanning 1986 to mid-2009 from a cross-section of countries and uses panel-econometric methods. This research strategy warrants several comments.

First, there is a natural tendency when studying occurrences of financial imbalances and their resolution to focus on the most pronounced episodes of asset-price bubbles. Our views on monetary policy and financial imbalances risk being excessively influenced by a few specific events, such as the experiences of Japan in the last two decades. In the subsequent analysis we therefore use data from a range of countries that have had different experiences with respect to size, duration and frequency of asset-price bubbles: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States.

Second, one drawback with this approach is that it requires us to focus on a few macroeconomic time series for each country and thus leads us to disregard other data – such as housing starts, price-to-rental ratios and risk spreads in financial markets – that may provide information useful for diagnosing financial imbalances in real time, but that may only be available for a few countries and for short periods. Furthermore, we recognize that capital flows, investment-to-GDP ratios, monetary aggregates and potentially other variables might be useful for diagnosing financial imbalances. In what follows we focus on credit and asset prices because of space constraints and since these variables have been identified in the literature as being key indicators of risks to financial stability.

Third, while the panel approach provides a natural way of summarizing the data, it imposes a number of restrictions on them. The standard fixed-effects esti-

[6] See, for instance, Adalid and Detken (2007), Borio and Drehmann (2009), Borio and Lowe (2002, 2004), Detken and Smets (2004), Goodhart and Hofmann (2008).

mator assumes that all countries share the same economic structure and allows only for country-specific differences in levels of the data. By contrast, the mean-group estimator suggested by Pesaran and Smith (1995) provides an estimate of the average effect while assuming that there are differences across countries. Thus, it provides an estimate for a hypothetical 'average' economy.

Fourth and finally, macroeconomic developments have been much calmer since the mid-1980s than in the 15 years before. This has made it more difficult to find variables that forecast future inflation and economic activity.[7] However, the earlier period is characterized by large macroeconomic fluctuations, including in asset prices and credit, which arose largely as a consequence of poor monetary policy responses and large oil price shocks.[8] Since then a number of institutional developments have taken place – including increased central bank independence, improved decision-making procedures and a strengthening of transparency arrangements – which imply that data from the earlier period are not representative for modern economies. Since the experiences of the 1970s are of little relevance today, we start estimating in 1986, recognizing that modern central banks face a much harder forecasting problem than central banks in the 1970s.[9]

The data set ends in the second quarter of 2009 and thus covers the beginning of the global financial crisis triggered by the developments in the US subprime mortgage market. The fact that the onset of crisis in 2008 is included in the sample allows us to study the predictive ability of financial imbalances in a period in which they triggered a massive economic downturn.

3.1. Measuring credit

In this study we use Bank for International Settlements (BIS) and IMF data on credit as measured by claims of the financial sector on the domestic non-financial private sector. While the IMF uses a harmonized framework to structure the credit data, the BIS adopts the classification from the national statistics, which varies considerably across countries.[10] For Canada, Sweden and the United States, where institutions other than banks are important providers of credit, the IMF statistics contain an additional section that aggregates credit from banks and non-bank financial institutions, which we use as our preferred measure.

[7] See Stock and Watson (2007).

[8] Indeed, the sharp rise in oil prices in 2007 elicited strong monetary policy responses across the world in sharp contrast to the episodes in the 1970s.

[9] As Ahearne *et al.* (2005) and Girouard and Blöndal (2001) note, many countries deregulated their mortgage markets during the early to mid-1980s, suggesting that estimates relying on older data are unlikely to be representative. Goodhart and Hofmann (2008) also study a subsample spanning 1986 to 2006 and find that this later period indeed differs from the earlier part of their sample.

[10] Since the BIS database does not contain credit data for Ireland and Austria, we take them from the OECD.

For most countries, data from both sources are quite similar, as evidenced by the credit-to-GDP ratios shown in Figure 1. For Japan and the United States (and to a lesser extent Canada and Denmark), the IMF data result in much higher ratios.

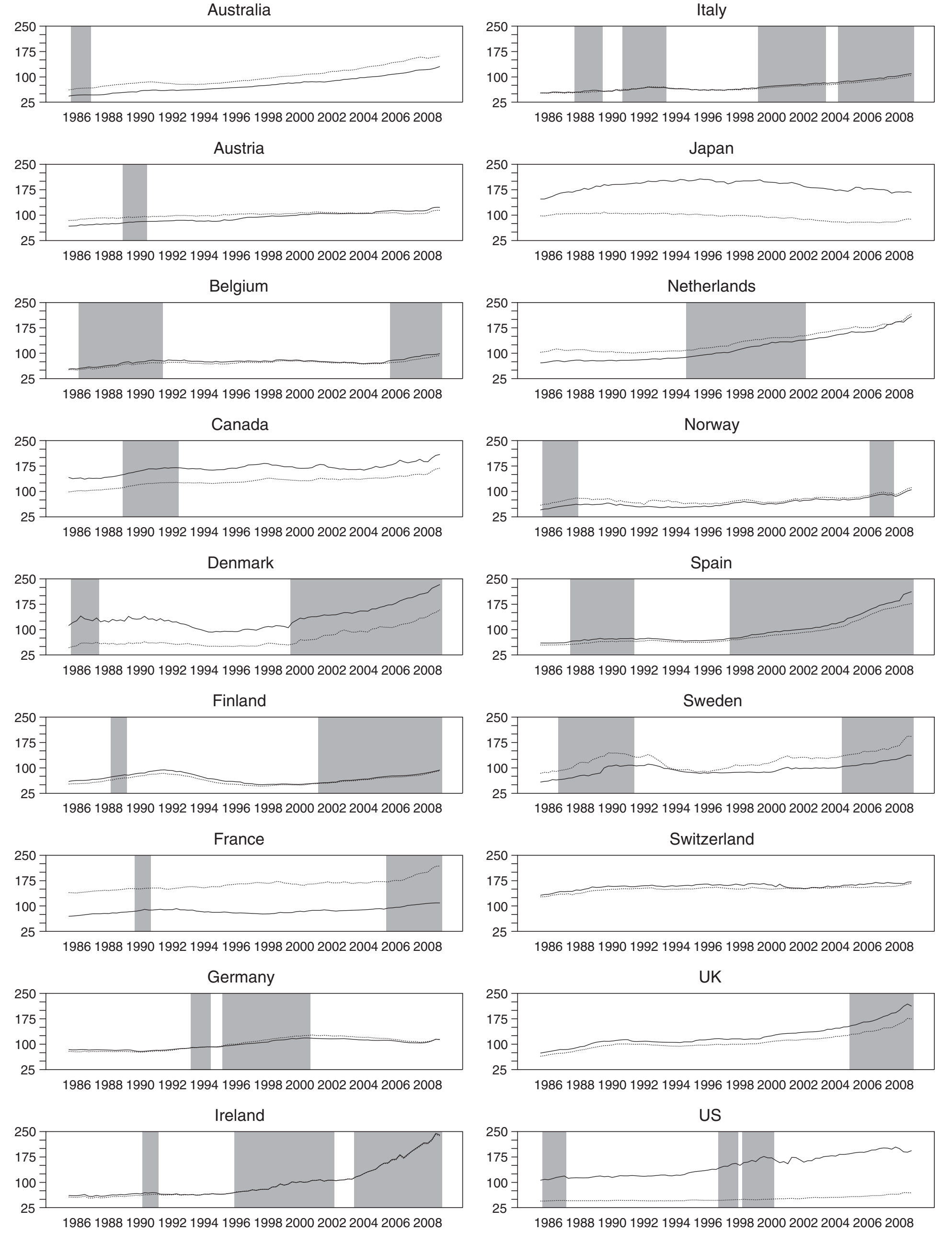

Figure 1. Credit-to-GDP ratios from the International Financial Statistics (solid line) and the BIS (dashed line) statistics

This is due to the fact that when defining credit we opt for data on lending from the whole financial sector instead of a strict definition of credit from banks only, whereas the BIS data seem to employ a narrower definition of lenders.[11] Though a measure of credit including loans to the financial sector may be better able to predict financial crises that are caused by excessive leverage, our aim is to predict consumer-price inflation and output. For that purpose, credit to the non-financial sector seems more appropriate.

For Australia, France, the Netherlands, Norway and Sweden, the IMF data indicate lower credit volumes than the BIS statistics. Though it is difficult to trace back the precise reason for these differences, they seem mainly due to whether interbank bond holdings, that is, bonds issued by one bank that are held by another bank, are included in the credit aggregate. While the IMF employs a framework of sectoral balance sheets and therefore excludes interbank bond holdings, the national statistics differ in this respect. Nevertheless, despite the difference in levels, the correlation of the credit gaps derived from the BIS and the IMF credit data is high (0.88).

Because of its reliance on a unified framework, we use the IMF credit data in the empirical analysis conducted below.[12] Turning to the sources of the other data, consumer-price and equity-price indices as well as short-term interest rates are from the OECD Main Economic Indicators, whereas GDP and residential property prices are from the BIS database. A detailed description of the data and their transformations can be found in Assenmacher-Wesche and Gerlach (2008b).

Figure 1 shows that the credit-to-GDP ratio has risen over time in all countries. It varies between 43% for Australia in 1986 and 235% for Japan in 1996. Countries with below-average credit ratios include Belgium, Finland, France, Germany, Italy and Norway. By contrast, in Denmark, Ireland, Spain, the United Kingdom and the United States the credit ratio exceeds 200% in 2008.

Figure 1 also marks the periods in which the credit-to-GDP ratio deviated by more than 4% from trend, which, according to Borio and Lowe (2002), provides a real-time indication of whether a credit bubble is forming. Except for Japan and Switzerland, all countries in our sample experienced periods of large credit gaps, though they are unevenly distributed across countries. Spain and Italy stand out with 60 and 52 quarters of credit gaps exceeding 4%. It can be seen that episodes of large credit gaps tend to become more persistent at the end of the sample, suggesting that excessive credit creation did play a role in setting the stage for the recent crisis. Nevertheless, almost half of the countries, including the United States,

[11] For Japan, for example, the credit aggregate from the BIS covers only domestically licensed banks, but other institutions like cooperative and rural banks, branches of foreign banks, housing and loan corporations etc. are not included.

[12] Nevertheless, the IMF aggregates frequently exhibit breaks. In the case of a recognized break, as marked by a specific flag in the IMF statistics, we link the series using the growth rate from the BIS credit series, which often does not show a break at the same time.

did not experience large credit gaps in the recent past, which raises doubt on the ability of the credit gap to predict the current downturn. Of course, the credit gap only reflects developments in the official statistics and may miss developments in the shadow banking system.

3.2. Defining the asset-price gaps

Though it is often argued that credit expansion is closely linked to asset-price bubbles, it seems more intuitive to define asset-price bubbles relying on price data.[13] Next we review the behaviour of equity prices and residential property prices for the 18 countries in our sample. While Borio and Lowe (2002) and Adalid and Detken (2007) use an asset-price index that combines property and equity prices, IMF (2003) finds that property-price bubbles are less frequent and have a larger impact on the economy than equity-price bubbles, which makes it preferable to investigate them separately.

Figure 2 shows real equity prices, together with periods of large equity-price gaps, based on a 10% threshold as proposed by Adalid and Detken (2007). Interestingly, equity-price misalignment are relatively evenly distributed across countries. In many countries the equity-price misalignments occur around 2000, that is, before the burst of the ‘dot-com’ bubble. Nevertheless, also in the late 1980s and around 2006 large equity-price gaps can be observed for several countries in the sample.

Figure 3 shows the property-price gaps when a threshold of 7.5% is used. It turns out that only Germany did not experience any large property-price misalignments. Many countries experienced episodes of large property-price gaps in the late 1980s and the early 1990s. Moreover, except for Austria, Germany, Ireland, Italy, Japan and the Netherlands, all countries also experienced positive gaps at the end of the sample period.

Looking at Figures 1 to 3, it is apparent that there is considerable variation across countries in the way financial imbalances evolve. For instance, while in some episodes asset-price gaps have been accompanied by credit gaps, in most cases the correlation between the different gap measures is low.

3.3. Defining adverse macroeconomic conditions

To investigate formally the link between financial imbalances, recession and deflation, we next define an indicator variable that signals ‘adverse macroeconomic conditions’ (AMCs). We first do so by relying on the behaviour of real economic

[13] Alternatively, one could use the interest rate as the price for credit. Nevertheless, credit rates deviate from money market rates because of risk premia and the creditworthiness of the borrowers. It is therefore difficult to find credit interest rates for the countries in our sample.

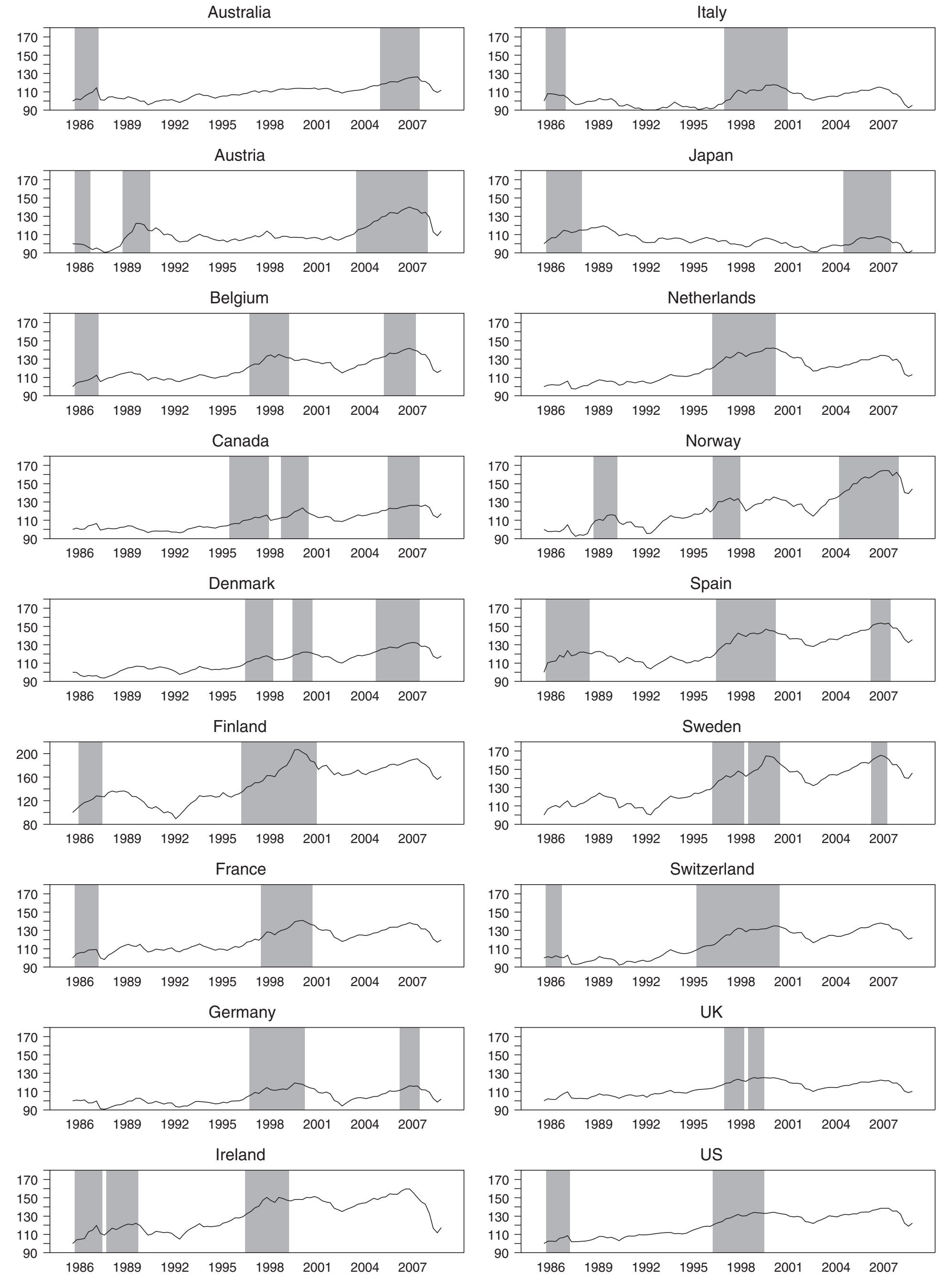

Figure 2. Real equity prices and misalignment periods (shaded areas)

activity. Unfortunately, a variety of different approaches have been suggested in the literature and it is impossible to investigate all of them here. While the National Bureau of Economic Research (NBER) has developed recession chronologies for

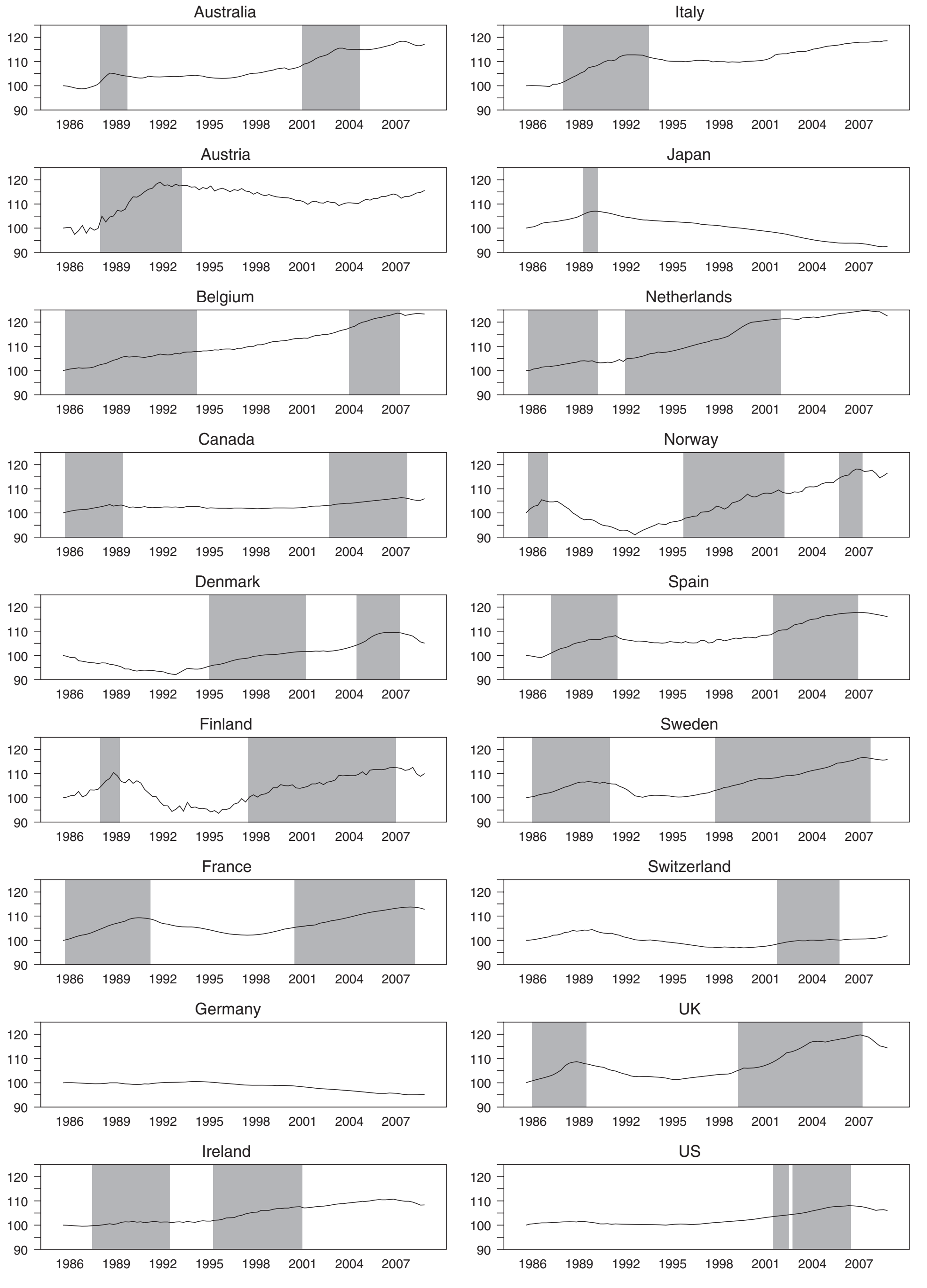

Figure 3. Real property prices and misalignment periods (shaded areas)

the United States, such measures are not readily available for all countries in our sample. Based on the data we have, we instead consider the average output gap over four successive quarters. We define an 'adverse state' when the average output gap for the current and the next three quarters exceeds −1%. This threshold value was selected so as to match as closely as possible the NBER recession dates.[14] As the results of our forecasting exercise depend on the definition of the AMC indicator, we will check robustness to alternative definitions of the indicator in Section 4.4.

Proponents of the activist view might argue that our forecast exercise is biased towards not finding a systematic relation between asset-price booms and recessions because our definition of recessions does not depend on whether the adverse event was caused by an asset-price boom or a banking crisis. Of course, some recessions occur for other reasons than financial imbalances, implying that credit and asset-price gaps are unlikely to be helpful in predicting them. However, studying only the subset of sharp macroeconomic contractions that are due to financial imbalances seems circular, since credit and asset prices predict these by definition. We nevertheless think that our forecast exercise is not unduly unfair to the activist view since the credit and asset-price gaps enter our model only during those periods when financial imbalances actually were present. In that way we ensure that only those recessions that happened in a certain period after a financial imbalance are actually regressed on the credit and asset-price gaps.

Figure 4 shows the output gap together with our indicator. We obtain 326 quarters with AMCs when the output gap is used to define them or 19% of the observations. This accords well with conventional wisdom regarding the frequency of recessions. The figure also shows that adverse states tend to be correlated internationally. Most countries experienced a recession around 1990–2 and a second one in 2001–2002. With respect to the second downturn in 2001–2002, our indicator does not signal recessions in Australia, France, Italy, Spain and the United Kingdom. Moreover, except for Denmark, Italy and the United Kingdom, all countries experienced large negative output gaps at the beginning of the sample.

Next we consider defining AMCs by relying exclusively on the behaviour of inflation. Only Japan experienced deflation – a prolonged period of falling prices – in our sample.[15] We therefore define AMCs as a situation in which the inflation rate is either negative or it falls by more than two percentage points over the current and the next three quarters. This yields a total of 210 quarters or 12% of the observations (see Figure 5). In contrast to those computed using data on output, however, these states are less evenly distributed across countries. In particular, Japan stands out with 45% of the observations in the bad state. By contrast, for

[14] Applying the above definition, our indicator signals recessions in the United States in 1990Q4 to 1991Q3 and 2002Q1 to 2003Q1. The NBER dates are 1990Q3 to 1991Q4 and 2001Q1 to 2001Q4. Moreover, our indicator signals the start of a third adverse state in 2008Q3, which is three quarters after the latest turning point the NBER has announced for 2007Q4. By contrast, using the conventional definition of two successive quarters of negative GDP growth we would obtain only a single recession quarter in 1990Q4 and two more in 2008Q3–Q4.

[15] Several countries had negative inflation rates during a few quarters, namely Finland, Germany, the Netherlands, Norway, Sweden and Switzerland. These events, however, were of a temporary nature and cannot be regarded as deflations.

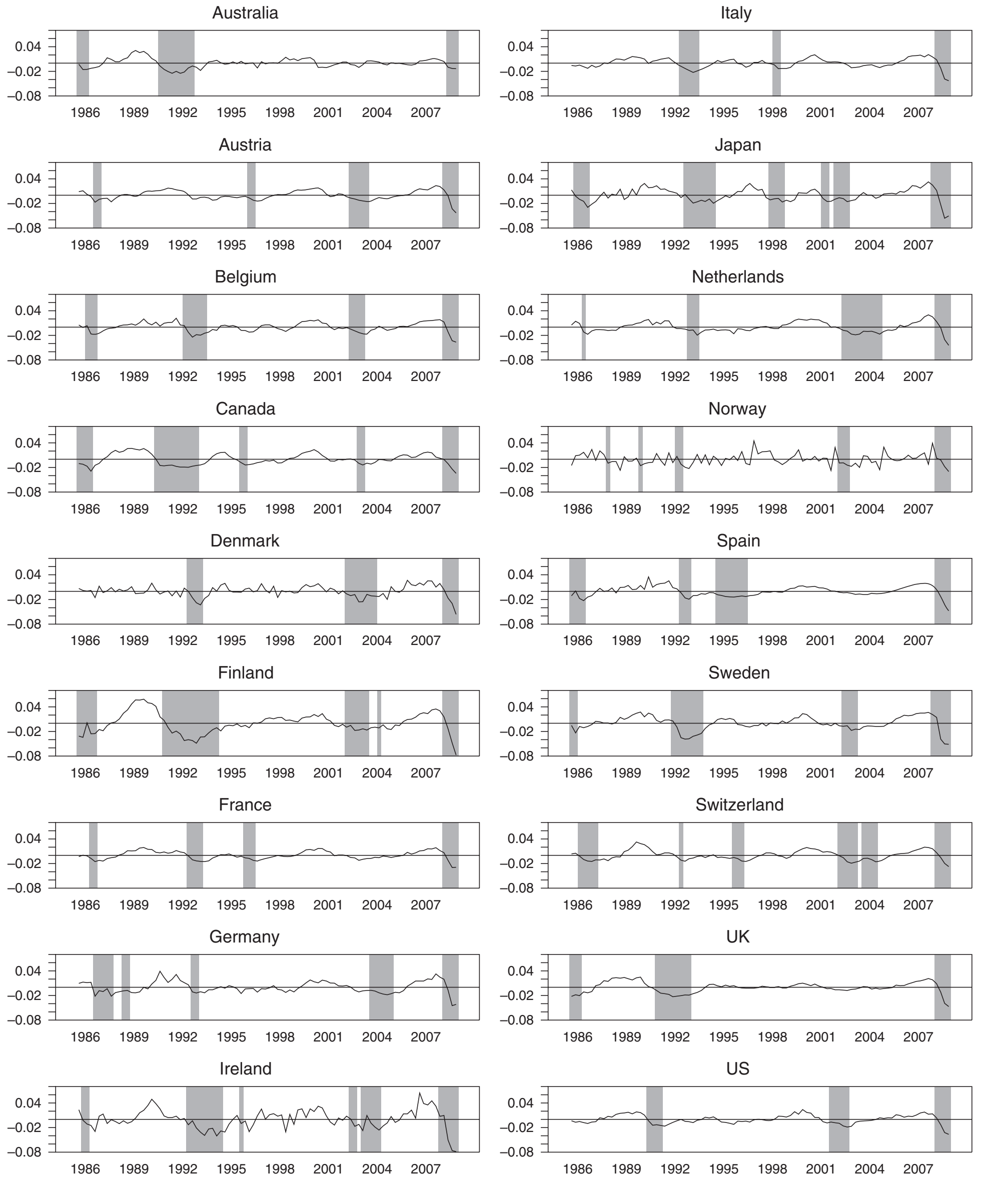

Figure 4. Output gap and adverse output states (shaded areas)

Austria, Belgium and France only the most recent drop in inflation rates is considered as moving the economy into an adverse state. It is noticeable that all countries are in an adverse state after the recent drop in inflation.

4. THE PREDICTIVE ABILITY OF CREDIT AND ASSET PRICES

In this section we explore the information content of the indicators of financial imbalances. Before turning to the results, several issues warrant discussion.

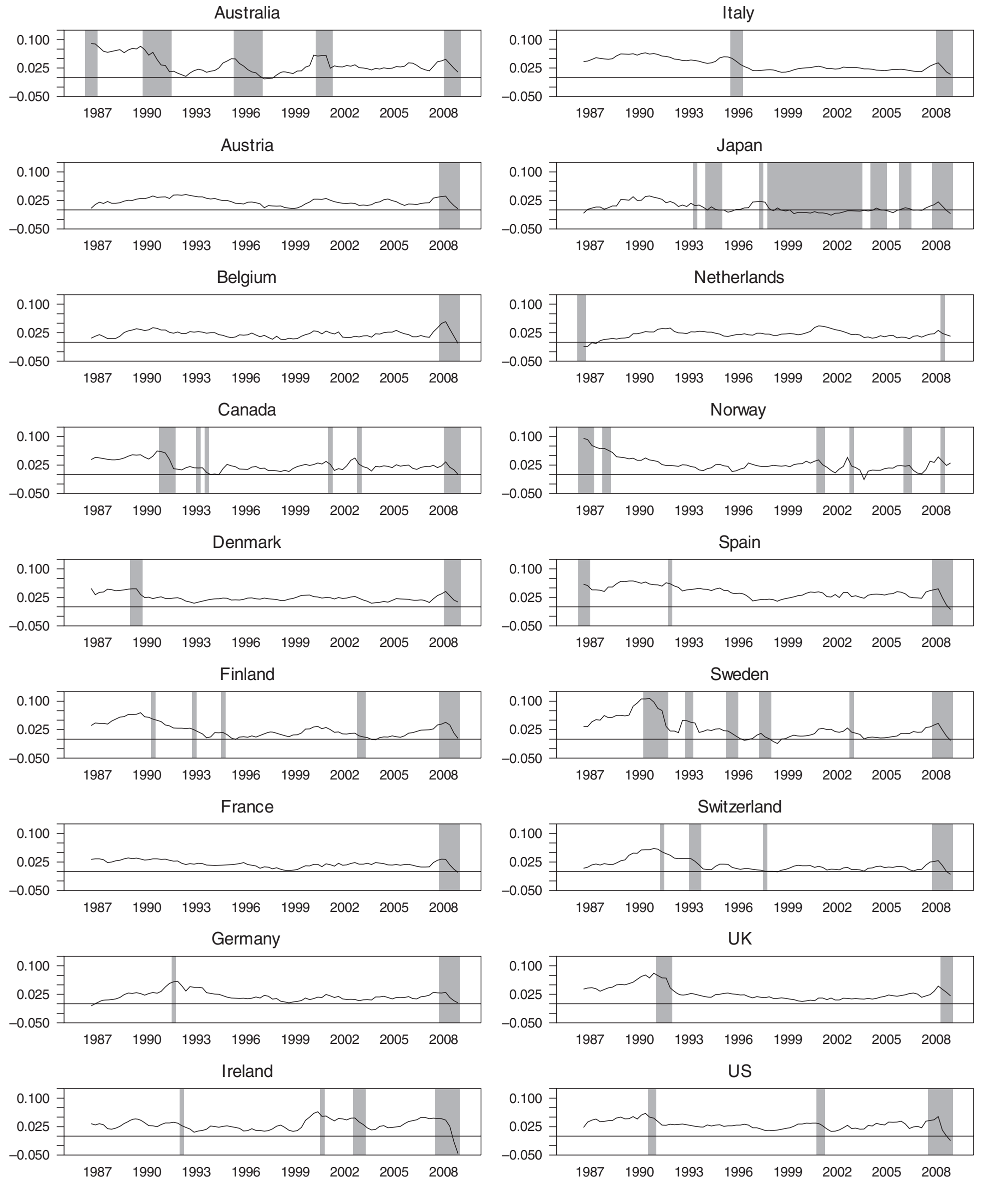

Figure 5. Inflation and adverse inflation states (shaded areas)

First, most of the literature investigates whether measures of financial imbalances help predict the burst of an asset-price bubble and its effects on asset prices and financial stability.[16] While that is appropriate from a financial stability perspective, here we focus on the information they contain about future inflation and output,

[16] See, in addition to the papers already cited, Alessi and Detken (2009), Agnello and Schuknecht (2009), Gerdesmeier *et al.* (2009). Goodhart and Hofmann (2007) also investigate the predictive content of property prices for inflation.

which are the goal variables for monetary policy-makers. The motivation for posing the forecasting question in this way is simple: There is plainly no reason for central banks to adjust monetary policy in response to evidence that financial imbalances are forming if the resolution of such imbalances does not have any macroeconomic effects. While the forecasting exercise is somewhat different from that of Borio and Lowe (2002), banking and financial crises are typically associated with severe macroeconomic developments (see IMF, 2008), suggesting that in practice there may not be a major difference between predicting financial crises and predicting severe macroeconomic weakness. Nevertheless, we find that indicators of financial imbalances have little forecasting power for inflation and the output gap, also at longer horizons. While this finding reflects the difficulty of forecasting macroeconomic variables at long horizons, it raises doubts about the feasibility of the activist view. When considering the prediction of adverse macroeconomic conditions, however, our results are somewhat more positive.

Second, excessive credit and asset-price gaps and severe economic downturns occur only rarely. This suggests that data from individual countries may therefore not contain enough information to obtain clear estimates of the relationship between these variables. To extract the information in the data more efficiently, we use a panel approach.

Third, in practice central banks of course use much more information than the few time series we study here and consequently are better able to assess whether financial imbalances are forming in real time. Thus one can argue that our forecast exercise will not do justice to the activist approach. Nevertheless, if there is a *systematic* relation between asset-price bubbles and macroeconomic outcomes, we should be able to find at least some predictive ability of the indicators we are considering, even if by using more information the results could be improved. If the credit and asset-price gaps are unable to improve the benchmark model's forecasts of output and inflation, they are unlikely to be useful information variables for policy purposes.

4.1. Predicting output and inflation

To assess the information content of credit and asset prices we estimate single-equation models with either the output gap or inflation as dependent variables. We fit the models using data until the last quarter of 1999 and then perform recursive out-of-sample forecasts starting in the first quarter of 2000.[17] Since the activist view asserts that financial imbalances are helpful in forecasting the economy at horizons

[17] The number of forecasts we evaluate for each country and each model therefore ranges from 36 for the one-quarter horizon to 16 for the 20-quarter-ahead forecasts. Though the predictive content of credit and asset prices can also be assessed by testing whether they are Granger causal for the output gap and inflation, out-of-sample forecasts constitute a much stronger test of their usefulness for forecasting (Stock and Watson, 2003; Estrella and Mishkin, 1998).

beyond the 2- to 3-year period central banks focus on, we consider forecasts up to 20 quarters ahead.[18]

Based on the three different measures of financial imbalances discussed in the previous section, we choose the following approach for the evaluation of their predictive content for output and inflation. We first adopt a benchmark model, against which we will evaluate the information content of the credit and asset-price gaps, that contains the current short-term interest rate, output gap and inflation, which are generally used to characterize monetary policy decisions of central banks. Next we specify a set of alternative models, which augment this benchmark specification with all possible combinations of the credit and asset-price gaps discussed above. This results in seven different models that are listed in Table 1.

The activist view holds that only situations in which credit and asset prices are distinctly above trend indicate financial imbalances that raise the risk of a financial crisis and macroeconomic dislocation. As discussed in Section 3, we therefore define indicator variables that take the value of zero if the threshold is not surpassed and equal the original gap series if it is. We chose a threshold of 4% for the credit gap, 10% for the equity-price gap and 7.5% for the property-price gap. Since these values are arbitrary, we report robustness checks in the next section.

As dependent variables we consider the output gap and inflation.[19] We investigate the predictive ability, which we measure by the root mean squared forecast error, of the eight different models listed in Table 1, containing all possible combinations of the three gap variables. Since the time-series dimension of our data set is

Table 1. Models

Model	Variables included
Benchmark	Inflation, output gap, interest rate
Model C	Benchmark model plus credit gap
Model E	Benchmark model plus equity-price gap
Model P	Benchmark model plus property-price gap
Model CE	Benchmark model plus credit gap and equity-price gap
Model CP	Benchmark model plus credit gap and property-price gap
Model EP	Benchmark model plus equity-price gap and property-price gap
Model CEP	Benchmark model plus credit gap, equity-price gap and property-price gap

[18] We calculate direct forecasts from single-equation regressions, conditioned on the most recently observed data, because they do not rely on potential misspecifications in the forecast equations for the right-hand side variables, which, as for instance equity prices, may be much harder to forecast than output or inflation. Alternatively, we could compute dynamic forecasts from a vector autoregressive system. While dynamic forecasts are optimal if the assumed model is correctly specified, direct forecasts are often more precise, especially for long forecast horizons (see Bhansali, 2002).

[19] In contrast to the approach used to define the credit and asset-price gaps discussed in Box 1, we apply the usual value of $\lambda = 1600$ to quarterly data when calculating the output gap. Moreover, when the next observation is added in the recursive estimation, the whole output-gap series is updated and not only the last observation as in the case of the credit and asset-price gaps.

Box 1. Defining financial imbalances

We follow the literature in defining financial imbalances by deviations of credit and asset prices from trend because this concept stresses the importance of cumulative processes that are not captured by growth rates. The credit gap is calculated as the deviation of the log of the ratio of credit to nominal GDP from trend, the equity price gap is the deviation of the log of equity prices deflated by the consumer price index (CPI) from trend and the property price gap is the deviation of the log of property prices deflated by the CPI from trend.

The trend is calculated recursively using the HP filter and the deviation from the most recent value of this trend is used as the asset price and credit gaps. The smoothing parameter, λ, is set to 100,000. This large value implies that the HP-filtered trend is virtually indistinguishable from a linear trend. This method gives rise to a series of end-of-sample estimates, which are inherently imprecisely estimated, of the trend. Note that when new observations become available, the estimates of the past realization of the trend may also change, potentially leading us to change our assessment about past financial imbalances. However, following the literature we do not update past observations. Detken and Smets (2004, p. 10) note that this approach generates boom periods that start earlier than when calculated as the deviations from a trend estimated over the full sample. Nevertheless, the result from this approach depends on the length of the starting window for the trend (for which we use data from 1980 to 1985) and tends to identify more boom periods in the later part of the sample because the trend estimates become increasingly less sensitive to the addition of new observations, leading to larger deviations from trend. Moreover, while a gap derived from a trend estimated over the full sample has a zero mean over the sample period, recursively calculated gaps do not have this property.

Another issue is how to choose the threshold that defines ‘large’ deviations from trend. Below we use a 4% threshold for credit, 7.5% for property prices and 10% for the equity prices. Borio and Lowe (2002) argue that deviations of the credit-to-GDP ratio from a one-sided HP-filtered trend exceeding 4% are informative about the likelihood of future banking crises. The 10% threshold we use for equity prices is much lower than the 40–60% threshold recommended by Borio and Drehmann (2009). Nevertheless, using a 40% threshold, that is, the lower bound of the range proposed by Borio and Drehmann (2009), results in equity-price bubbles occurring only in Austria, Finland and Norway, which seems too restrictive. The choice of a threshold for property prices is even more difficult.

Borio and Drehmann (2009) argue that a threshold in the range of 15–25% is appropriate. Adalid and Detken (2007) use a 10% threshold with a minimum duration of 4 quarters, whereas Goodhart and Hofmann (2008) set their threshold at 5% but require a minimum duration of 12 quarters. Our 7.5% threshold lies between the values used by Adalid and Detken (2007) and Goodhart and Hofmann (2008).

In order to capture only persistent deviations, we require the deviations to exceed the threshold for four quarters. In addition, we set the thresholds such that we obtain a similar number of quarters that are classified as boom periods in all three cases.

In total, we have 424 quarters with large positive credit gaps out of a total of 1,656 observations. Moreover, our definition gives us 393 quarters of large equity-price gaps, which is comparable to the number of excessive credit gaps we have. Adalid and Detken (2007) also classify about a fourth of their total observations as boom periods though they apply their threshold to a combined asset-price index comprising equity and property prices. Finally, our threshold classifies 528 quarters as periods of property-price misalignments. Though this is slightly more than a quarter of the observations, a higher threshold would have excluded the boom episodes in Japan and the United States that are generally recognized as property-price bubbles.

In sum, while the choice of the threshold is arbitrary, the resulting episodes of asset-price misalignments broadly correspond to those identified in the literature. Moreover, though a change in the threshold of course leads to a reclassification of boom periods, the changes are relatively minor. What turns out to be more important is the way the trend is calculated, in particular whether past estimates of the gap are updated as more observations become available.

large, we estimate the models country by country without restricting the regression coefficients to be identical across countries. In total, we have 2,880 different regressions (i.e., for 18 countries, 8 models and 20 time horizons) for each variable we want to forecast.[20] For inflation, we assess how well the models predict the price level over the forecast horizon.[21] By contrast, for the output-gap models we report the predictive ability in a specific quarter, which entails the assumption that the alternative models lead to the same trend forecast as our benchmark model.

[20] Since financial imbalances (as defined in Section 3) have not been present in all countries, the number of countries for which the Models P and EP can be evaluated declines to 17, whereas the results for Models C and CE relate to 16 countries and those for Models CP and CEP to only 15 countries.

[21] We are grateful to an anonymous referee for making this suggestion.

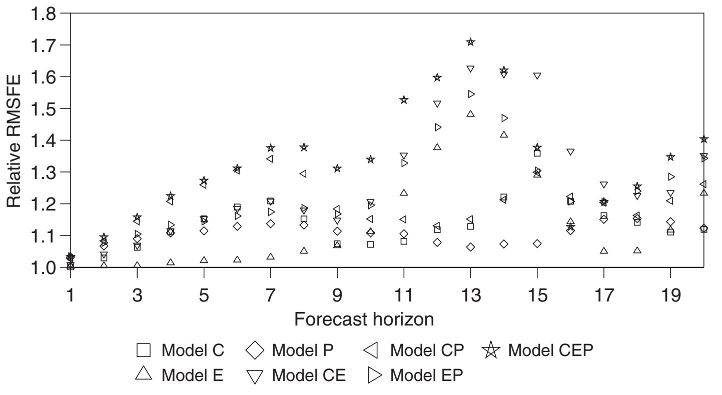

Figure 6. Relative predictive ability for the output gap

Figure 6 shows the predictive ability of the alternative models relative to that of the benchmark model. Values above unity indicate that the alternative model performs worse than the benchmark model containing only past inflation, the output gap and the interest rate. We conclude that there is no evidence that the gap variables have any predictive power beyond that included in the current output gap, inflation rate and short-term interest rate. Not surprisingly, Model CEP with the highest number of additional regressors, generally performs worst, indicating that the gap variables mainly introduce noise.

We next turn to the information content of the gap variables for inflation. Figure 7 indicates that the alternative models also in this case perform worse than our benchmark model, especially at longer horizons. In particular, models including equity prices lead to a large deterioration of predictive ability, indicating that inflation is largely unrelated to stock-market developments.

4.2. Robustness analysis

We explore the robustness of our results in several ways. First, we increase and decrease the thresholds that define the gaps by half. While decreasing the thresholds by 50% has almost no effect on the ability of the models augmented with the credit and asset-price gaps to predict the output gap and inflation, the forecast performance can be enhanced by increasing the thresholds, although it remains much worse than for the benchmark model. Overall, we conclude that the poor forecast performance of the gap variables is not due to the choice of the threshold.

Second, we disregard the thresholds and use simply the deviation of asset prices and credit from trend. While the model augmented with equity prices forecasts the output gap better than the benchmark model for horizons of less than five quarters, the other augmented models all generate less precise forecasts for the output gap and inflation than the benchmark model.

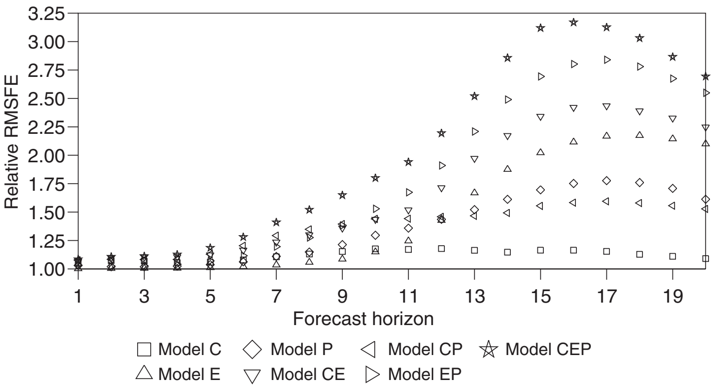

Figure 7. Relative predictive ability for inflation

Third, we use quarter-on-quarter growth rates of the credit-to-GDP ratio, real property and real equity prices instead of deviations from trend. Though the literature stresses that the build-up of disequilibria is not captured by growth rates, the quarterly growth rate of the financial variables generates better forecasts than the benchmark model for the output gap and for inflation at horizons of less than six quarters. At longer horizons, however, the benchmark model generally still performs best.

Finally, we considered output growth as the dependent variable instead of the output gap. As in the case of inflation, we evaluate whether the regressions are able to predict the level of output (i.e. the cumulative growth) over the forecast horizon. Interestingly, output is easier to predict than the output gap, perhaps because the output gap is a derived variable that is subject to revisions when the estimate of the trend changes. It turns out that the best results are obtained using no thresholds and the growth rates of the financial variables as regressors. Figure 8 shows that the majority of financial variables is helpful in predicting output up to five quarters ahead and at horizons of more than three years.

While the figure indicates that financial variables help to predict future output growth it does not indicate how useful this information is in practice. We therefore test for how many countries the improvement in forecast performance shown in Figure 8 is significant. Figure 9 presents results from tests of equal forecast errors for seven models augmented with the growth rates of financial variables relative to the benchmark model. Since our models are nested, we use the F-test proposed by Clark and McCracken (2001) in order to assess how frequently the forecasts from the alternative models significantly improve on those from the baseline model.[22] At

[22] The Clark–McCracken test is valid for one-step-ahead forecasts. For multistep forecasts the distribution applies if the unrestricted model contains one additional regressor, which is the case for Models C, E and P (see Clark and McCracken, 2004). For the other models, the asymptotic distribution depends on nuisance parameters and the results thus have to be interpreted with care.

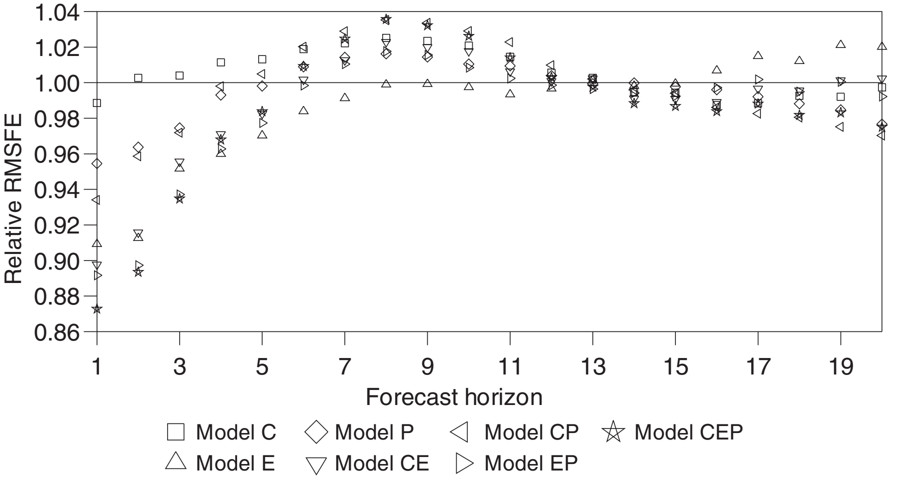

Figure 8. Relative predictive ability for output growth using growth rates of financial variables

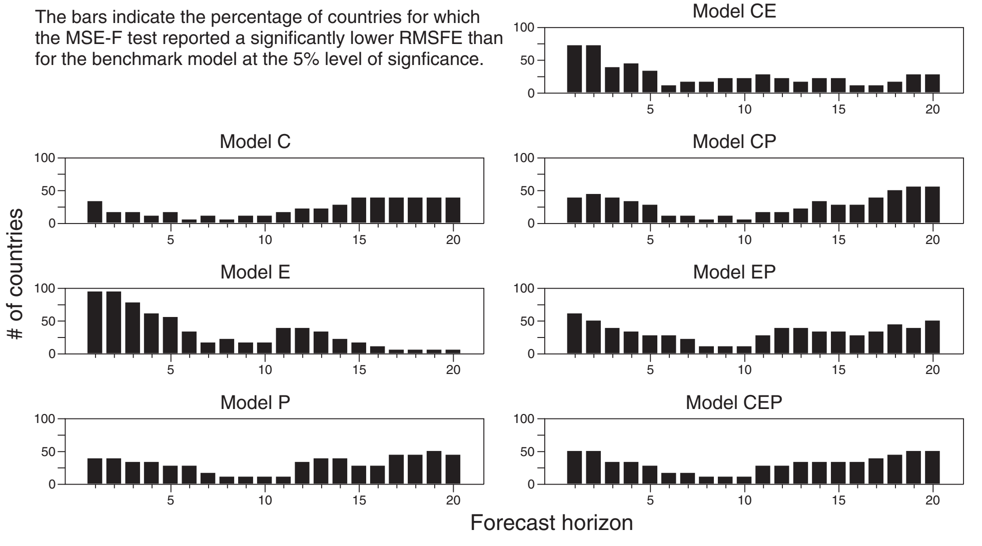

Figure 9. Clark-McCracken tests for output growth with growth rates of financial variables

short horizons of one to two quarters the most noticeable improvement can be seen for models including equity prices, where forecasts improve for half or more of the countries considered. At long horizons, however, it is credit and property prices that contain information for future output. Nevertheless, even the best performing model containing credit and property prices significantly improves predictions only for about half of the countries considered.

Overall, these results suggest that while there is some information in credit and asset prices for inflation and output, detrending these variables reduces their forecasting ability. Moreover, while equity prices seem to contain information for output in the short term, their ability to provide useful long-term forecasts is limited.

So far we have only discussed the forecast precision of the different models that include the gap variables, relative to our benchmark model. A final question concerns how useful all these models are relative to a naive forecast that assumes that the output gap and inflation will equal their historical means. It turns out that for inflation all the models considered provide better forecasts than the naive model even at long horizons; for the output gap the naive forecasts beat all the models for horizons of five quarters or more.

4.3. Predicting adverse macroeconomic conditions

Despite our extensive specification search, the results above suggest that credit and asset-price gaps do not help predict output and inflation. But these exercises assume that the central bank is equally concerned about all macroeconomic outcomes. We therefore next explore whether measures of financial imbalances contain information useful in assessing the risk of AMCs.

So far we have studied the forecasting performance on a country-by-country basis. When predicting the occurrence of AMCs, however, we often have only one or two such episodes in the data for each country. We therefore move to a panel setting, estimating the forecasting regressions jointly for all countries but allowing for country-specific intercepts (fixed effects). Moreover, when assessing the forecast performance of the model it is important to capture as many episodes of AMCs as possible. Since the panel increases the degrees of freedom, we start our forecasting exercise in 1995.[23] In that way we can explore whether the models forecast the recession that occurred in many countries around 2001 and the current recession.

In defining AMCs we rely on the indicators discussed in Section 3.3. Thus, when using the output gap, we identify an adverse output state as a situation with the average output gap for the current and the next three quarters of less than –1%; an adverse inflation state is defined as the annual inflation rate being either negative or falling by more than two percentage points over the current and the next three quarters. The occurrence of such severe events is captured by an indicator variable that takes the value of unity if the event occurs and zero otherwise.

We compare the predictive ability of our benchmark model over forecast horizons up to 20 quarters ahead, to the alternative models shown in Table 1. As before, we interact the gap variables with an indicator that signals financial imbalances.

[23] Our initial sample for the one-step-ahead forecasts thus consists of 630 observations, of which 136 are classified as AMCs when relying on the output gap. Moreover, there is sufficient country variation in the indicator for adverse output states across countries which allows us to estimate the initial model. Furthermore, the number of observations rises as the model is re-estimated.

In a probit model the dependent variable is a zero-one indicator that signals if a certain event occurred at a specific observation. The model is said to predict an event if the estimated probability exceeds a given cut-off level. The choice of a cut-off level entails two types of errors. First, some adverse states may be missed (type I error) and, second, some 'normal' states may be incorrectly classified as adverse (type II error). Changing the cut-off level increases the probability of one type of error relative to the other. To evaluate the predicted probability of a model, we choose the cut-off level that minimizes the average share of type I and type II errors in the sample on which the model is estimated. Moreover, following the literature on predicting asset-price bubbles, we regard a forecast as correct if the predicted event occurs within the coming four quarters.

The literature on crises prediction generally measures the usefulness of a probit model by its noise-to-signal ratio. It is defined as the share of 'false alarms' (type II errors), divided by the share of correct signals, that is, fields [B/(B+D)]/[A/(A+C)] in Table 2. The noise-to-signal ratio is useful if the sample has only few occurrences of AMCs since in that case a naive forecast of the economy being in the 'normal' state at all points in time leads to a high share of correct predictions. For a model to predict better than a purely random indicator, the noise-to-signal ratio should be smaller than unity.

Figure 10 shows that all models are useful for predicting adverse output states for horizons of up to 12 quarters ahead. At forecast horizons of more than three years the noise-to-signal ratio exceeds unity, meaning that the models do not have predictive power. More importantly, the benchmark model generally produces lower noise-to-signal ratios than the alternative models for the time horizons during which the model forecasts are useful.

We next investigate the models' ability to predict adverse inflation states. Figure 11 shows that for adverse inflation states most models deliver useful forecasts as the noise-to-signal ratios are generally below unity. Nevertheless, also in this case the benchmark model forecasts better than the alternative models. Only at horizons of 18 to 20 quarters does the inclusion of the financial gaps improve forecasts of adverse inflation states.

4.4. Robustness of the probit results

Next we explore robustness of our forecast results along several dimensions. First, we decrease and increase by 50% the values of the thresholds that define finan-

Table 2. Noise-to-signal ratio

		True state of the economy	
		AMC	No AMC
Predicted state of the economy	AMC	Correct prediction (A)	Type II error (B)
	No AMC	Type I error (C)	Correct prediction (D)

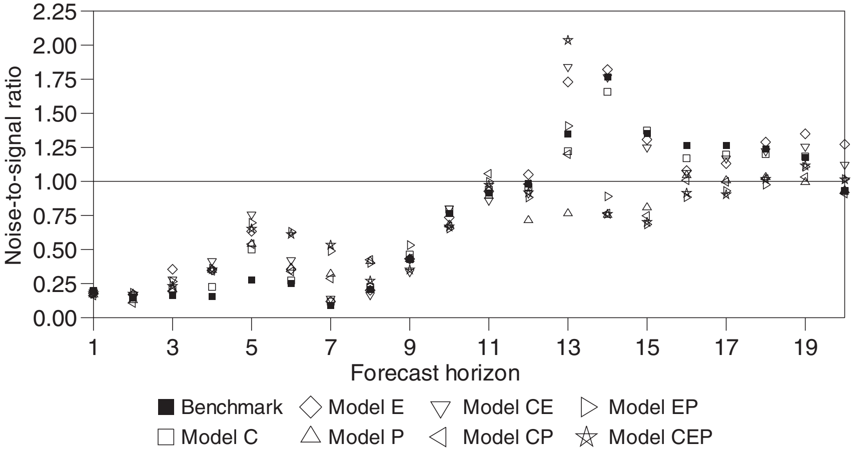

Figure 10. Noise-to-signal ratio for adverse output states

cial imbalances as measured by credit and asset prices. Lowering the thresholds or not using any threshold at all generally worsens the forecast performance of the alternative models for adverse output and adverse inflation states. Interestingly, the benchmark model continues to deliver the most precise forecasts over a horizon of up to 12 quarters. For adverse output states, none of the models provides useful forecasts at longer horizons as evidenced by a noise-to-signal ratio above unity.

Second, we use the quarterly growth rate of financial variables in the regression instead of the gaps. Forecasts remain basically unchanged compared to those presented in Figure 10 and Figure 11. For a few models, however, mainly those including credit and/or equity prices, forecasts improve slightly at forecasts horizons of three to six quarters though the difference in the noise-to-signal ratios is small.

Third, we redefine an adverse output state as output growth being below its country-specific mean for four quarters but find that the results are unaffected. The results are more favourable when we use the change in the financial variables as regressors but only for a forecast horizon of up to six quarters.[24]

Fourth, we explore the sensitivity of the results with respect to the window used to evaluate the models' signals. Classifying a forecast as correct only if the event occurs in the quarter for which the forecast is made (rather than during a four-quarter period), the noise-to-signal ratios increase. Moreover, the models provide useful forecasts only up to nine quarters ahead although the noise-to-signal ratios

[24] We also consider a business-cycle indicator from the Economic Cycle Research Institute as our dependent variable, which uses a similar methodology as the NBER to compute business-cycle chronologies for a number of countries. This indicator is only available for 12 countries in our sample. Nevertheless, the forecasting results are comparable to the results we obtain when using our AMC indicator for adverse output states.

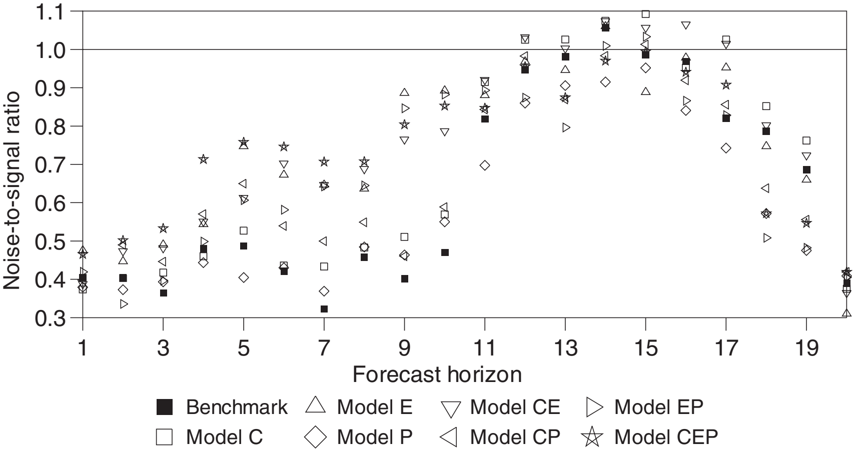

Figure 11. Noise-to-signal ratio for adverse inflation states

exceed unity for some models also at the four-to-five quarter horizon. When considering an eight-quarters window, the forecasts deteriorate compared to the four-quarters window. We conclude that the models can at best forecast whether an AMC may develop in a specific four-quarter interval but are unable to provide a policy-maker with a more precise timing of a severe downturn.

Fifth, we investigate whether model forecasts are robust with respect to the weight attached to type I and type II errors. By construction the noise-to-signal ratio puts heavy weight on the correct prediction of the rare state, accepting a high share of false alarms. Figure 12 therefore shows the share of correct predictions (i.e., cell A in Table 2) of adverse inflation states and the share of type II errors in percent for the same models as Figure 11. It is apparent that the forecast performance of all models is quite similar. Moreover, at longer horizons the share of false alarms is about as high as the share of correct predictions. This is unfortunate, since a false alarm may be more costly than a missed crises, as Alessi and Detken (2009) argue, because a central bank would pre-emptively tighten monetary policy without an asset-price bubble actually developing, which would entail an unnecessary loss in output.

4.5. Summary

While we recognize that our forecasting exercise is subject to several caveats, we believe that it provides little evidence in support of the activist view. One can imagine several different reactions to this finding.

First, it could be argued that the sample period we study was far too placid to contain much variation – and thus information – in the data. However, as we discussed earlier, we think it would be imprudent to base policy on older data that

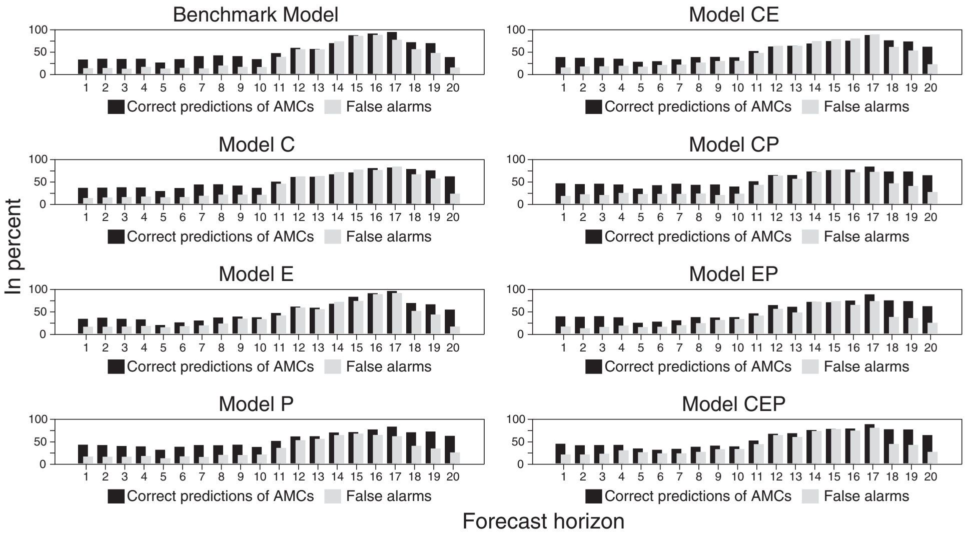

Figure 12. Correct predictions and false alarms for adverse output states

was generated during a period with a very different monetary policy regime in place.

Second, it may be that the lack of support for the activist view arises because the measures of financial imbalances that we study are too coarse, in particular since they lack any theoretical underpinnings. This critique of course applies to all studies that have used indicators of financial imbalances of the type pioneered by Borio and Lowe (2002). For instance, one possibility would be to use price-earnings ratios (or dividend yields) to try to detect bubbles in equity prices and analogue constructs to assess property prices. We are sympathetic with this view; here we only show that the measures of financial imbalances proposed to date do not contain much useful information.

Third, one may hypothesize that using better data, in particular on property prices and credit, may improve the forecasting performance. While this possibility is worth exploring, to date there is little indication in the literature that the information content of the indicators of financial imbalances are sensitive to the exact choice of data. We are therefore doubtful whether this will lead to better out-of-sample predictions.

Fourth, it could be that we find no forecasting power for the various measures of credit and financial imbalances because such measures were indeed used by the monetary policy-makers as indicators of future 'macroeconomic' disruption. Thus they might not have any forecasting power due to policy reactions that, if successful, eliminates totally or in part their correlation with future outcomes. However, few central banks, if any, have to date declared that they have been leaning against asset prices. Indeed, a primary policy issue at the time of writing is whether they should start to do so. Thus, we do not believe that this is the reason for the poor forecasting performance.

Fifth, one may argue that the lack of predictive ability reflects the inherent problem of forecasting rare events on the basis of a short sample, and that one should not overestimate the lack of statistical power. While we agree with the first part of that statement, whether the second part makes sense depends on the costs of tightening monetary policy in response to a perceived bubble which in fact is not one; in the next section we show that these are large. Thus, we find the issue of statistical power is germane and not merely of academic interest.

But even if these criticisms contain a grain of truth, it seems that the forecasting ability of these measures of financial imbalances is more limited than the proponents of the activist view believe.

5. CAN MONETARY POLICY INFLUENCE ASSET PRICES?

Next we turn to the question whether a tightening of monetary policy can help prevent asset-price bubbles from becoming too large without causing an excessive contraction in real economic activity or a large decline in inflation. Assenmacher-Wesche and Gerlach (2008c) study the effects of monetary policy shocks using a panel vector autoregression (VAR) incorporating prices, real GDP, interest rates, credit, property prices and equity prices, estimated on data on the same countries studied here. They demonstrate that the effects of monetary policy shocks on real economic activity are large relative to those on property and equity prices, suggesting that a leaning-against-the-wind policy is likely to be costly in terms of output foregone. Furthermore, while equity prices respond rapidly to monetary policy shocks, property prices decline only gradually. These different time profiles suggest that it is difficult to stabilize both asset prices.

However, that analysis is subject to three shortcomings. First, the estimates stem from a sample period in which few, if any, central banks leaned against asset prices. This raises the possibility that the behaviour of the economy could change if central banks announced that they would lean against financial imbalances and proceeded to do so. If so, it is sometimes argued, rising asset prices would not attract new investors that borrow to enter the market and sustain the upswing since they would expect the central bank to tighten monetary policy if prices rose too sharply. Thus, provided that central banks' announcements are credible, bubbles may never form. Under this view, no past data can contain information about a leaning against the wind policy. However, another interpretation of such a policy is that, in practice, few central banks would lean heavily against a credit and asset-price boom in light of the limited signalling properties of indicators of financial imbalances. Thus, an activist policy may in fact be broadly similar to the current conduct of monetary policy by many central banks, except that on occasion interest rates would be changed marginally in response to asset-market developments. Under this view, past data would be informative about the behaviour of the economy even under a new leaning-against-the-wind policy.

Second, Assenmacher-Wesche and Gerlach (2008c) do not incorporate credit in their analysis. Rapid expansion of credit has played a central role in many historical episodes of financial bubbles and one naturally hesitates to accept an analysis that disregards it.

Third, the estimates assume that there is a single regime in force, an assumption that clashes with the idea that bubble periods in some sense are different from other periods, for instance, because 'irrational exuberance' dwarfs the effects of monetary policy. Following the approach of Goodhart and Hofmann (2008), who estimate a VAR separately for boom periods, which they treat as exogenously given, we re-estimate the panel VAR in Assenmacher-Wesche and Gerlach (2008c), but allow the parameters to shift depending on whether the credit gap signals that a financial imbalance is forming.

Below we present impulse responses for booms and normal times from a panel VAR to study the effects of monetary policy on asset prices, real economic activity and inflation under the assumption that a leaning-against-the-wind policy may not be so different from the conduct of monetary policy in recent years so as to render past data uninformative.[25] Impulse responses from a non-linear system are more difficult to interpret since they depend on the initial state of the economy and on the type of shock hitting the system. In particular, the analysis reported below assumes that during the time horizon for which the response is calculated the system does not change from one state to the other.

Figure 13 shows the impulse responses of the variables in the system to a monetary policy shock during episodes of financial imbalances and normal times. The solid line shows the reaction to a 25 basis point increase in the short-term interest rate during periods with financial imbalances, together with the 68% confidence bounds (dotted lines). The long dashes are the median impulse-responses in normal times. The shaded area indicates the 68% bootstrapped confidence interval for those times.

We first discuss the reactions of the variables to a 25 basis point monetary policy shock in normal times. After a monetary policy shock the interest rate slowly returns to its initial level. The consumer price index (CPI) and real GDP start to fall. Real credit increases on impact but then decreases following real GDP, suggesting that the decrease is demand driven. Property and equity prices decrease ahead of GDP, which is compatible with the existence of a wealth effect that impacts on consumption. While property prices decrease gradually, equity prices reach their trough in the first quarter after the shock, suggesting that it may be difficult to stabilize both at the same time.

[25] Details on the specification of the VAR and the identification of the impulse responses can be found in the appendix.

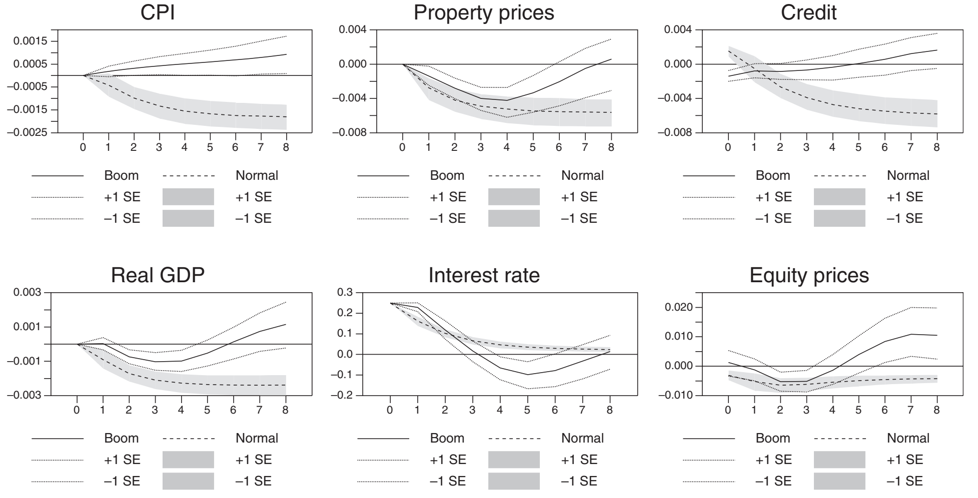

Figure 13. Impulse responses to a monetary policy shock during credit booms (solid) and normal times (dashed, shaded)

The estimated responses in normal and boom times warrant several comments. First, the dynamics in boom times are less precisely estimated since they are based on a smaller number of observations. As a consequence, only rarely are the differences between the normal response and the response in boom times significant. Second, the responses in boom times are more volatile. This is true for the interest rate, which falls below baseline after four quarters after the monetary policy shock, leading real GDP, equity prices and credit to return to baseline much quicker in boom periods than in normal times. Third, while the CPI falls in response to a monetary policy shock in normal times, there is a price puzzle in boom times, suggesting that the price level is unaffected or even rises when the interest rate is increased. Fourth, while in normal times credit falls only after two quarters, in boom periods it falls immediately. Fifth, while the trade-off between asset prices and output is slightly more favourable during boom periods than in normal times, in the sense that a monetary policy shock induces a larger reaction in asset prices and a smaller reaction in GDP, the differences are small.

Our results for normal times are comparable to the estimates of Jarocinski and Smets (2008). We find a 0.12% deviation of GDP and a 0.5% deviation of residential property prices after a year in response to a 25 basis point shock in the interest rate. The response in equity prices is slightly larger with 0.6%. Nevertheless, this indicates that monetary policy faces a high cost when attempting to stabilize asset prices. Table 3 shows that, if the central bank tries to bring equity prices down by 10% (which was our definition of a financial imbalance) back to trend after two quarters (which is the time horizon at which monetary policy, according to our estimates, has the largest impact on equity prices), this would require an increase in the interest rate by 3.8% and reduce output by 2.6%. Of course, this may be less

Table 3. Financial sacrifice ratios in normal and boom times

10% drop in	Interest rate reaction		GDP reaction	
	Boom times	Normal times	Boom times	Normal times
Equity prices	5.27	3.81	−1.36	−2.62
Property prices	8.82	5.88	−2.28	−4.04

of a concern if the central bank responds to output consequences of a financial bubble. Looking at the estimates in Table 3, however, it turns out that in that case monetary policy would need to raise interest rates even more strongly and GDP would still fall by more than 1%. Moreover, this policy is no different from a standard flexible inflation targeting strategy.

The table shows the reaction necessary to induce a 10% drop in equity or property prices and the ensuing reaction of GDP, based on the estimated impulse-response functions shown in Figure 13.

Overall, our findings imply that monetary policy has a relatively large impact on economic activity, suggesting that leaning against asset-price increases may have large output costs.[26]

6. CONCLUSIONS

The current financial crisis raises again the question what role financial stability considerations should play in the setting of monetary policy and, in particular, whether central banks should lean against credit and asset-price bubbles. In this paper we study two aspects of this question.

First, we explore whether macroeconomic measures of financial imbalances defined by the deviation of credit, property prices and equity prices from one-sided trends can serve as useful policy indicators. This is an important issue since it seems plausible that such measures contain information about future economic activity and inflation beyond the traditional two-year horizon used by most central banks when setting policy. Evidence that such financial imbalances are forming might lead central banks to conclude that, unless the bubble is checked, it will grow larger and its eventual burst may cause deflation and a collapse in output.

The data we study here, which stems from 18 countries and span more than 20 years, do not support the notion that such indicators of financial imbalances contain useful information for predicting the future economic conditions. While other indicators and the use of better data may overturn this conclusion, we believe that the information content of popularly proposed indicators of financial imbal-

[26] These reactions are symmetrical and do not depend on the fact that we are considering a cut in interest rates.

ances based on credit and asset-price data is much less than many authors have argued. This suggests to us that it would be more important to explore how policies making the financial system resilient to shocks can be designed, rather than to focus on forecasting the unwinding of financial imbalances.

Second, we study the effects of monetary policy shocks on asset prices both in normal times and in boom periods. Interestingly, we find that a monetary policy tightening will be effective to slow asset price increases but it also has a large impact on real economic activity. As a consequence, tightening monetary policy to depress asset prices is likely to be costly in terms of real output foregone. Of course, this argument is irrelevant if an asset-price bubble is associated with an increase in economic activity. In that case, however, there is no need to lean against asset prices since a standard flexible inflation targeting strategy, which entails responding to deviations of inflation from target and to economic activity but not to financial developments *per se*, would require the central bank to tighten monetary policy.

That said, a leaning-against-the-wind policy could be thought of as an entirely new policy framework in which the central bank announces that it will react to financial imbalances and in doing so engenders stabilizing expectations. If this description is correct, there are no estimates that can be used to evaluate the effects of such a policy. But since the estimates presented above suggest that a leaning-against-the-wind policy would be costly in terms of real economic activity foregone, such policies must be adopted in the firm belief that the macroeconomic effects estimated here do *not* come to pass. That seems quite a stretch.

It should be recalled that these conclusions are drawn without a formal structural model of the economy. Such a model would be important for fully understanding the interactions between asset prices, credit and broad economic conditions, and the role of monetary policy. However, since no generally accepted theoretical model in which these questions can be studied exists at the present time, and since any conclusions about the conduct of monetary policy in the presence of asset-price bubbles are likely to be highly sensitive to the exact assumptions underlying such a model, we find it useful to proceed in an agnostic fashion. Of course, any theoretical model needs to account for the stylized facts established above.

In conclusion, standard measures of financial imbalances contain little information useful for forecasting future economic conditions, and reacting to them with monetary policy is likely to be associated with large output losses. The notion that an activist monetary policy strategy offers an effective way to deal with credit and asset-price bubbles seems to be a fiction poorly grounded in facts. In turn, this suggests that ensuring greater financial stability in the years ahead will require a much better regulatory and supervisory framework, which is the focus of much work at the present time.

Discussion

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This paper provides an empirical assessment of the question whether and how central banks in their role of monetary policy-makers should react to the build-up of asset-price bubbles. In so doing, it challenges what the authors call the 'activist approach', according to which central banks should react to, or lean against, signs of financial imbalances when setting monetary policy.

According to the activist approach, central banks should react to financial imbalances over and beyond what they imply for inflation at the 2- to 3-year policy horizon that central banks typically employ. The reason for this is that a bursting asset-price bubble can have disproportionately large effects on inflation and economic activity at longer time horizons than central banks normally consider when setting interest rates.

Four implicit assumptions underlie the activist approach. First, central banks can determine in real time what constitutes an asset-price bubble by looking for signs of financial imbalances that are supposedly easily identifiable. Second, such imbalances contain information that is useful for forecasting the likely future path of inflation and output, also beyond the 2- to 3-year horizon. Third, monetary policy can be used to influence asset prices. Furthermore, there is no risk of 'non-linearities' in the sense that a small increase in interest rates might lead to a collapse in asset prices and trigger a deep recession. Fourth, the improvement in economic performance resulting from a tightening of monetary policy to forestall an asset-price bubble exceeds the short-run costs of inflation falling below target and economic activity being weaker than it otherwise would have been.

The paper asks whether these assumptions are indeed supported by the data. In so doing, it considers quarterly data spanning 1986 to 2008 from 18 economies (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States). In particular, the authors focus on general insights that can be learned using a limited number of financial indicators.

First, are the signs of financial imbalances easily identifiable? The authors' answer is negative. Central banks, however, use much more information than the few time series the authors study, so their forecast exercise does little justice to the activist approach.

Second, have credit and asset prices any predictive ability? The authors show that indicators of financial imbalances have little forecasting power for inflation and the output gap, also at longer horizons. In other words, they have little additional informational content when inserted in a 'benchmark model' already including inflation, output gap and interest rate. In addition, the information contained in the gaps typically worsens the accuracy of forecasts for output and inflation and thus suggests that no importance should be attached to these measures of financial imbalances in setting policy.

Third, do financial imbalances help predicting adverse macroeconomic outcomes? The authors find that the majority of models including the gaps measuring financial imbalances lead to better forecasts than the benchmark model. However, although the financial gaps improve the forecasts, they remain far from satisfactory.

Fourth, can monetary policy influence asset prices? Overall, monetary policy has a relatively large impact on economic activity, suggesting that leaning against asset price increases may have large output costs.

Overall, this is a timely well-written paper. While building on previous and parallel works by the same authors, its contribution is accurately placed into context. However, whereas the findings are generally convincing, their interpretation is less so. The first issue is that the authors work on a somewhat partial (partisan?) representation that makes life hard for what they call the 'activist approach'. They occasionally admit this is the case, but they tend to give little weight to this aspect in the readings of their findings.

The second issue is that, though well informed about the theory, the authors take their empirical findings a bit too much at face value. Again, they occasionally wonder this might be the case (e.g. role of credible announcements, Lucas critique, etc.) but tend to be rather dismissive. There is only somewhat limited effort at discussing an underlying model or story that could tell us which additional variables we should incorporate in the analysis.

To summarize, the presentation of the findings in terms of activist versus wait-and-see approaches in the presence of potential bubbles is sometimes too simplistic and may not convey the right message about the findings of the paper. It is not even clear that it helps to shed light on the key questions: 'Can we learn anything from the crisis? Should we rethink the information set on which monetary policy is based?' In other words, if central banks faced again exactly the same evolution of financial variables within exactly the same regulatory framework we had before this crisis, should they care or not? The authors' concluding answer is negative: 'The notion that an activist monetary policy strategy offers an effective way to deal with credit and asset-price bubbles seems to be a fiction poorly grounded in facts.' A more precise reading of their findings seems instead to be the following: The notion that 'coarse measures' of financial imbalances provide relevant guidance for an activist monetary policy based on theory-blind econometric models cannot be grounded on facts.

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This well-written paper deals with a timely and important question, in particular in view of the rather widespread perception that monetary policy has been one of the contributing factors to the current financial and economic crisis. During and after the burst of the dotcom bubble, the US Fed quickly and drastically lowered official interest rates, but it was too slow to raise them as asset and property prices started to pick up again, thereby creating the conditions for the emergence of new price bubbles, as is sometimes argued. However, this paper suggests that this conclusion is false. It demonstrates that asset prices contain little predictive power about future output and inflation above and beyond the information already contained in macroeconomic variables. Using a panel VAR analysis it also shows that deflating asset bubbles may be costly in terms of economic activity. Interestingly, in this latter exercise, the paper distinguishes regimes of 'normal times' and 'boom times' in calculating impulse responses. Under both regimes a moderate reduction in equity or property prices requires a substantial output loss. Hence, the paper draws the broader conclusion that monetary policy is not a substitute for a better regulatory and supervisory framework.

The theoretical consequences of financial imbalances are distortions in economic and financial decisions, in particular over-borrowing and over-investing as a result of capital gains and higher collateral values. At some moment, the bubble bursts, after which the economy suffers from excess capacity, low investment and low consumption spending. This suggests that by smoothing the course of asset and property prices, the 'real economy' will also follow a smoother trajectory, thereby avoiding the potential welfare losses associated with unnecessary fluctuations in the economy. Earlier empirical work quoted in the paper indeed indicates that financial imbalances carry substantial macroeconomic costs. For example, the IMF's World Economic Outlook (2003) estimates those costs at 4% of GDP for an equity burst and at 8% of GDP for a housing bubble burst.

In the presence of these possible spill-overs of financial imbalances onto the macroeconomy the central bank faces several options. One is to simply wait and see. A second is to include asset prices in the price index that the central bank is targeting. A third option is to eliminate bubbles by tightening. However, as argued by Kohn (2008), the complications are that bubbles are difficult to identify and that a monetary contraction may come too late, thereby acting in a destabilizing way. Finally, there is the possibility to 'lean-against-the-wind'. That is, tighten in an early stage and err on the side of caution. It is sometimes claimed that the mere awareness that this policy is followed already prevents bubbles from emerging (Cecchetti *et al.*, 2000). However, this would only be the case if the central bank can commit to contracting in response to emerging imbalances and this in turn depends on the macroeconomic costs of such a contraction.

Part of my comments concerns the need for a deeper investigation into the weak predictive power of financial imbalances for the macroeconomy. The authors define financial imbalances in deviations from trend, while moreover the trend is estimated recursively, which could render its estimates rather inaccurate at the beginning of the sample. An alternative would have been to estimate the trend over the entire sample of data. However, the (maybe unintended) advantage of the present approach is that the authors essentially work with the data and trend estimates available to central banks at the moment they needed to decide whether or not to respond to financial imbalances. The inaccuracy in the data reflects the uncertainty policy-makers had about the consequences of financial imbalances for the macroeconomy. Seen from this perspective, it may also not be so surprising that the constructed figures for the financial imbalances contain little predictive power for inflation and output above and beyond that already contained in macro variables.

A more fundamental question is whether deviations from trend form the most relevant measure of fiscal imbalances to predict the future macroeconomy. *Grosso modo*, over time and until recently, we have observed upward trends in all three measures of fiscal imbalances. In many cases the trend itself captures most of the overall movement in the underlying variables. One may ask whether the trends in these variables, or even their total levels, are the more relevant measures for predicting the future course of the macroeconomy. In this connection one might ask what is the fundamental difference between the trend component and the deviation from trend in predicting the future course of the economy? More specifically, could the current economic crisis, which is the deepest since the Great Depression, not at least be a partial consequence of a long-term trend increase in credit and asset values relative to GDP? It seems that we are in a desperate need for a good theoretical model to make those judgments.

There may be other plausible reasons why financial imbalances provide little predictive power for inflation and output. On the one hand, country-specific factors could play an important role. For example, over the past 15 years my own country, the Netherlands, saw a combination of increased female labour participation (and, hence, rising household incomes), relaxation of borrowing rules and an inelastic housing supply result in rapidly increasing residential property prices. Those factors had little to do with over-optimistic market sentiments and the only conceivable sources of a collapse of property prices would be a reversal of those factors or adverse macroeconomic developments, such as higher interest rates or a recession. However, those developments are already captured by the benchmark model. Indeed a central bank which considers reacting to emerging financial imbalances would be well advised to first analyse the sources of those imbalances. On the other hand, the benchmark models and their variations may unduly neglect the role of international factors. For many other countries, and in particular small open economies, US financial imbalances may play as an important role for the domestic economy as national imbalances do, if the accumulation of US imbalances has indeed adverse repercussions for the United States and thereby for the world economy.

My final set of remarks addresses the panel VAR analysis. Some further scrutiny of the identification strategy would have been desirable. In particular, the authors could have tried to order property prices after the interest rate, the logic being that an increase in the interest rate is transmitted into the cost of a mortgage and thereby also affects the demand for property. However, the more substantial issue concerns the rather strong conclusions drawn from this analysis. The results show a relatively small effect of a monetary contraction on asset prices relative to output, which makes the authors sceptical about the leaning-against-the wind approach; a moderate fall in equity or property prices would only be achieved at a high output cost. The conclusion that a leaning-against-the-wind approach is unduly costly seems premature. An evaluation of the cost of leaning-against-the-wind would require a breakdown of the analysis in several steps. First, how frequently does a small financial imbalance develop into a large and potentially dangerous financial imbalance? If this frequency is low, the opportunity cost of a monetary contraction is large, *ceteris paribus*. Vice versa, if this frequency is high. Second, to what extent might even a small negative effect on asset prices prevent a dangerous self-fulfilling spiral in asset prices? If such a small movement in asset prices is enough to deter a bubble, it might be well worth a small monetary contraction at an early stage of build-up of financial imbalances. Then, given that a large financial imbalance has developed, how likely is it that it results in a substantial correction that, moreover, has seriously negative consequences for the economy? Extreme imbalances would typically be those that arise from over-optimism and self-fulfilling expectations that in turn result in the abovementioned economic distortions. This inspiring paper raises a number of unanswered questions that provide fruitful thought for policymakers.

Panel Discussion

Kevin O'Rourke suggested that central banks should not only take account of output inflation but should also be concerned with the cost to the taxpayer of bank bailouts, for example. Huw Pill mentioned that research in the ECB has focused on the relationship between global financial imbalances and crises. The findings suggest that national financial imbalances do not play an important role and echoed the author's findings. On the merits of forecasting, Huw Pill believed that central banks have to care about the indefinite future and that focusing on a 2- to 3-year time horizon is a practical shortcut and not a statement of their mandate. He agreed that some aspects for modelling monetary policy such as financial imperfections are still lacking. The implications of these shortcomings are that while 2- and 3-year forecasts can be accurate for a long period, forecasts can be badly wrong on occasion and it is important to take this into account. He believed the work done by the authors on the low frequency movement of money and credit and their association with prices is very constructive in providing information on the medium term.

APPENDIX: DEFINITION OF THE DATA

Our VAR system consists of the CPI, real GDP, real property prices, the short-term interest rate, real credit and real equity prices. We distinguish between 'normal' times and episodes of financial imbalances, which we identified as periods in which the credit gap exceeds 4%. The reason for not choosing the equity or property-price gap as the indicator is that we are mainly interested in the response of property and equity prices to monetary policy shocks. By selecting episodes based on the property-price and equity-price gap indicators we bias results to finding large increases in these variables after a monetary policy shock since we estimate the coefficients on periods in which asset prices rose considerably. By interacting all right-hand side variables in the VAR with the chosen indicator, we can estimate the impulse responses to monetary policy shocks under the hypothesis that there were financial imbalances and compare them to the impulse responses obtained for normal times.

We estimate the panel VAR using a combination of the fixed effects and the mean group estimator, which is simpler but close in spirit to the pooled mean group estimator proposed by Pesaran *et al.* (1999). It is well known that estimation of dynamic panels involves a bias (Holtz-Eakin *et al.*, 1988), but in our case the time dimension is large and this bias is likely to be negligible. What will matter, however, is the bias introduced by possibly heterogeneous slope coefficients across countries. The solution to this bias would be to use the mean-group estimator by Pesaran and Smith (1995). Since there are few episodes of imbalances in our sample, this strategy is not feasible with our data. As it is likely that the impact of the financial variables differs across countries due to different structures of financial markets, we interact the financial indicators with country-specific dummies in the VAR and use the average of the country-specific coefficients to calculate the impulse responses. By contrast, we assume that the coefficients on lagged inflation, output and interest rates are identical across countries. We estimate the VAR with two lags.

When calculating the impulse-responses to a 25 basis point monetary policy shock during boom and normal times, we assume that the system does not change from one regime to the other during the time horizon of the impulse responses.

Another implicit assumption is that the shock occurs at the moment when the credit gap equals the threshold. By having the threshold effect operating only at the time of the shock the non-linearity of the responses is likely to be underestimated (see Koop *et al.*, 1996).

In assessing the effects of monetary policy we focus on monetary policy shocks as opposed to systematic monetary policy since this is the empirical counterpart to asking what effect a change in monetary policy has (see Walsh, 2003, ch. 1). Though systematic monetary policy accounts for the main part of movements in the interest rate, an investigation of the effect attributable to monetary policy (comparable to the *ceteris-paribus* assumption in the theoretical model) requires disentangling the endogenous reactions and the exogenous shocks.

To identify monetary policy shocks, we use a Choleski decomposition, with the variables ordered as above. Note that to identify a monetary policy shock, only the relative position of the interest rate among the other variables in the VAR matters. While it is standard in the monetary transmission literature to order output and prices before the interest rate (see Christiano *et al.*, 1999), the inclusion of credit, property and equity prices warrants discussion. We chose to order property prices before the interest rate, under the argument that housing markets respond only gradually to changes in interest rates, but that underlying disturbances correlated with movements in the stock of housing can impact on interest rates within the quarter. In turn, this implies that credit and equity prices are ordered after the interest rate. Although central banks react to changes in credit and equity prices (because they influence aggregate demand and inflation pressures), barring exceptional circumstances one would not expect any reactions to be instantaneous but rather to occur if credit aggregates or equity prices rise or fall for some time. By imposing a triangular identification structure we thus assume that output, the price level and property prices react only with a lag to monetary policy shocks, whereas credit and equity prices may respond immediately.

To obtain the confidence bounds for the impulse responses we perform bootstrap simulations drawing from the two different sets of residuals for normal and for boom times. The simulated data then were reconstructed using the indicator variable. The confidence bounds are based on 1,000 replications.

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