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Asset Prices and Consumer Prices: Exploring the Linkages

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Abstract

It is a well-established fact in monetary economics that money and credit developments may affect consumer price inflation directly as well as indirectly via changes in asset prices, while at the same time asset price fluctuations can independently affect monetary and real developments. This has led to proposals to assign a more prominent role to asset prices in central bank's toolkit of leading indicators for future developments in consumer price inflation. In this study, we examine, in the context of reduced-form inflation equations, the importance of different variables (including standard explanatory variables) as well as some specific asset price variables (i.e., the changes in housing and equity prices, a yield spread and oil prices). Against this background, we make use of a panel approach, covering data for 17 industrialised countries and the euro area. Three main results emerge out of our analysis. First, a standard framework explaining current inflation by (lagged) developments in inflation, the output gap, short-term interest rates, oil prices, house and stock prices and the exchange rate seems to perform quite well, although the explanatory power of the equations decreases with the length of the time horizon. Second, as regards the role of asset prices, it can be shown that house price movements seem to provide more useful information on future consumer price developments than movements in equity prices. Finally, the results of the analysis show that broad monetary developments become more relevant as the time horizon lengthens. By contrast, equity prices and the yield spread seem to be somewhat less informative.

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1. Introduction

Most central banks are endowed with a mandate of maintaining price stability in terms of consumer prices. Given the usual lags in the transmission process of monetary policy, it is obvious, however, that central banks must act in a forward-looking way, which implies that they must rely on leading indicators for inflationary pressures. With consumer prices being subject to a certain degree of stickiness, it is a matter of fact that the effects of monetary policy manifest themselves inter alia in changes in asset prices. This outcome could in turn lead to the conclusion that asset prices would need to be encapsulated in the set of economic indicator variables used by central banks when forming an assessment about the future risks to price stability. The latter proposition, however, hinges critically on the forecasting performance of asset prices, which might differ from country to country depending – among other things – on the characteristics of the monetary policy transmission process.

The focus of this study is to examine the importance of explanatory variables in (reduced-form) inflation equations, which include asset price variables (such as, for instance, changes in housing and equity prices and a yield spread). For this purpose, use is made of a panel approach, covering data for 17 industrialised countries. Three main results emerge out of our analysis. First, a standard model explaining current inflation by (lagged) developments in inflation, the output gap, short-term interest rates, oil prices, asset prices and the exchange rate seems to work quite well, although the explanatory power of the inflation equations decreases with the length of transmission between the changes in the explanatory variables and the effects on inflation. Second, as regards the role of asset prices, it can be shown that house price movements seem to provide more useful information on future consumer price developments than movements in equity prices. Finally, the results seem to show that broad monetary developments become more relevant as the time horizon lengthens. By contrast, equity prices and the yield spread being somewhat less informative. Taken *per se*, this would speak in favour of a separate role for house prices and money in such a framework.

The paper is organized as follows. In Section 2 we provide some conceptual remarks regarding the interlinkages between asset prices and consumer prices. Section 3 presents a review of the recent literature. Section 4 describes the used data set for 17 industrialised countries, while the empirical results of the panel estimates are given in Section 5. Section 6 concludes.

2. Some Conceptual Remarks

Over the past decades, asset markets have played a growing role in macroeconomic dynamics. Policy-makers have become increasingly aware of the fact that sizeable changes and significant periodic corrections in asset prices may lead to financial and, ultimately, macroeconomic instability.[1] For example, rapidly rising asset prices are often associated with an easing of credit conditions, increased spending (on account of wealth increases and a relaxation of credit constraints) and, ultimately, inflationary pressures. The bursting of an asset price bubble, however, could imply significant financial losses by institutions and investors, and a sharp drop in aggregate demand, leading to deflationary risks via both direct wealth effects and instability in the financial sector.[2]

Moreover, a zero lower bound on nominal interest rates, as well as heightened uncertainties with respect to the monetary transmission mechanism in times of turmoil, could then make it more difficult for central banks to maintain price stability. The interaction between asset prices and monetary developments is, therefore, worthy of close attention.

At the same time, it is a widely accepted fact in monetary economics that nominal monetary shocks have real effects on activity primarily because certain prices and wages are 'sticky' and do not adjust pro rata. With prices / wages being sticky, the initial effect of monetary shocks is likely to be on (clearly more) flexible asset prices although, at least in theory, the combination of flexible asset prices and sticky goods / labour prices could lead to a tendency of 'overshooting' in asset prices, though strong empirical support for such phenomena is in practice hard to detect. This notwithstanding, it seems uncontested that the initial effects of monetary shocks are likely to be initiated via changes in asset prices, and much of the subsequent transmission mechanism will occur as a result of higher asset prices stimulating expenditures and activity.

Generally speaking, the exact process of transmission of changes in asset prices on aggregate expenditures can, in principle, work via a number of channels, such as, for instance, via Tobin's Q effects on investment, via wealth effects on consumption and via exchange rate changes on net trade (see, for example, Mishkin, 2016). At the same time, it goes without saying that the timing, strength and magnitude of the aforementioned channels is subject to a number of uncertainties and, therefore, cannot easily be measured with a sufficient degree of accuracy.

Regarding the question which kind of asset prices should be taken into account, it should be noted that the inclusion of the foreign exchange market has a long tradition in this respect.[3] This has its roots in the well-known fact that – at least for small open economies – a majority of activities and transactions are dominated by the effects of the exchange rate.[4] What distinguishes the foreign exchange market from

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1 See, for instance, Bernanke and Gertler (2000).

2 As shown in Reinhart and Rogoff (2014), the output losses are particularly strong if the financial crisis impacts to a significant extent on bank balance sheets.

3 For euro area evidence for an exchange rate channel based on VAR models, see for instance, Peersman and Smets (2003) or in the context of structural macroeconomic models, see van Els et al. (2003).

other asset markets, however, is that the former is *a priori* more sensitive to such developments in the foreign economy. In particular, a depreciation in the exchange rate may come about because of a collapse in output and prices abroad, and not because of a domestic expansion. So, although the importance of the exchange rate to economic developments is undeniable, the information content of exchange rate changes for domestic developments, taken on their own, may be quite low. Besides, like every other asset market in an economy, the foreign exchange rate can be affected by shifts in preferences, supply shocks, expectations of future returns and profits, and risk premia of various kinds, in addition to concerns about current and future interest rates, monetary growth and inflation. However, apart from the exchange rate, in the literature many studies have focused on the effect of property and equity prices on inflation.[5] Looking through the several channels of the transmission mechanism, an increase in property or equity prices, which positively affects private sector wealth, will lead to higher consumption demand and may feed into higher consumer prices via this "wealth effect" (see IMF, 2001; ECB, 2009). In particular, the larger is the share of residential property in total wealth, the stronger will be the effect of a change in residential property prices in private sector wealth and, therefore, more likely, consumer prices will be affected. What remains to be investigated in more detail from an empirical perspective is the degree in which the (perceived) difference between transitory or permanent changes in asset prices matter in this respect. For the OECD countries, the share of residential property in private sector wealth is between 60% and 80%, the share of commercial property between 5% and 20%, and the share of equities between 5% and 35%.[6] This implies that a change in residential property prices will affect private sector wealth much more strongly than the same change in commercial property or equity prices, and is thus also more likely to affect consumer prices.

Another channel mentioned above refers to the relationship between investment demand and equity prices as implied by Tobin's Q-theory of investment (see Tobin, 1969). Tobin's Q is defined as the market value of capital relative to the replacement cost of capital. If Q rises because of an increase in equity prices, firms can buy more capital for the equity they issue. This makes it more attractive for firms to acquire new capital and, thus, increases investment demand, which may again feed through into higher goods and services prices. As the capital stock gradually adjusts to its higher long-term value, Q will revert to a normal level. However, several factors may weaken this channel: uncertainty, adjustment costs and the irreversible nature

4 The dominant role, the exchange rate plays not only in the transmission process but also for the assessment of the monetary stance *per se* has led to the construction of so-called "Monetary Conditions Indices" which combine interest rates and exchange rates into a measure for overall monetary conditions. For a critical review, see Eika et al. (1996) and Peeters (1999).

5 According to theory, bond yields can provide a measure of the private sector's expectations of future inflation. See, for instance, Fisher (1930).

6 See Borio et al. (1994), p. 80, Table AI.2.

of investment decisions. Uncertainty regarding the future profitability of an investment and the existence of sunk costs imply, first, that waiting may be valuable, which affects the timing of investment decisions, and, second, that there may be threshold effects, which implies that rates of return may have to move substantially for an investment to be undertaken.

Asset prices may also affect consumer prices through the link between residential property prices and wages. Higher house prices, although not being included in the consumer price index, raise the cost of living for workers, thus causing them to demand higher wages. Firms may react to higher wage demands by raising their prices (for instance, by following a mark-up procedure), so that eventually goods and services prices increase. Other effects might arise due to the impact that stock prices may have on investment and consumption via "confidence effects". For example, a decline in stock prices may signal increased downward risks to future economic activity and employment, which may hurt consumer confidence and actual consumption spending.[7] Likewise, a general fall in stock prices may lead even firms that have not issued quoted shares to revise their profit expectations and investment plans downwards.

More recent work has put emphasis on the indirect impact of asset prices feeding into consumer price inflation via the "credit channel" (Bernanke et al., 1994; de Bondt, 2000). In particular, due to the imperfections in the credit market, firms and households may be constrained in their borrowing because of asymmetric information in credit markets, giving rise to adverse selection and moral hazard problems. The lower the net worth of firms and households, the more severe these problems are and, therefore, also the borrowing constraints, since there will be less collateral available to secure loans. A rise in asset prices improves the borrowing capacity of firms and households by increasing the value of collateral. Seen from that perspective, lending decisions may be influenced by the amount of collateral that borrowers can put up to secure their loan. In this respect, some studies seem to find a role for 'mortgage equity withdrawal' (Greenspan and Kennedy, 2007). This phenomenon is driven by a relatively high value of the housing stock, which makes it easier for borrowers to 'withdraw equity' by borrowing on mortgage for non-housing purposes. The additionally available credit can be used to purchase goods and services and may, thus, ultimately lead to higher consumer price inflation. At the same time, a part of the additionally available credit may also be used to purchase assets, pushing up asset prices even further, so that a self-reinforcing process can evolve. To the extent that higher asset prices stimulate expectations of future asset price increases and capital gains, the relevant real interest rate to borrowers falls. While in theory, except in the case of a bubble, asset prices should reflect the level that equates expected returns (adjusted for risk), in practice there often seem to be cases when expectations of abnormal future capital gains appear, at least superficially, to be driving bank lending, monetary growth and large segments of real expenditures. Simi-

7 For some euro area evidence, see for instance, Jansen and Nahuis (2003).

larly, during asset price booms, the balance sheet positions of financial and non-financial companies improve and the value of collateral increases, permitting a further extension of bank credit for firms' investments. Banks' leverage ratios fall with rising asset prices, allowing them to issue new liabilities (possibly increasing broad money). The additional funds of financial and non-financial companies might partly be invested in the booming asset, which would lead to further asset price increases – which represents again a self-reinforcing mechanism.

The role of credit market conditions has already been considered by Fisher (1932), amongst others, to explain the Great Depression. The interaction of credit and asset prices was reassessed by Minsky (1986), and has regained some popularity recently (see for example Bernanke and Gertler, 1989; Kiyotaki and Moore, 1997; Bernanke et al., 1998). These recent theoretical studies show how the interaction between credit limits and asset prices transmits shocks to the economy and may cause large and persistent business cycle fluctuations. This phenomenon is also referred to as the 'financial accelerator'.

Finally, as mentioned at the beginning of this section, the exchange rate also has a major influence on the economy. It is determined in the currency market, but affects prices at which goods and services are imported into the country. Another channel of influence runs from the exchange rate to the competitiveness of domestic and foreign output and, hence, to the level of activity in the domestic economy and its inflation rate.

Turning to the monetary perspective, the question arises whether asset prices can have an additional impact over and above monetary developments for consumer price inflation. In this respect, a number of remarks are worth noting. First and foremost, although there seems to be a consensus that the long-run link between money and prices is uncontested, it cannot be denied that – at least over shorter horizons – other factors, such as, for instance, asset prices play a role in that respect. Second, experiences in many countries have shown that asset prices changes (often triggered by financial innovation) can become a source of instability *per se*, and by impacting on velocity patterns, can disturb the long-run monetary relationships to a significant degree.

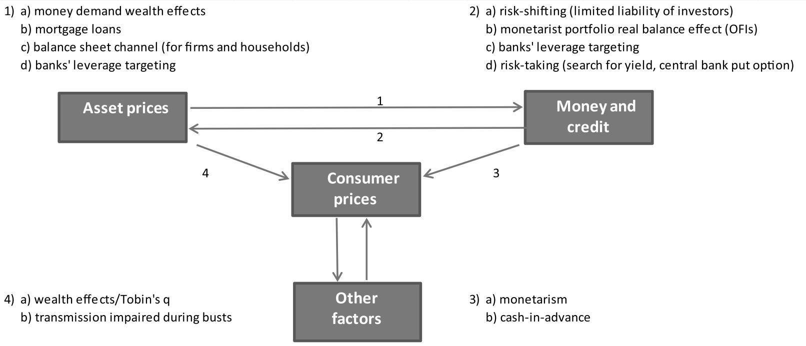
At the same time, money and credit can influence asset prices and then have a subsequent impact on consumer prices.

Overall, as regards the ultimate impact of money, credit and asset price developments on consumer prices, direct and indirect effects have to be distinguished (see Detken, Gerdesmeier and Roffia, 2010 and ECB, 2010). On the one hand, there is a direct link between money, credit and consumer prices working through the standard transmission channels in the presence of financial frictions such as, for instance, a "cash-in-advance constraint" (see arrow 3 in Chart 1). On the other hand, several indirect effects can be at work as explained above ("wealth effect", Tobin's q effect, through wages, "confidence effects") (see arrow 4 in Chart 1).

While the underlying trend in money and credit growth will be positively linked with consumer price inflation in the long run (arrow 3 in Chart 1), deviations from trend money and credit developments have been found to lead costly asset price boom-bust cycles, and may thus be associated with deflationary – rather than inflationary – risks at the time the bubble bursts (arrows 2 and 4 in Chart 1). Furthermore, the possibility of significant non-linearities exists, such that, at times (for example, in asset price boom periods) money and credit growth would predominantly fuel asset price inflation (arrow 2 in Chart 1), while strong monetary growth would, in normal times, be reflected in subsequent consumer price inflation (arrow 3 in Chart 1). Such a non-linearity would make the early warning and leading indicator properties of money and credit dependent on the prevailing bubble or no-bubble regime.

Finally, expectations of rising future income and the associated demand for housing may increase the expected fundamental property prices, thus leading to an increase in credit demand (see arrow 1 in Chart 1). At the same time, the causality might also run in the opposite direction (arrow 2 in Chart 1). For example, rising demand for assets stemming from increasingly leveraged investment positions may augment asset prices in a world with financial frictions. Furthermore, a high level of money holdings might signal a large amount of liquidity being invested in potentially higher-yielding opportunities, which could then fuel a bubble once a trend has been triggered and herding behaviour sets in. At the heart of this could be a real portfolio balance effect of other non-monetary financial intermediaries (OFIs): too much liquidity on their balance sheets would trigger the desire for portfolio reallocation, increasing the share of other assets.

Chart 1. Links between money/credit and asset and consumer prices



3. Review of the Recent Literature

In the recent decade, there have been different approaches to study the empirical link between asset prices and inflation. As regards the methods taken into consideration, the range covers, on the one hand, rather simple methods testing for an impact of asset on consumer prices in a time series framework as well as, on the other hand, more sophisticated procedures, such as large factor model approaches incorporating more than 100 data series to forecast inflation, including different kinds of asset price variables.

The study by Goodhart and Hofmann (2000) might serve as an ideal starting point. The authors test for the influence of asset prices in a consumer price inflation framework for a sample of 11 countries. The benchmark inflation equation in their time series framework can be described as follows:

$$\Delta cpi_{t+i} = \alpha + \beta_0 \Delta cpi_{t-j} + \beta_1 \Delta gdp_{t-j} + \beta_2 \Delta m_{t-j} + \beta_3 ir_{t-j} + \beta_4 \Delta exr_{t-j} + \varepsilon_t \tag{1}$$

where Δcpi_{t+i} represents the rate of consumer price inflation 4 and 8-quarters ahead (being i=4,8), Δgdp_{t-j} stands for real GDP growth, broad money growth is denoted by Δm_{t-j}, nominal short-term interest rates by ir_{t-j} and the rate of change in the nominal exchange rate by Δexr_{t-j}. The suffix j represents the lags up to 4 or up to 8 quarters. The extended asset price equation can then be expressed as follows:

$$\begin{aligned} \Delta cpi_{t+i} = \alpha + \beta_0 \Delta cpi_{t-j} + \beta_1 \Delta gdp_{t-j} + \beta_2 \Delta m_{t-j} + \beta_3 ir_{t-j} + \beta_4 \Delta exr_{t-j} + \\ + \beta_5 \Delta hp_{t-j} + \beta_6 \Delta sp_{t-j} + \beta_7 ys_{t-j} + \varepsilon_t \end{aligned} \tag{2}$$

where the rate of change in residential property (house) prices (Δhp_{t-j}), the rate of change in share prices (Δsp_{t-j}) and the yield spread (ys_{t-j}) are added. The authors find that the predictive power for inflation using a reduced-form equation and standard explanatory variables can be improved by adding other asset price variables, i.e., the changes in house and equity prices and a yield spread. In their cross-country time series exercise, the authors find that housing price movements do provide useful extra information on future inflation, while equity prices and the yield spread are somewhat less informative.

A broadly similar approach, although with a focus on a more global perspective, is used by Sekine (2009). The framework used by the latter is based on the observation that relative price adjustments taking place in the global economy are an important cause of the lower inflation rates observed in the recent decades. A mark-up model shows substantial effects of declines in wage costs and import prices on consumer prices. The equation considered is represented by an inflation relation extended by a global dimension:

$$\begin{aligned} \Delta cpi_t = {} & \alpha_0 + \alpha_1 (cpi - w)_{t-1} + \alpha_2 (cpi - imp)_{t-1} \\ & + \beta_1 \Delta cpi_{t-j} + \beta_2 \Delta w_{t-j} + \beta_3 \Delta imp_{t-j} + \varepsilon_t . \end{aligned} \tag{3}$$

The author estimates single equation models for eight countries (United States, Japan, Germany, United Kingdom, France Canada, Sweden, Australia) and finds that the two mark-up terms (imports and wages) are important to explain the average disinflation. In a subsequent step, the approach is extended to a system framework in order to endogenise the developments of the two mark-ups and the interest rate, which also includes the output gap and the policy interest rate as explanatory variables. The author finds that out of the 5 percentage point decline in the inflation rates in eight OECD countries from 1970–1989 to 1990–2006, global shocks to the relative prices seem to have accounted for more than 1.5 percentage points, while a monetary policy shock seems to have added another 1 percentage point.

Turning to different approaches, Stock and Watson (2008) conduct an extensive empirical factor analysis that recapitulates and clarifies the literature on pseudo out-of-sample evaluation of inflation forecasts using a consistent data set and methodology. The empirical results indicate that Phillips curve forecasts (broadly interpreted as forecasts using an activity variable) perform better than other multivariate forecasts, but only episodically with respect a univariate benchmark.[8] The generic framework used for forecasting the h-period inflation can described in terms of the following equation:

$$\pi_t^h = h^{-1} \sum_{i=0}^{h-1} \pi_{t-i} \tag{4}$$

where $\pi_t = 400 \ln(P_t / P_{t-1})$ is the (annualised) quarterly rate of inflation. Inflation forecasting (h) tends to focus on the one-year or two-year horizons. The different approaches can be summarised in the following categories:

(a) Forecasts based on past inflation including *univariate time series models* such as ARIMA models and nonlinear or time-varying univariate models. In this context, the typical equation would take the following form:

$$\pi_{t+h}^h - \pi_t = \mu^h + \alpha^h(L)\Delta\pi_t + \nu_{t+h}^h \tag{5}$$

where μ^h is a constant, $\alpha^h(L)$ is a lag polynomial written in terms of the lag operator L, ν_{t+h}^h is the h-step ahead error term and the superscript h denotes the number of periods for the h-step ahead direct regression. The number of lags is determined by an information criterion like the AIC or HQ. Alternatively a random walk model or an unobserved components-stochastic volatility model could be used.

(b) *Phillips curve forecasts.* Phillips curve forecasts are defined as approaches which include an activity variable in the forecast equation. For example, the model of Gordon (1982) explains inflation by lagged inflation, the unemployment rate u_t and supply shock variables z_t:

$$\pi_{t+1} = \mu + \alpha(L)\pi_t + \beta(L)u_{t+1} + \gamma(L)z_t + \nu_{t+1}. \tag{6}$$

[8] See also the results in ECB (2014).

Alternatively, the Phillips curve model is a version without the supply shock variables. It is specified as an autoregressive distributed lag model:

(7) $$\pi_{t+h}^{h} - \pi_t = \mu^h + \alpha^h(L)\Delta\pi_t + \beta^h(L)u_t + \nu_{t+h}^{h}$$

(c) Forecasts *based on inflation expectations*. The third procedure computes inflation forecasts from explicit or implicit inflation expectations. These forecasts include regressions based on implicit expectations derived from asset prices:

(8) $$\pi_{t+h}^{h} - \pi_t = \mu + \alpha(L)\Delta\pi_t + \beta(L)spread_t + \nu_{t+h}^{h}$$

where the spread is the difference between 1-year Treasury bonds and 90-day Treasury bills.

(d) Forecasts *based on other predictors*: The fourth procedure consists of inflation forecasts based on variables other than activity or expectations variables. In an early paper, Stock and Watson (2003) used a general approach:

(9) $$\pi_{t+h}^{h} = \beta_0 + \beta_1(L)\pi_t + \beta_2(L)X_t + \nu_{t+h}^{h}$$

Because the data are overlapping, the error term ν_{t+h}^{h} is serially correlated so the test of predictive content based on this equation should be computed using HAC standard errors. As explanatory variables, the authors use in the class of asset prices interest rates, term spread, default spread, and other financial indicators like exchange rates, consumption-wealth ratio and housing prices.

The countries under analysis are Canada, France, Germany, Italy, Japan, United Kingdom and United States. According to the results of the analysis, some asset prices seem to predict either inflation or output growth in some countries for some periods quite well.

It is, however, not easy to give a well-structured interpretation to the results, since a good forecasting performance by an individual indicator in one period does not necessarily imply that the same indicator also has a good forecasting performance in another period. This kind of "instability", which prevails at all horizons and for all variables being forecasted, seems to be a striking regularity of the forecasts based on individual indicators and – according to the authors – should not be seen as a surprise, as the predictive power of asset prices should depend on the nature of the shocks hitting the economy, and the degree of development of financial markets and other institutional details differ across countries. In fact, it seems that, as for inflation (after controlling for lagged inflation), there is little or no evidence that individual asset prices or spreads systematically help to predict inflation at horizons through two years. This notwithstanding, intriguingly, forecasts produced by combining these unstable individual forecasts appear to improve reliably upon univariate benchmarks. The latter fact leads the authors to conclude that, rather than focusing on individual asset prices, all of which have their deficiencies as leading indicators, a combination of a large number of asset prices can lead to reliable forecasts. Moreover, instead of using conventional regression techniques, the authors find it useful to get additional information from the asset price indicators by pooling the individual indicator forecasts, either by computing a trimmed mean or the median forecast.

Along the same lines, Forni et al. (2003) consider a large dataset, consisting of hundreds of macroeconomic time series for the main countries of the euro area, in order to simulate out-of-sample predictions of euro-area industrial production and the harmonized consumer price index and to evaluate the role of financial variables in forecasting. Comparing the forecasts based on two models, which use large panels of time series, with the forecasts of a simple univariate AR model, the authors find that multivariate methods outperform univariate methods for forecasting inflation at one, three, six, and twelve months and industrial production at one and three months. In this respect, financial variables do help forecasting inflation, but do not help forecasting industrial production.

A similar approach to forecast inflation based on a large set of variables has been used more recently by Monteforte and Moretti (2008). As a novelty of their approach, the authors construct models based on monthly variables that are highly correlated with (future) inflation while, at the same time, also include financial indicators that are available on a daily basis and which, in principle, give some timely information about changes in inflation expectations. For the analysis, the authors use a mixed-frequency model (the Mixed Data Sampling Regression Models). The results found suggest that predictions stemming from this type of model outperform those of standard benchmark models based only on monthly variables. Besides, simply daily forecasts are more accurate than those implied in financial market expectations extracted from future contracts and help to reduce the forecasting errors with respect to models with only monthly variables. In this respect, daily financial variables seem to help to improve inflation forecasts.

Finally, Ciccarelli and Mojon (2005) derive a national inflation equation depending on global factors, with the inflation equation of the following type:

$$\Delta\pi_{i,t} = \alpha_{i,0} + \alpha_{i,1}(L)\Delta\pi_{i,t-1} + \alpha_{i,2}(\pi_{i,t-1} - \lambda_i f_{t-1}) + \alpha_{i,3}(L)\Delta f_t + \varepsilon_{i,t} \tag{10}$$

where Δ is the first difference operator, $\alpha_{i,j}(L)$ are polynomial in the lag operator L, $\pi_{i,t}$ is inflation, f_t is the common factor, and λ_i is the factor loading of country *i*. The authors test the common factors for 22 industrialised OECD countries using the following variables: growth rate of industrial production, nominal wages inflation, unit labour cost growth rate, import prices inflation, growth rate of broad monetary aggregate, money market interest rates, long-term interest rates, the yield curve and oil prices. Inflation in industrialized countries turns out to be largely a global phenomenon. First, a simple average of 22 OECD countries inflation accounts for 70% of the variance of inflation in these countries between 1960 and 2003. This large variance share is not only due to the trend components of inflation but also to fluctuations at business cycle frequencies. Besides, global inflation is, consistently with standard models of inflation, a function of real developments at short-term horizons and monetary developments at longer horizons. Finally, there is a very robust "error correction mechanism" that brings national inflation rates back to global inflation.

In a more recent paper, Assenmacher-Wesche and Gerlach (2010) study the relationships between inflation, economic activity, credit, monetary policy, and residential property and equity prices in 18 OECD countries, using quarterly data for 1986–2008. Using a panel VAR, plausible and significant responses to a monetary policy shock are found. Shocks to asset prices have a positive and substantial effect on GDP and credit after three to four quarters, whereas prices start to increase much later. When modelling the transmission of US shocks to the other economies more explicitly, it can be deducted that, while monetary policy and equity price shocks are directly transmitted internationally, property prices and credit shocks affect the other countries through their indirect effects on US interest rates and equity prices.

A slightly different approach based on frequency decomposition techniques is followed in a study by Andersson (2011), which builds on Assenmacher-Wesche and Gerlach (2008a and 2008b). The author analyzes the relationship between money growth and different price indices, such as the consumer price index, GDP deflator, share price index and house price index for eight developed countries (Australia, Canada, the Euro Area, Japan, Switzerland, Sweden, the United Kingdom and the United States) for a sample ranging from the end of 1977 to the end of 2009. Using a panel data approach, the results show that money growth is correlated with financial asset price inflation in the short, medium and long run. Real asset price inflation and money growth are correlated over the medium and long term, while consumer inflation and money growth are correlated only over the long term. Since all movements in money growth are associated with price changes in the short and long term, the paper also concludes that money growth may serve as a useful proxy for the overall inflation rate.

4. The Data Set

The literature review provides an overview of different specifications to explain the inflation process, where different time lags between the changes in the explanatory variables and the effect on inflation can be observed. In this study, the different explanatory variables are tested in the context of "ex post" relationships. More precisely, the present study is based on a rich set of macroeconomic indicators which can be broadly separated into three main categories, containing historical series for monetary, financial and real economy variables. Among the first set of variables, we use broad monetary aggregates, roughly equivalent to M2 or M3 (depending on the country) and credit to the private sector (or loans to the private sector whenever available).[9] Concerning financial variables, we consider the short-term (three-month money market) and long-term (ten-year government bond yield) interest rates, the nominal and real effective exchange rates and oil prices (in national currency). For the real economy, we focus on prices – consumer prices, GDP/consumption/investment deflators, house prices and equity/stock prices – while other variables are represented by the nominal and real GDP, investment and consumption. The main sources of the series are: BIS, DataStream, the Euro area Wide Model (AWM), European Central Bank (both official and internal databases), Eurostat, Global Financial Data, IMF International Financial Statistics, the respective National Central Banks for each country, OECD Main Economic Indicators and Reuters.

The dataset used for the analysis consists of quarterly data collected for 18 main industrial economies (also including the euro area as a whole) and spans over more than three decades, starting in 1969 Q1 and ending in 2014 Q2. The countries considered in the sample set are the following: Australia (AU), Canada (CA), Denmark (DK), the euro area (EA), France (FR), Germany (DE), Ireland (IE), Italy (IT), Japan (JP), the Netherlands (NL), New Zealand (NZ), Norway (NO), Portugal (PT), Spain (ES), Sweden (SE), Switzerland (CH), the United Kingdom (UK) and the United States (US).

5. Empirical Results

To estimate the inflation equations we apply a panel data approach and consider the main variables which, according to the findings in the literature, have been found to have some predictive content for inflation. These are, beyond lagged inflation, the output gap, the short-term interest rate, house and stock prices, broad money and credit, the effective exchange rate and oil prices. We start the analysis by including 4 lags of these variables (both in nominal and real terms) and, in a subsequent step, exclude those variables which prove to be insignificant. The following tables (see Table 1, Table 2 and Table 3) summarise the results for different forecasting horizons (1, 4 and 8 quarters ahead respectively) and different specifications, and also report the number of lags for every variable in the equations. The main findings can be summarised as follows.

First of all, it turns out that the longer the time lags between changes in the explanatory variables and the reaction of inflation, the lower the explanatory power of the equations (as denoted by a decrease in the adjusted R-squared) which, therefore, points to a decrease in the models' ability in explaining inflation. Second, on the basis of the statistical properties of the models, it can be concluded that, the longer the

[9] All series are seasonally adjusted. Whenever available, quarterly series are calculated as averages of monthly series.

time horizon, the more significant and higher the coefficients are for monetary developments – and, thereby, especially the broad monetary aggregate M3. Third, a clear and significant difference between house and stock prices seems to exist, whereby house prices perform much better in predicting inflation than equity prices. In terms of lags, house prices are generally leading by one quarter, whereas the lag in equity prices is longer. These results are robust to the inclusion of oil prices in the equations. In addition, the findings are also in line with other parts of the literature looking at the relationship between asset prices and macroeconomic instability, whereby house price booms/busts are less frequent, but more damaging, for the economy.

Table 1

Results of Inflation Forecast 1-Step Ahead: Pooled Regression Results (Fixed Effects)

Lag inflation	Lag output gap	Short-term interest rate	House price	Stock price	Broad money	Credit	Real effective exchange rate	Oil prices	Adjusted R square	DW
1,2,3	1,3	1,2							0.75	2.00
1,2,3	2,3	1,2	Nominal 1, (6.05)						0.76	2.00
1,2,3	2,3	1,2	Nominal 1, (5.29)			2,3			0.76	1.99
1,2,3,4	2,3	1,2	Nominal 1, (4.72)		1,3				0.76	2.00
1,2,3	2,3	1,2	Nominal 1, (6.48)				1		0.76	2.00
1,2,3	2,3	1,2	Real 1, (6.42)						0.76	2.00
1,2,3	2,3	1,2		Nominal 1,2 (3.18, –3.04)					0.76	2.00
1,2,3	2,3	1,2		Nominal 1,2 (3.31, –3.21)		2,3			0.76	2.00
1,2,3	2,3	1,2		Nominal 1,2 (3.14, –3.19)	1,3				0.76	2.00
1,2,3	2,3	1,2		Nominal 1,2 (2.87, –2.91)			1		0.76	2.00
1,2,3	2,3	1,2		Real 1,2 (3.18, –3.04)					0.76	2.00
1,2,3	2	1,2	Nominal 1, (5.84)					1	0.76	2.01
1,2,3	2,3	1,2		Nominal 1,2 (3.59, –2.82)				1	0.77	2.00

Notes: the countries in the table are the following: Australia (AU), Canada (CA), Denmark (DK), the euro area (EA), France (FR), Germany (DE), Ireland (IE), Italy (IT), Japan (JP), the Netherlands (NL), New Zealand (NZ), Norway (NO), Portugal (PT), Spain (ES), Sweden (SE), Switzerland (CH), the United Kingdom (UK) and the United States (US). The cells of the table include the lag order of the corresponding variable. All variables are in first differences with the exception of the output gap, which is the difference between the logarithm of real GDP and the CF-filtered logarithm of real GDP. The coefficients of house and stock prices additionally contain the respective t-values.

Table 2

Results of Inflation Forecast 4-Steps Ahead: Pooled Regression Results (Fixed Effects)

Lag inflation	Lag output gap	Short-term interest rate	House price	Stock price	Broad money	Credit	Real effective exchange rate	Oil prices	Adjusted R square	DW
1,2,3,4	1,3	1,4							0.63	1.03
1,2,3,4	2,3	1,4	Nominal 1, (4.78)						0.63	1.04
1,2,3,4	2,3	1,4	Nominal 1, (3.81)			1,2			0.64	1.04
1,2,3,4	2,3	1,4	Nominal 1, (2.92)		1,3,4				0.64	1.06
1,2,3,4	2,3	1,4	Nominal 1, (4.93)				1,4		0.63	1.05
1,2,3,4	2,3	1,4	Real 1, (5.24)						0.63	1.04
1,2,3,4	2,3	1,4		Nominal 1, (2.63)					0.64	1.03
1,2,3,4	2,3	1,4		Nominal 1, (2.64)		1,2,4			0.64	1.04
1,2,3,4	2,3	1,4		Nominal 1, (2.41)	1,3,4				0.65	1.06
1,2,3,4	1,2	1,4		Nominal 1, (2.53)			1,4		0.64	1.04
1,2,3,4	1,2	1,4		Real 1 (2.50)					0.64	1.03
1,2,3,4	2,3	1,4	Nominal 1, (4.07)					1	0.63	1.01
1,2,3,4	1,2	1,4		Nominal 1 (2.49)				1	0.64	1.00

Notes: see Table 1.

Table 3

Results of Inflation Forecast 8-Steps Ahead: Pooled Regression Results (Fixed Effects)

Lag inflation	Lag output gap	Short-term interest rate	House price	Stock price	Broad money	Credit	Real effective exchange rate	Oil prices	Adjusted R square	DW
1,2,3,4	1,2	4							0.56	0.82
1,2,3,4	1,2	2,4	Nominal 1, (3.55)						0.55	0.83
1,2,3,4	1,2	2,4	Nominal 1, (2.96)			2,3			0.56	0.84
1,2,3,4	1,2	2,4	Nominal 2, (1.57)		1,3,4				0.58	0.88
1,2,3,4	1,2	2,4	Nominal 1, (3.65)				2		0.55	0.84
1,2,3,4	1,2	2,4	Real 1, (4.23)						0.56	0.84
1,2,3,4	1,2	4		Nominal 4 (–5.94)					0.57	0.84

Continued next page

Table 3 (continued)

Lag inflation	Lag output gap	Short-term interest rate	House price	Stock price	Broad money	Credit	Real effective exchange rate	Oil prices	Adjusted R square	DW
1,2,3,4	1,2	2,4		Nominal 4 (–6.12)		1,3			0.58	0.86
1,2,3,4	1,2	2,4		Nominal 2,4 (–2.34,–5.92)	1,2,3,4				0.60	0.89
1,2,3,4	1,2	2,4		Nominal 4 (–5.50)			2		0.57	0.84
1,2,3,4	1,2	4		Real 4 (–5.94)					0.57	0.84
1,2,3,4	1,2	4	Nominal 1,2 (2.69,2.37)					1	0.55	0.85
1,2,3,4	1,2	4		Nominal 4 (–4.94)				1	0.57	0.84

Notes: see Table 1.

6. Some Concluding Remarks

The recent decade has witnessed proposals to assign a more prominent role to asset prices in central bank's toolkit of leading indicators for future developments in consumer price inflation. The latter proposition, however, hinges critically on the forecasting performance of asset prices in standard traditional macroeconomic models.

This study analyses whether the predictive power of a reduced-form equation for inflation, including some standard explanatory variables, can be improved by adding specific asset price variables (i.e., the changes in housing and equity prices and a yield spread). For this purpose, we make use of a panel approach, covering data for 17 industrialised countries and the euro area for the sample period 1969Q1–2014Q2.

Three main results emerge out of our analysis: First, a standard model explaining current inflation by (lagged) developments in inflation, the output gap, short-term interest rates, asset prices and the exchange rate seems to work quite well, although the explanatory power of the equations decreases with the length of the time lags between the explanatory variables and the reaction in inflation. Second, as regards the role of asset prices, it can be shown that house price movements seem to provide more useful information on future consumer price developments than movements in equity prices. Finally, the results seem to show that broad monetary developments become more relevant as the time horizon lengthens. By contrast, equity prices and the yield spread seem to be somewhat less informative. Taken *per se*, this would speak in favour of a separate role for money in such kind of inflation frameworks.

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