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"Seeking price and macroeconomic stabilisation in the euro area: The role of house prices and stock prices"

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Abstract

We propose an Economic Stability Index (ESI) incorporating house prices and stock prices as components of the measure of the inflation rate in order to allow the European Central Bank (ECB) to achieve both price and macroeconomic stability. We use an optimisation approach to estimate target weights for different sectoral prices in the broader price index, which depend on sectoral parameters other than those used to compute the Harmonised Index of Consumer Prices applied by the ECB to gauge price stability in the euro area (EA). Our results suggest that if the ECB had targeted the ESI, it would have implemented a different monetary policy which would had increased stability in the EA's economic activity and would have helped to create adequate preconditions for sustainable economic growth and job creation.

JEL classification: C32, D53, E31, E52, E58, G12, 052, R31.

Keywords: Stock prices; House prices; Inflation targeting; Macroeconomic stabilization; Euro area.

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I. Introduction

Monetary policy in most modern economies aims to maintain price stability over the medium term. Price stability plays an important role in the economy, since price levels affect economic activities, the financial sector, and investment decisions; it implies an efficient allocation of resources through an informative relative price mechanism, competitiveness, lower interest rate risk premia, appropriate conditions for investment, and so on. All these factors are preconditions for economic growth.

One of the main lessons for monetary policy-making after the Great Inflation of the 1970s is that a strong and credible nominal anchor is essential to keep inflation expectations firmly in check (see, e.g., ECB, 2010), highlighting the need to provide agents with clear guidance regarding likely future inflation rates. As a result, a growing number of countries have adopted inflation targeting as a monetary policy strategy.

While the European Central bank (ECB) has a single objective (a low and stable inflation rate), the Federal Reserve System has a dual mandate of price stability and maximum employment. For its part, the Bank of England's primary objective is to control the inflation rate; maintaining full employment and maximum growth of real Gross Domestic Product (GDP) are secondary objectives.

The length and the severity of the Great Recession aroused great interest in the redefinition of monetary policy in order to react to financial imbalances. The debate focused not only on the approach of the monetary authorities to their traditional objectives, but also on the possible direct response to additional variables (such as different measures of asset prices) to integrate financial stability considerations. In the context of inflation targeting, as reflected in Bean (2003), there appears to be a shift towards the middle ground with the debate centering on how to operationally utilise and respond to the information content of these additional variables. Given their forward-looking nature, house prices and stock prices are obvious variables to monitor and assess from this perspective[1].

House prices have been a key indicator in assessing the state of the euro area (EA) economy since the financial crisis (ECB, 2015). The rationale for including house prices in the pursuit of price stability is that they represent the most important asset for households in industrialised countries (see Goodhart and Hofmann, 2007a). Unlike other assets, housing has

[1] Chen and Ranciere (2016) show that stock prices and house prices have high predictive power for macroeconomic variables in advanced economies.

the dual role of being both a store of wealth and an important durable consumption good (see Case *et al.*, 2001, or Corradin *et al.*, 2014, among others). Housing markets are historically prone to boom and bust episodes (see Beltratti and Morana, 2010). Furthermore, house prices affect credit markets, as they determine the value of collateral that households can borrow and banks can lend against[2]. Nutahara (2017) finds that if housing prices are a target of a central bank, monetary policy response to asset prices is helpful for equilibrium determinacy.

As for stock prices, the question of whether central banks should react to their developments has been hotly debated. There are two broadly opposing views in the literature on this issue. The first one is represented in Blanchard *et al.* (1993), who concluded that fundamental movements in asset prices have a larger influence on investment, which in turn affects output and inflation, and in Cecchetti *et al.* (2003), who argued that monetary authorities should give substantial consideration to asset price fluctuations as well as aggregate price movements, so as to reduce misalignments and thus minimise the risk of macroeconomic instability; they recommend that central banks should react to the fundamental movements of asset prices through the interest rate in order to minimise macroeconomic volatility[3]. Borio and Lowe (2002) and Woodford (2012) also favour a "leaning against the wind" approach which considers that an expansionary monetary policy contributes to the emergence of asset price bubbles, and that restrictive policies can reduce them. The second school of thought takes the opposite view, arguing that central banks should not use the interest rate to influence stock prices and should rely on macroprudential tools (see Bernanke and Gertler, 2001; Schwartz, 2003; Greenspan, 2007; Gerlach, 2010, Svensson, 2012; Blot *et al*., 2015; and Collard *et al*., 2017). More recently, Farmer (2009) has argued that governments can smooth out swings in the financial markets by buying or selling shares in exchange-trade funds in response to movements in the unemployment rate. A similar idea was proposed by Kimball (2013), which he termed a "sovereign wealth fund". In this respect, Carlstrom and Fuerst (2007) find that monetary policy response to stock prices is a source of equilibrium indeterminacy in a sticky-price economy.

[2] Goodhart and Hofmann (2007b) argue that real house prices should receive a significant weight in the Monetary Conditions Indexes computed to measure the stance of monetary policy, because of their large impact on the economy and inflation in particular.

[3] MacDonald *et al.* (2011) suggest that central banks should re-assess monetary policy during periods of asset price inflation and rising price inflation; both pre-emptive and progressive interest rate increases are needed to weaken the asset price increases and also to contain future inflation. Kontonikas and Montagnoli (2005) found that fundamental asset price volatility affects future inflation and current period inflation through wealth effects on aggregate demand, concluding that central banks should therefore incorporate fundamental asset price changes in their monetary policy.

Our paper is linked to theoretical research into the appropriate monetary policy target. Indeed, it can be regarded as the empirical counterpart to this theoretical research. We contribute to the existing literature by analysing the role of two asset prices – house prices and stock prices – in a broader measure of the price index in the EA, using an optimisation approach. In particular, we propose an Economic Stability Index (ESI) incorporating house prices and stock prices to allow the ECB to achieve both price stability and macroeconomic stabilisation. The ESI is an index depending on sectoral characteristics (cyclical sensitivity, idiosyncratic shocks, consumption weight and price rigidities) which differs clearly from the ones applied to compute the ECB's target inflation rate, including the use of core inflation to capture the underlying inflationary pressures in the economy by excluding or down-weighting the more erratic and transitory components of consumer prices indices[4]. Moreover, the broader price index proposed in this paper generates counterfactual scenarios in which to analyse the monetary policy responses the ECB would have applied if it had targeted these characteristics, and to compare them to the actual monetary stance implemented in the EA.

The rest of the paper is organised as follows. Section 2 introduces the analytical framework. Section 3 describes the data used in the analysis. Empirical results are presented in Section 4. Finally, some concluding remarks and policy implications are provided in Section 5.

2. Analytic framework

2.1. The basic model

This study assumes that the central bank's objective is to minimise the variance of output gap from the target price value with a view to achieving macroeconomic stability. A central bank that targets its inflation rate hopes to achieve stability in both price and output. In our view, a key principle for monetary policy is that price stability is a means to endorse sustainable economic growth and stability. A key question for policy makers is how central banks seek to attain price stability. The central bank's problem can be formulated as follows[5]:

$$\min_{\{\omega_j\}} Var(y_t) \text{ for } \quad j=1, 2, \ldots, J \tag{1}$$

where y_t denotes the output gap (the deviation of output from its natural level) at time t and ω_j denotes the weight for sectoral j.

[4] ECB (2013) contends that none of the sub-indices of the HICP provide an adequate description of the medium-term price developments relevant for monetary policy.

[5] The theoretical model and notation are analogous to that used by Mankiw and Reis (2003).

Central banks have applied many different approaches to reduce the detrimental effects of inflation and to maintain it at a level that is compatible with the overall objective of economic stability. The benchmark typically applied by monetary authorities for inflation targeting is the consumer price index (CPI). However, existing literature argues that the CPI covers only the current cost of living and does not include expected inflation (Alchian and Klein, 1973; Goodhart, 2001; Mankiw and Reis, 2003; Kent and Low, 1997; Shiratsuka, 1999; Charemza and Shah, 2013 and Shah and Ahmad, 2017). A central bank faces the problem of how to choose an appropriate price index as a measure of inflation which would help to reduce output instability.

Mankiw and Reis (2003) proposed a model for investigating the choice of an optimal price index by a central bank committed to maintaining an inflation target, which it uses as a measure of inflation to maintain price and output stability. These authors analysed the microeconomic foundations of their model by building a general equilibrium model with various sectoral prices and including only a single period at a time. The weight assigned to each sector is estimated with regard to four characteristics. To formalise these sectoral differences, they used the so-called new Keynesian literature on price adjustment (see Aoki, 2001; and Mankiw and Reis, 2002).

Firstly sectoral prices differ according to their responsiveness to the business cycle (i. e., some sectors' equilibrium prices are more sensitive to output gap than others). In Mankiw and Reis (2003)'s general equilibrium model, changes in output gap influence equilibrium prices through marginal costs and the market power of firms. A second sectoral equilibrium price difference lies in the variance of their idiosyncratic shocks. The idiosyncratic relative price shocks can be interpreted as representing the sectoral shocks to productivity[6]. Kaufmann and Lein (2011) define this sector supply shock as a sector-specific error term, which captures idiosyncratic inflation dynamics that are not attributed to macroeconomic fluctuations. The desirable price equation is given by;

$$p^{e}_{t,j} = p_t + \gamma_j y_t + u_{t,j} \qquad (2)$$

where $p^{e}_{t,j}$ is the desirable (equilibrium) price in sector *j*, p_t is the aggregate price index, γ_j is the responsiveness of sector *j*'s equilibrium price to the business cycle, and $u_{t,j}$ represents

[6] Idiosyncratic sectoral shocks are residuals that are unconditionally related to the explanatory variable but conditionally uncorrelated to the dependent variable.

idiosyncratic shock to sector *j* with variance σ_j^2. Equation (2) states that the desired (equilibrium) price in a sector depends on the aggregate price level, the state of the business cycle and idiosyncratic shocks[7]. The desired relative price in a sector $\left(p_{t,j}^{e} - p_t\right)$ increases in booms and declines in recessions.

The price adjustment mechanism is the third characteristic that results in sectoral price differences. The model considers that each firm sets its prices in each period, and that there are some firms that gather updated information about the current state of the economy and adjust the desirable path of their future prices. Other firms, with lags in information processing, do not respond immediately to changing circumstances, and thus set prices based on outdated information. This concept is in line with models suggesting that some sector prices are sticky while others are flexible, reflecting the costs of acquiring or processing information. Mankiw and Reis (2002) indicate that current expectations of future economic situations play a significant role in determining the inflation rate in the standard sticky price model. Fischer (1997) emphasises that sticky prices are set in advance by nominal contracts and are slower to respond to changing economic conditions. Let λ_j be the proportion of the price setters in sector *j* that set their prices based on updated information, while (1- λ_j) set prices based on outdated inflation and old plans. The sector price in period *t* is given by:

$$p_{t,j} = \lambda_j p_{t-1,j}^{e} + \left(1-\lambda_j\right) E\left(p_{t-1,j}^{e}\right) \tag{3}$$

where $E\left(p_{t-1,j}^{e}\right)$ denotes the expected value of desirable sectoral *j* price in time *t-1* for time *t*, and the parameter λ_j measures sluggishness of prices in sector *j*. The value of λ_j falls between 0 and 1. Low values (close to zero) of λ_j indicate that sectoral prices do not respond immediately to news about equilibrium prices. However, high values of λ_j (close to 1) suggest that the sector's actual price is close to its desirable price level. The model postulates that if all firms set their prices with updated information (rigidity parameter λ_j=1), then a sector's actual price $p_{t,j}$ is equal to its desired price $E\left(p_{t-1,j}^{e}\right)$.

Finally, sectoral prices differ according to their weights in aggregate price index (such as the CPI). The formation of these weights is based on the amount of money spent by the typical household on different goods; they are referred to as consumption or expenditure weights. If there are *J* sectors, the simplest specification of the aggregate price index is given by:

[7] Notice that all variables are expressed in logarithms.

$$p_t = \sum_{j=1}^{J} \delta_j p_{t,j} \tag{4}$$

where δ_j represents the proportion of expenditure made in sector j with respect to total expenditure made by all households, and $p_{t,j}$ is the sector price for sector j .

2.2. Optimal weights for the Economic Stability Index

The aim of this study is to choose optimal weights ω_j for constructing a price index that would help to achieve greater economic stability. The resulting index is referred to as the Economic Stability Index (ESI). The weight of a sector in the ESI depends on its characteristics, including cyclical sensitivity (γ_j), consumption weight (δ_j), variance of idiosyncratic shocks (σ_j^2), and the speed with which the prices in each sector respond to changing economic conditions (λ_j). It is assumed that, before shocks occur, the central bank chooses a price index and commits itself to keeping a weighted average of sectoral prices at a given level, which can be set equal to zero without loss of generality. The ESI can be described as:

$$\widehat{p}_t = \sum_{j=1}^{J} \omega_j p_{t,j} \tag{5}$$

where $\widehat{p}_t$ is the ESI, and ω_j is the target (optimal) weight in sector *j.* The target weights are choice variables of the central bank taking the sectoral characteristics (γ_j, δ_j, σ_j^2, and λ_j) as exogenous. The sum of the target weights ω_j is equal to one.

$$\sum_{j=1}^{J} \omega_j = 1 \tag{6}$$

Mankiw and Reis (2003) derive several propositions that can be obtained from these optimal weights to interpret the nature of the solution. The summary of their propositions is that if the two sectors have same sectoral characteristics, then the ESI gives them equal optimal weights ω_j; and when two sectors have divergent sectoral characteristics, then the ESI assigns them different optimal weights ω_j. The propositions put forward by Mankiw and Reis (2003) are as follows:

i. Regarding the effect of cyclical sensitivity parameter γ_j on the optimal weights, if a sectoral price is more responsive to the output gap, it should be assigned a higher optimal weight in the ESI. Therefore, this suggests that the optimal weight ω_j rises with an increase in γ_j.

ii. As for the variance of idiosyncratic shocks (σ_j^2), the greater the magnitude of sectoral shocks, the lower the weight that that sectoral price should receive in the ESI. This means that a reduction in σ_j^2 increases the optimal weight ω_j. Cecchetti *et al*. (2000) contend that a large and unexpected price change is likely to be followed by large idiosyncratic shocks, hence carrying relatively little information about price trends which, in turn, leads to a small weight in the target (optimal) price index. In this regard, Chamberlin (2009) argues that food and energy prices are the most commonly excluded items because they are highly volatile and have only transitory effects on the rate of inflation. Kaufmann and Lein (2011) find that disaggregated prices react relatively quickly to idiosyncratic shocks.

iii. In relation to price sluggishness, if ω_j <1, then a rise in λ_j reduces the optimal weight ω_j. That is, the more sluggish a sectoral price, the more weight it is assigned in the ESI. Many of the goods that reveal higher price instabilities, including food and energy, are traded in competitive markets, while in markets where goods are monopolistically produced prices are adjusted more slowly[8]. Sluggishness in price exacerbates the effect of the business cycle on a sectoral price. Kiley (2000) suggests that price stickiness is good indicator for measuring persistent output movements in response to aggregate demand shocks. Kaufmann and Lein (2011) find that sectors in Switzerland, which change prices infrequently, react less strongly; however, if they do change their prices, they adjust them by large amounts, corroborating evidence for the US (Boivin *et al.*, 2009; Mackowiak *et al.*, 2009) and the UK (Mumtaz *et al.*, 2009). Ball *et al*. (2005) explain that optimal monetary policy comprises price level targeting in the sticky information model.

iv. Finally, with reference to the consumption weight (δ_j), a sectoral price with a comparatively high weight in the aggregate price index should receive a small optimal weight ω_j. Thus, keeping all the other characteristics constant, sectors with a small share in the aggregate price index should be assigned a larger weight in the ESI.

2.3. Formulation of the central bank objective function

Mankiw and Reis (2003) derived a two-sector theoretical analysis of the central bank's problem. Later, Charemza and Shah (2013) and Shah and Ahmad (2017) extended further the

[8] Aoki (2001) developed an approach that considers flexibly-priced goods in a competitive market and a continuum of differentiated goods with sticky prices. He suggests that optimal monetary policy should target prices in the sticky-price sector.

theoretical analysis for a four-sector setting and derived its algebraic solution[9]. As mentioned above, the central bank's objective is to promote economic stability by choosing a target price index, given the constraints imposed by the price-setting procedure. The central bank derives the optimal weights to minimise the variance of the output gap. The following assumptions are used to derive the four-sector framework:

a. There are only four sectors, called sectors 1, 2, 3 and 4 (j= 1, 2, 3, 4).
b. The model includes only a single period of time.
c. The cyclical sensitivity parameters γ_j are greater than zero.
d. The optimal weights ω_j are non-negative.
e. Sum of the optimal weights must equal to one.

All variables are expressed as deviations from their expected values. This is indicated by the tilde over the variables $\tilde{y}_t = y_t - E(y_t)$, $\tilde{p}_t = p_t - E(p_t)$, $\tilde{p}_{t,j} = p_{t,j} - E(p_{t,j})$, and $\tilde{u}_{t,j} = u_{t,j} - E(u_{t,j})$, ;the expected value of all variable in the deviation form is zero.

The algorithm to derive the analytic solution to the central bank's problem contains three steps. First, for the equilibrium output gap in the economy, by solving the set of the following equations including the four sectoral price equations in its derivation form $(j = 1,2,3,4)$, we obtain the condition that the weight average of sectoral prices is equal to zero and the aggregate price index:

$$\tilde{p}^e_{t,j} = \tilde{p}_t + \gamma_j \tilde{y}_t + \tilde{u}_{t,j} \tag{7}$$

$$\tilde{p}_{t,j} = \lambda_j \tilde{p}^e_{t-1,j} + (1- \lambda_j) E(\tilde{p}^e_{t-1,j}) \tag{8}$$

$$\tilde{p}_{t,j} = \lambda_j \left(\tilde{p}_t + \gamma_j \tilde{y}_t + \tilde{u}_{t,j} \right) \tag{9}$$

$$\tilde{p}_t = \sum_{j=1}^{4} \delta_j \tilde{p}_{t,j} = \delta_1 \tilde{p}_{t,1} + \delta_2 \tilde{p}_{t,2} + \delta_3 \tilde{p}_{t,3} + \delta_4 \tilde{p}_{t,4} \tag{10}$$

$$\sum_{j=1}^{4} \omega_j \tilde{p}_{t,j} = 0 \tag{11}$$

Second, we compute the conditional output gap variance by taking the conditional expectation of the square of the output gap, conditional upon I_{t-1} (where I_t is information up to time t).

[9] See Mankiw and Reis (2003) and Shah and Ahmad (2016) for the full derivation and discussion of the theoretical details.

This is because the conditional variance of the output gap is computed with regard to the deviation from the sector prices. Therefore the variance of the output gap is computed based on the following expression:

$$\mathrm{Var}\left(\tilde{y}_t \middle| I_{t-1}\right) = f\left(\gamma_j, \delta_j, \lambda_j, \sigma_j^2, \sigma_{jk}, \omega_j\right) \tag{12}$$

As can be seen in equation (12), all parameters are exogenous and time-specific when they are estimated based on the information at *t-1* for time *t*.

Finally, the variance of the output gap (12) is minimised with respect to target weights $(\omega_1, \omega_2, \omega_3, \omega_4)$ given values of the exogenous parameters $\left(\gamma_j, \delta_j, \lambda_j, \sigma_j^2, \sigma_{jk}\right)$ that are functions of the sectoral characteristics. The optimal weights for ESI can be computed by following this three-step algorithm.

3. Data description and estimation procedure

3.1 Data description

After a decade of preparations, the euro was launched on 1 January 1999[10]. A key milestone was the European summit in Madrid in December 1995, where it was reaffirmed that European Union (EU) countries would work towards the creation of the EA along the lines of the Maastricht Treaty, and a number of important decisions were taken regarding the single currency[11].

To take these institutional developments into account and to have sufficient observations for training the algorithm, we use quarterly data for the EA covering the 1996:I-2016:II period (a total of 82 quarterly observations). We consider seven variables: food prices, energy prices, other goods and services (non-food and energy, which for brevity we will refer to as “other goods”) prices, house prices, stock prices, all-item (HICP) prices and output gap. The first three prices (food, energy and others) are categories of the Harmonised Index of Consumer Prices (HICP)[12], while house prices refer to analytical house price indicators, a measure of the

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[10] When the euro was first introduced in 1999, the EA was made up of 11 of the then 15 EU Member States (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, The Netherlands, Portugal and Spain). Greece joined in 2001, followed by Slovenia in 2007, Cyprus and Malta in 2008, Slovakia in 2009, Estonia in 2011, Latvia in 2014 and Lithuania in 2015. Today, the EA numbers 19 EU Member States.

[11] The European Monetary Institute was established to strengthen central bank cooperation and prepare for the European System of Central Banks (ESCB). The plan for the transition to the euro was designed, the future governance of the EA was defined, and substantial achievements were recorded in economic convergence between the Member States.

[12] The term “harmonised” denotes the fact that it is calculated using a common methodology across all Member States. The HICP provides the official measure of consumer price inflation in the EA and is used by the ECB to gauge price stability in the EA. The common classification for the HICP is the COICOP (Classification of

prices at which dwellings are bought and sold over time. Regarding the stock prices indicator, we use the Euro Stoxx 50 index, which is widely considered as the reference index of the EA[13]. All series are obtained from the Organisation for Economic Cooperation and Development (OECD) data base. Following the common practice with macroeconomic data, the output gap for EA is computed by de-trending actual real GDP using the Hodrick–Prescott (HP) filter (Hodrick and Prescott, 1997). The study uses the weights of different sectors in the typical consumer's budget for the EA, which are taken from Eurostat[14].

3.2. Estimation procedure

As explained in Section 2, the optimisation approach estimates the target weights applied to different sectoral prices in the ESI, where target weights depend on sectoral parameters. In order to compute the relevant parameters, all the variables in the model are expressed in their derivation form (i.e., they are disturbance variables), as in equation (9) to obtain two sectoral parameters γ_j and σ_j^2.

$$\tilde{p}_{t,j} = \lambda_j \left(\tilde{p}_t + \gamma_j \tilde{y}_t + \tilde{u}_{t,j} \right)$$

Mankiw and Reis (2013) used an autoregressive (AR) model with a constant and a time trend to obtain the deviation form for the six disturbance variables. This approach can only be maintained if all variables on the right hand side (RHS) are regressed against the same numbers of lagged $p_{t,j}$ on the left hand side. Moreover, if we assume that all variables on the RHS are AR processes, then together they are Autoregressive-Moving Average (ARMA) rather than AR processes. Additionally, sectoral idiosyncratic shocks can be correlated with the output gap, causing identification problems. To address these issues, rather than Mankiw and Reis, we follow Charemza and Shah (2013) and Shah and Ahmad (2017) and apply a Vector Autoregressive (VAR) model to compute the disturbance variables from original data series. The VAR model has several advantages over the AR model; for instance, it maintains

Individual Consumption by Purpose). The HICP is produced and published by Eurostat, the statistical office of the European Union. The HICP does not account for the single biggest cost a household is likely to face in life, i.e., buying a property; it only covers current rentals for housing and regular maintenance and repair of the dwelling. Using data since the early 1980s, the ECB (2014) found that the theoretically suggested co-movement between house prices and rents is very limited, exhibiting divergent developments for protracted periods of time.

[13] The Euro Stoxx 50 index is developed by Stoxx Limited, a joint venture between the firms Deutsche Börse, Dow Jones & Company and SWX Swiss Exchange. The most important feature of this index is that it brings together the 50 largest companies among the 19 supersectors in terms of market capitalisation in eleven member countries (Austria, Belgium, Germany, Finland, France, Italy, Ireland, Luxembourg, Netherlands, Portugal and Spain). It is an index weighted by stock market capitalisation. It is the main European index and one of the largest in the world in terms of the market capitalisation of the companies that compose it.

[14] http://ec.europa.eu/eurostat/cache/metadata/en/prc_hicp_esms.htm.

equality among the variables as it uses the same number of lags for all equations as well as addressing the potential problem of identification of the model (Lütkepohl, 2005)[15]. The following VAR of order p is considered:

$$x_t = c + \sum_{i=1}^{p} \beta_i x_{t-i} + \nu_t \tag{13}$$

where X_t is a (*nx1*) vector of endogenous variables, $c = (c_1, c_2, \ldots, c_n)'$ is the (*nx1*) intercept vector of the VAR, β_i is the *ith* (*nxn*) matrix of VAR coefficients for $i = 1,2,\ldots,p$, and $(\nu_t = v_{1t}, \ldots, v_{nt})'$ is the (*nx1*) generalisation of a white noise process. For estimation purposes, the following set of variables is used: output gap, all-item (HICP) prices, food prices, energy prices, other goods prices, and house (or stock) prices. The lag order of the VAR model is selected using the Akaike Information Criterion (AIC), which suggests to lags for estimating VAR to obtain the disturbance variables[16]. The VAR model in equation (13) is estimated for both house prices and stock prices along with five other variables separately to compute the disturbance variables. These disturbances, which are by construction stationary variables, are the data subsequently used to compute the sectoral parameters.

4. Empirical Analysis

4.1. Estimation of optimal weights and the ESI: The case of house prices

We first evaluate the ESI using house prices [ESI (house prices)], since house price indices are among the most closely watched economic indicators in most EA countries. We follow the methodology proposed by Charemza and Shah (2013) and extended by Shah and Ahmad (2017) to estimate the sectoral parameters and target weights for the ESI, where the aim of the central bank is to obtain greater economic stability. Firstly, the sectoral parameters are set or estimated in order to compute the target weights for the ESI. The model assumes that the parameter that measures the degree of price sluggishness λ_j is equal to one for a fully flexible sector, so we set λ_j=1 for food and energy prices, imposing that prices respond immediately to changing circumstances[17]. Further, we assume that other goods prices and both asset prices

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[15] Additionally, the VAR model is a multivariate linear regression model which contains more information than a univariate AR model; it does not require specification of which variables are exogenous or endogenous since all variables are endogenous.

[16] Ivanov and Kilian (2005) show that the AIC tends to produce the most accurate structural and semi-structural impulse response estimates for realistic sample sizes.

[17] Álvarez *et al.* (2005) examine inflation persistence in the EA and in its member countries using micro data on consumer (CPI) and producer (PPI) price indices, as well as survey information, concluding that price

(house and stock prices) are sluggish, and set λ_j=0.5 [18]. The parameter capturing the consumption weight δ_j is taken from the proportion of expenditure made in each sector with respect to total expenditure made by all households as computed by Eurostat, while the consumption weight for house prices is zero[19]. The generalised method of moment (GMM) is used to estimate two remaining parameters: cyclical sensitivity (γ_j) and the variance of idiosyncratic shocks (σ_j^2) [20]. There are several significant advantages to using the GMM method compared with maximum likelihood or two-stage least square techniques; (a) it allows economic models to be specified while avoiding often unwanted or unnecessary assumptions, such as specifying a particular distribution for the error terms; (b) it allows estimation under theoretically sound restrictions; and (c) it allows adequate treatment of potential endogeneity problems (see Wooldridge, 2001). The role of GMM is to estimate γ_j by using orthogonal condition the $E[\tilde{y}_t'(\tilde{p}^*_{t,j} - \gamma_j \tilde{y}_t)] = 0$. The sectoral disturbance variable (Equation 9) is rewritten by dividing the sluggishness (rigidity) parameter in sector j (γ_j) and subtracting from the aggregate price disturbances:

$$\tilde{p}_{t,j} = \gamma_j \tilde{y}_t + \tilde{u}_{t,j} \tag{14}$$

where $\left(\dfrac{\tilde{p}_{t,j}}{\lambda_j} - \tilde{p}_t \right)$

Equation (14) states that the disturbance of relative sectoral prices is a function of the output gap disturbances and the white noise error term, where the sluggishness parameter for each sector is exogenous and independent of the aggregate (HICP) price. Equation (14) is estimated by using the GMM approach to obtain the parameters γ_j and σ_j^2. To test the reliability and validity of the approach, we estimate the three models separately for house prices, fundamental house prices and bubble house prices along the three components of

adjustment is heterogeneous across sectors. For consumer prices, flexibility is highest for energy and unprocessed food and lowest for services. Moreover, Meyler (2009) estimates that on average across the EA, approximately 75% of the movements in oil prices are passed through to consumer prices within three weeks, and more than 90% within five weeks.

[18]For the robustness analysis of the results, we also estimate the model with other values of the sluggishness parameter λ_j obtaining the same qualitative conclusions. These additional results are not shown here for reasons of space, but they are available from the authors upon request.

[19]We use 2014 HICP weights. To check for the robustness of the results, further experiments were carried out for different weights and obtained the same qualitative conclusions.

[20]The GMM is based on the idea that population moment conditions provide information which can be used to estimate population parameters. See Hansen (1982) and Ogaki (1993) for a general discussion of the GMM method and applications.

HICP[21]. In this application, we use the HP filter to obtain a smooth estimate of the long-term components of the house prices series that we consider to be representative of the underlying fundamentals (see Beveridge and Nelson, 1981). The cyclical component of the time series is inferred to capture the non-fundamental (bubble) component of the house prices.

Table 1 reports the sectoral parameters for the EA obtained for the ESI (house prices). As can be seen, the cyclical sensitivity parameter γ_j for the energy sector is larger than that estimated for all the other sectors, and the variance of the sectoral shock σ_j^2 and the sluggishness parameter for the energy sector are also high, reflecting the fact that energy prices are the most volatile component of the HICP. The results further suggest that food prices in the EA are pro-cyclical, experience a smaller dispersion in idiosyncratic shocks (except when compared to other goods) and present lower consumption weights (except for energy), indicating that food should have a substantial weight in the ESI (house prices). As for other goods and fundamental house price sectors, we impose a sensitivity parameter γ_j equal to zero, given that the estimated values suggest that they are counter-cyclical sectors. In relation to house prices, the cyclicality parameter is positive (indicating pro-cyclicality), whereas their consumption weight in the HICP is zero. These features, in addition to the sluggishness parameter λ_j, suggest that the house price sector is a desirable component of the ESI. The variance of idiosyncratic shocks σ_j^2 and the sluggishness parameter λ_j for the other goods sector are lower than all the other sectors, making it a good candidate for receiving a sizeable optimal weight in the ESI.

[21]. Blinder (1997) states that policy should concentrate on the permanent or durable part of current inflation that is likely to persist once the transitory or fleeting influences on price movements have worked through or have been reversed.

Table 1: Summary of the sectoral parameters for the euro area: ESI (house prices)

Sector	λ_j	δ_j	γ_j	σ_j^2
Food	1.0	0.20	0.185	50x10^{-6}
Energy	1.0	0.11	6.270	485x10^{-6}
Other goods	0.5	0.69	0.000	37x10^{-6}
House	0.5	0.00	0.403	148x10^{-6}
Fundamental house	0.5	0.00	0.000	108x10^{-6}
Bubble house	0.5	0.00	0.154	52x10^{-6}

The next step of the empirical analysis is to compute optimal weights for the sectoral prices under study. To this end, the parameters for each sector are substituted in equation (12) and the variance of the output gap is then minimised with respect to optimal weights ω_j subject to the constraints established in equations (2) to (6). To analyse the sensitivity and consistency of the results due to the unknown and uncertain true value of sluggishness parameter λ_j, we use intervals of [0.9, 1] for energy and food sectors and [0.45, 0.55] for other goods and house sectors, where prices are assumed to be less flexible. The experiment is repeated by 12,000 sampling draws applying the Newton-Raphson optimisation algorithm method, an iterative process that computes maximum likelihood estimates based on the constraints in Section 2. Additionally, the relative variance of the output gap is computed for both ESI (house prices) and HICP separately for comparison by using sectoral parameters and optimal weights in the case of ESI and actual consumption weights in the case of HICP. Estimation results are reported from three models. The first set of results estimates the optimal weights and variance of the output gap for food, energy, other goods, and house prices. The second and third sets of results compute the optimal weights and output gap variances by replacing house prices with fundamental and bubble house prices, separately, as a fourth sector along three sectors of HICP. Table 2 reports the average optimal ESI weights, the HICP weight, output gap variance and output gap variance reductions from 12,000 optimisation experiments for correlated shocks. The correlation matrix of the sector shocks is presented in Table A5 in the Appendix. As can be seen in Table 2, house prices are given a weight of 33% in the ESI, which is attributable to the combination of the pro-cyclical sensitivity parameter, zero HICP weight and less flexible parameters. The food and other goods sectors obtain optimal weights of 45% and 22% respectively in the ESI, while for energy the optimal weight is 0%. The relatively high weight assigned to the food sector could be related to the fact that the EA consumption structure is characterised by a larger share of food products (which are distinguished by frequent price changes – see Dhyne *et al*, 2006) and have been a key driver of the sharp rises and falls in headline inflation in recent years. When using fundamental house prices, the optimal weight assigned to house prices increases further. Interestingly, in the case of bubble house prices, the optimal weight of house prices rises to 61%, while that of other goods falls to zero; this may be related to the unprecedented house price boom registered in many EA countries which, in many cases, was succeeded by a significant bust, with real house prices in several countries falling by more than 30%. The output gap variance was significantly reduced (by about 93%) in the model which used the ESI compared to the alternative one based on the HICP. Additionally, stability in economic activity rises further when the fundamental and bubble house prices are used as a component in the ESI rather than observed house prices (by 94% and 77% respectively).

Table 2: Optimal weights and output gap variance from constrained optimisation for euro area when λ=0.5 for house prices and correlated shocks

	Food	Energy	Other goods	House	Output variance	Variance reduction
HICP	0.20	0.11	0.69	0.00	1803x10^{-8}	1.00
ESI (house)	0.45	0.00	0.22	0.33	133x10^{-8}	13.52
	(17.72)*	(0.00)	(4.74)*	(12.23)*		
ESI (fun)	0.41	0.00	0.08	0.51	117x10^{-8}	15.45
	(14.42)*	(0.00)	(1.54)	(11.38)*		
ESI (bub)	0.37	0.02	0.00	0.61	407x10^{-8}	4.42
	(12.82)*	(33.3)*	(0.00)	(23.66)*		

Notes: In the ordinary brackets below the parameter estimates, the corresponding *t*-statistics are shown
* indicates significance at 1% level
"house" stands for house prices, "fun" fundamental house prices and "bub" bubble (non-fundamental) house prices.

To check the robustness of the results, Table A1 in the Appendix shows the results from a similar empirical exercise but assuming this time that house prices are fully flexible and setting the sluggishness parameter λ_j=1. By doing so, we explore the possibility that the high optimal weights in the ESI are only driven by the assumption regarding the degree of price sluggishness. As can be seen, the optimal weights are in line with those reported in Table 2 and the substantial gains in cyclical stability are still present.

All in all, our findings suggest not only that the ESI (house prices) could be a better measure of the cost of living than the HICP in the EA during the period under study, but also that the reduction in output gap fluctuations is significantly higher in the ESI than in the HICP. Therefore, the ECB would have been justified in giving a substantial weight to house prices in its target inflation rate in order to achieve both price stability and macroeconomic stabilisation.

4.2. Estimation of Optimal Weights and the ESI: The case of stock prices

The question of whether central banks should react to stock price developments has been passionately debated. We contribute to this debate by computing an ESI for the EA that includes stock price developments, which we denote as the ESI (stock prices). Table 3 reports the sector parameters obtained in this case, distinguishing once again between actual stock prices, fundamental stock prices and bubble stock prices, the last being the part of stock price movement which remains unexplained and which may be related to short-run speculative dynamics. As expected, actual and bubble stock prices are pro-cyclical and experience large idiosyncratic shocks. The parameters of cyclical sensitive γ_j are 19.46 and 22.15 respectively, figures that are very high compared with those estimated for the remaining sectors. In contrast, our results suggest that fundamental stock prices are not very responsive to the output gap. Finally, energy and food prices are once again found to be pro-cyclical. Overall, findings for ESI (stock prices) are very similar to the ones for ESI (house prices) shown in Table 1.

Table 3: Summary of the sectoral parameters for the euro area: ESI (stock prices)

Sector	λ_j	δ_j	γ_j	σ_j^2
Food	1.0	0.20	0.153	$389x10^{-6}$
Energy	1.0	0.11	6.360	$35x10^{-6}$
Other goods	0.5	0.69	0.000	$34x10^{-6}$
Stock	0.5	0.00	19.46	$1863x10^{-6}$
Fundamental	0.5	0.00	0.000	$58x10^{-6}$
Bubble	0.5	0.00	22.15	$9230x10^{-6}$

In relation to the optimal weights and the variance of the output gap, the results in Table 4 indicate the ECB could also maximise economic stability by giving some weights to stock prices[22]. In particular, the optimal weight for actual stock prices is 2%, compared to 41% for other goods and 56% for food, and the bubble case is similar. The higher weight assigned to other goods is due to the low idiosyncratic shocks they experience compared to those registered in both actual and bubble stock prices. Furthermore, fundamental stock prices receive a weight of 58% in the ESI because changes in the fundamentals are more systematic and reflect permanent movements, and are more reliable than the actual or the bubble stock prices in cases of substantial stock price volatility such as those experienced by the EA during the sample. The energy price sector obtains a very low weight in relation to the one used in the HICP. As regards the estimated variance of the output gap, our results suggest a significant reduction for all ESIs compared to that obtained for the HICP: 92% for actual stock prices, 91% for fundamental stock prices and 86% for bubble stock prices. Our findings are in line with those reported in Charemza *et al.* (2013) and Shah and Ahmad (2017), who present evidence suggesting that incorporating stock prices into the price index targeted by the central banks increases output stability.

[22]. The correlation matrix of the sector shocks is presented in Table A6 in the Appendix.

Table 4: Optimal weights and output gap variance from constrained optimisation for the euro area when λ =0.5 for stock prices and correlated shocks

	Food	Energy	Other goods	Stock	Output variance	Variance reduction
HICP	0.20	0.11	0.69	0.00	1328×10^{-8}	1.00
ESI (stock)	0.56	0.01	0.41	0.02	104×10^{-8}	12.7
	(14.25)*	(1.10)	(12.81)*	(15.73)*		
ESI (fun)	0.38	0.04	0.00	0.58	123×10^{-8}	10.79
	(12.67)*	(9.5)*	(0.00)*	(22.57)*		
ESI (bub)	0.54	0.01	0.42	0.03	181×10^{-8}	7.33
	(11.63)*	(0.71)	(10.24)*	(10.34)*		

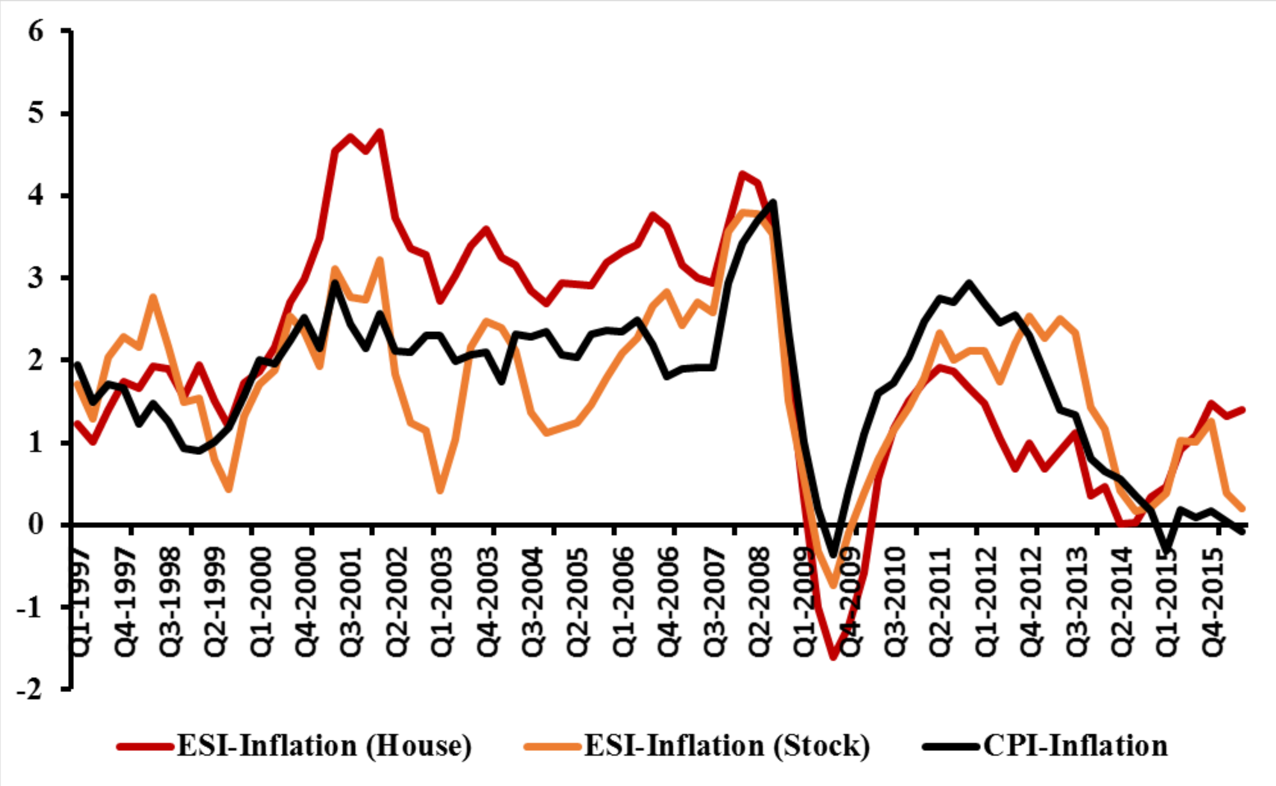
Notes: In the ordinary brackets below the parameter estimates, the corresponding *t*-statistics are shown
* indicates significance at 1% level
"stock" stands for stock prices, "fun" fundamental stock prices and "bub" bubble (non-fundamental) stock prices.

Tables A2 to A4 in the Appendix present the results of alternative empirical exercises considering HICP consumption weights for 2008 instead of those for 2014, assuming that stock prices are fully flexible (setting λ_j=1 instead of λ_j=0.5), and uncorrelated shocks respectively. As can be seen, the same pattern as the one documented in Table 3 emerges consistently from these alternative settings, suggesting that our results are robust to different parameter specifications.

4.3. Alternative inflation rates

For comparison purposes, we compute ESI (both for house prices and for stock prices) by using one time estimated optimal weights for the whole time period. We then calculate inflation rates using the three indicators as the percentage change over the last year's level in the corresponding quarter. These are depicted in Figure 1 where the black, red and orange lines (black, grey and light grey when viewed in grey scale) correspond to the headline (HICP) inflation, the ESI (house prices) inflation and the ESI (stock prices) inflation.

Figure 1: ESI Inflation and HICP Inflation in the euro area



As can be seen, both measures of the ESI inflation are higher and more volatile than headline inflation during the sample under study, the average rates being 2.04% for ESI (house prices), 1.79% for ESI (stock prices) and 1.75% for HICP and the standard deviations 1.43, 0.97 and 0.93 respectively. Furthermore, the ESI inflation rates became more negative than the HICP inflation rate from 2009-2010 onwards. This deflationary behaviour could be prevented by considering the asset prices as a target component. If we examine the evolution of the three inflation rates during the recessions and expansions recorded during the sample period (defined according to the EA Business Cycle Dating Committee – see Center for Economic Policy Research, 2015), we find that in the expansion that took place until 2008:I, the average rates for the ESI inflations were higher than that registered for the HICP, and were also more volatile. During both the 2008:1-2009:II recession and the 2009:II-2011:III expansion, the HICP had a higher average inflation rate than the ESI inflation rates, but the latter were volatile once more. For the 2009:II-2013:I recession, our results suggest that the HICP average inflation rate was higher than those experienced by both ESI inflation rates, with the ESI (house prices) inflation rates being more volatile than the headline and ESI (stock prices) inflation rates. Finally, for the unusually weak expansion that starts in 2013:I, the HICP presents a lower average inflation rate and a lower volatility than the ESI alternative measures.

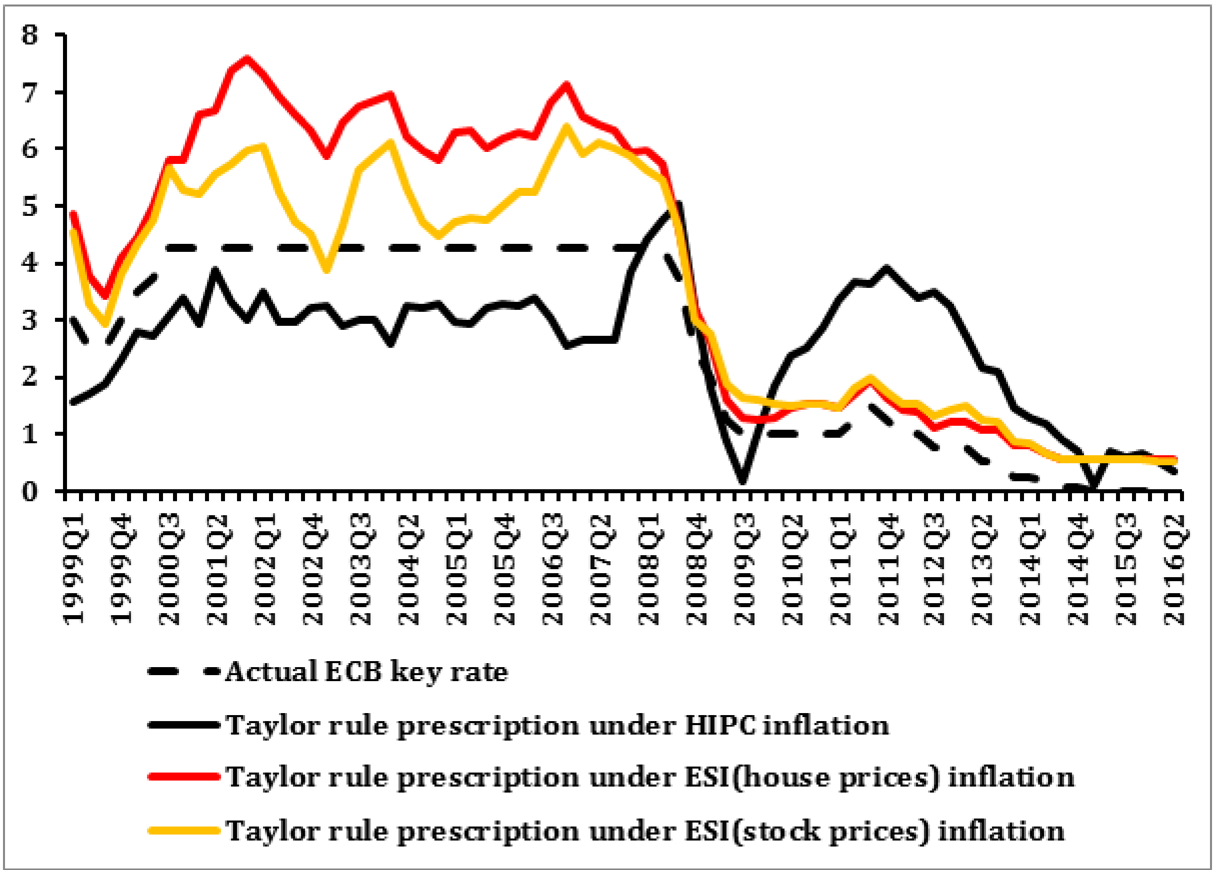
Therefore, our results suggest that, in addition to a significant reduction in the output gap variance, resetting the weights in the target price index of the EA by introducing house prices would have led to a significant increase in the inflation rate during the 2000:IV-2008:II and from 2015:I periods compared to the one actually registered by the HICP inflation, and to a significant reduction during the 2009:I-2013:I period. Turning to the case of the ESI based on stock prices, we find increased inflation episodes with respect the headline inflation during the 2006:III-2008:II, 2013:I-2014:I and 2015:I-2016:I periods. These findings are important especially within the framework of the inflation-targeting monetary policy regime applied by the ECB.

To illustrate the evolution of ECB monetary policy under two counterfactual scenarios reflecting the targeting of the ESI asset prices, we compute a simple Taylor rule, originally proposed by Taylor (1993), as a description of interest rate policy in the EA. As in Castelnuovo (2007) and many other studies, we estimate the following Taylor rule:

$$\mathrm{r}_{\mathrm{t}} = \alpha_0 + \alpha_1 \pi_t + \alpha_2 y_t + u_t \tag{15}$$

where π_t is the inflation rate and y_t is the output gap. This equation may be considered as the baseline monetary policy reaction function of macroeconomic modelling for the evolution of the key interest rate (r_t). We proxy r_t with ECB interest rate on the main refinancing operations (MRO), which provide the bulk of liquidity to the banking system. Figure 2 shows the results where the black, red and orange solid lines (black, grey and light grey when viewed in grey scale) correspond to the Taylor rule prescriptions obtained for the HICP inflation rate, the ESI (house price) inflation rate and the counterfactual values generated for the ESI (stock prices) inflation rate, and the black dotted line displays the actual ECB rate. As can be seen, the ECB would have had to apply a much tighter monetary policy during those periods of increased inflation and a looser monetary stance during the i periods of reduced inflation identified, especially during the Great Recession and the current weak expansion.

Figure 2: ECB key interest rate and Taylor rule prescriptions



Note: Actual ECB key interest rate is the interest rate on main refinancing operations

Our results are in line with those in Chatziantoniou *et al.* (2017), who provide evidence from the UK that the housing market and the stock market play key roles in inflation. They are also consistent with those presented in Antonakakis and Floros (2016), who find large spillovers of shocks from the housing market, stock market and economic policy uncertainty onto positions regarding inflation, economic growth and monetary policy for the United Kingdom in the wake of the global financial crisis.

5. Concluding remarks and policy implications

The international financial crisis provided a stark reminder that price stability is not sufficient to guarantee either financial stability or macroeconomic stabilisation. Central banks and other authorities were increasingly led to pursue macro-prudential policies in order to mitigate systemic risk (IMF-BIS-Financial Stability Board, 2011).

In this paper, making use of the analytical framework presented in Mankiw and Reis (2003) and extended by Charemza and Shah (2013) and Shah and Ahmad (2017), we have analysed whether the ECB should have adopted a broader measure of the price index (ESI) incorporating house prices and stock prices in addition to the price of consumer goods and services. Both house prices and stock prices are forward-looking variables and incorporate information about the future of the economy that is not yet reflected in the current macroeconomic outcome; as witnessed by the recent financial and economic crisis, they may have severe repercussions for the real economy. The presumption is that, by focusing on this broader price index with optimal weights, in addition to achieving price stability by effectively controlling expectations regarding the future level of inflation in the economy, the ECB could also have accomplished some degree of macroeconomic stabilisation by minimising the variance of the output gap.

Our findings indicate that a central bank intending to reduce distractions in economic activity should incorporate asset prices in the inflation-targeting price index. The findings confirm that ESI assigns substantial weight to both house prices and stock prices. The economic stability increases further when fundamental components of the asset prices are used as a component with HICP components. Overall, the reduction in output variance is improved when switching from HICP to the computed ESI in the EA. Our results suggest that if the ECB had targeted the broader price index proposed here, it would have implemented a different monetary policy and would have achieved greater stability in the EA economic activity, setting adequate preconditions for sustainable economic growth and job creation. This implies that the ESI provides a better target for monetary policy implemented through interest rate changes. Our findings corroborate the claim by Debortoli *et al.* (2017) that the incorporation of measures of economic activity into the objective function of a central bank provides good economic results, and also those recently reported in Aastvei *et al.* (2017) regarding the Federal Reserve System's response to house and stock prices in the USA.

Given that the ECB has adopted an inflation-targeting monetary policy regime without an implicit mandate on business cycle stabilisation, our results highlight the importance of the general economic conditions incorporated in house prices and stock prices for the pursuit of monetary policy in the EA. In particular, our counterfactual scenarios suggest that if the ECB had targeted an ESI inflation rate, it would have implemented a much tighter monetary policy before the Great Recession and a looser monetary policy afterwards.

Appendix

Table A1: Optimal weights and output gap variance from constrained optimisation when λ =1 for house prices and correlated shocks

	Food	Energy	Other goods	House	Output variance	Variance reduction
HICP	0.20	0.11	0.69	0.00	1986×10^{-8}	1.00
ESI (house)	0.54	0.00	0.00	0.46	113×10^{-8}	17.32
	(18.04)*	(0.00)	(0.00)	(15.63)*		
ESI (fun)	0.53	0.00	0.00	0.47	93×10^{-8}	20.95
	(16.94)*	(0.00)	(0.00)	(14.90)*		
ESI (bub)	0.51	0.00	0.00	0.49	284×10^{-8}	6.89
	(15.96)*	(66.7)	(10.3)	(15.28)*		

Notes: In the ordinary brackets below the parameter estimates, the corresponding *t*-statistics are shown
* indicates significance at 1% level
"house" stands for house prices, "fun" fundamental house prices and "bub"

Table A2: Optimal weights and output gap variance from constrained optimisation when λ =0.5 for stock prices and correlated shocks, with 2008 HICP consumption weights.

	Food	Energy	Other goods	House	Output variance	Variance reduction
HICP	0.20	0.10	0.70	0.00	2415×10^{-8}	1.00
ESI (house)	0.47	0. 00	0.20	0.33	119×10^{-8}	20.21
	(18.66)*	(0.00)	(4.95)	(14.42)*		
ESI (fun)	0.41	0.00	0. 04	0.55	115×10^{-8}	20.94
	(11.14)*	(0.00)*	(0.88)	(9.80)*		
ESI (bub)	0.37	0.01	0.00	0.62	405×10^{-8}	5.96
	(9.88)*	(2.56)*	(0.00)	(18.86)*		

Notes: In the ordinary brackets below the parameter estimates, the corresponding *t*-statistics are shown
* indicates significance at 1% level
"house" stands for house prices, "fun" fundamental house prices and "bub" bubble (non-fundamental) house prices.

Table A3: Optimal weights and output gap variance from constrained optimisation when λ=1 for shock prices and correlated shocks

	Food	Energy	Other goods	Stock	Output variance	Variance reduction
HICP	0.20	0.11	0.69	0.00	4045×10^{-8}	1.00
ESI (house)	0.79	0. 00	0.00	0.21	880×10^{-8}	4.59
	(123.72)*	(0.00)	(0.00)	(32.81)*		
ESI (fun)	0.83	0.17	0. 00	0.00	1791×10^{-8}	2.25
	(51.54)*	(10.57)*	(0.00)	(0.00)		
ESI (bub)	0.51	0.14	0.00	0.35	927×10^{-8}	4.36
	(23.89)*	(17.04)*	(0.00)	(14.40)*		

Notes: In the ordinary brackets below the parameter estimates, the corresponding t-statistics are shown
* indicates significance at 1% level
"house" stands for house prices, "fun" fundamental house prices and "bub" bubble (non-fundamental) house prices.

Table A4: Optimal weights and output gap variance from constrained optimisation for the euro area when λ=0.5 for stock prices and uncorrelated shocks

	Food	Energy	Other goods	Stock	Output variance	Variance reduction
HICP	0.20	0.11	0.69	0.00	3906×10^{-8}	1.00
ESI (stock)	0.78	0.01	0.41	0.22	805×10^{-8}	4.85
t-stat	(14.25)*	(1.10)	(12.81)*	(15.73)*		
ESI (fun)	0.78	0.22	0.00	0.00	2505×10^{-8}	1.56
t-stat	(12.67)*	(25.77)*	(0.00)	(0.00)		
ESI (bub)	0.53	0.13	0.00	0.34	829×10^{-8}	4.71
t-stat	(30.94)*	(13.53)*	(0.00)	(15.10)*		

Notes: In the ordinary brackets below the parameter estimates, the corresponding t-statistics are shown
* indicates significance at 1% level
"stock" stands for stock prices, "fun" fundamental stock prices and "bub" bubble (non-fundamental) stock prices.

Table A1 - Correlation matrix of shocks in the euro area: House prices

Sector	Energy	Food	Other goods	House
Energy	1.0000	-0.3333	-0.6802	-0.1592
Food		1.0000	-0.3547	0.0884
Other goods			1.0000	-0.0342
House				1.0000

Table A1 - Correlation matrix of shocks in the euro area: Stock prices

Sector	Energy	Food	Other goods	Stock
Energy	1.0000	-0.3276	-0.7015	0.2002
Food		1.0000	-0.2843	-0.0678
Other goods			1.0000	-0.1805
Stock				1.0000

References:

Aastveit, K. A., Furlanetto, F. Loria, F., 2017. Has the Fed responded to house and stock prices? A time-varying analysis. Working Paper 1/2017, Norges Bank, Oslo.

Alchian, A., Klein, B., 1973. On a correct measure of inflation. Journal of Money, Credit and Banking 5, 173-191.

Álvarez, J. L., Dhyne, E., Hoeberichts, M. M., Kwapil, C., Le Bihan, H., Lünnemann, P., Martins, F., Sabbatini, R., Stahl, H., Vermeulen, P., Vilmunen, J., 2005. Sticky prices in the euro area: A summary of new micro evidence. Working Paper 563. European Central Bank, Frankfurt am Main.

Antonakakis, N., Floros, C., 2016. Dynamic interdependencies among the housing market, stock market, policy uncertainty and the macroeconomy in the United Kingdom. International Review of Financial Analysis 44, 111-122.

Aoki, K., 2001. Optimal monetary policy responses to relative-price changes. Journal of Monetary Economics 48, 55-80.

Ball, L., Mankiw, N. G., Reis, R., 2005. Monetary policy for inattentive economies. Journal of Monetary Economics 52, 703-725.

Bean, C., 2003. Asset prices, financial imbalances and monetary policy: Are inflation targets enough? Working Paper 140, Bank of international Settlements, Basel.

Beltratti, A,, Morana, C., 2010. International house prices and macroeconomic fluctuations. Journal of Banking and Finance 34, 533–545.

Bernanke, B., Gertler, M., 2001. Should central banks respond to movements in asset prices? American Economic Review 92, 253-257.

Beveridge, S., Nelson, C., 1981. A new approach to decomposition of economic time series into permanent and transitory components with particular attention to measurement of the business cycle. Journal of Monetary Economics 7, 151-174.

Blinder, A., 1997. Measuring short run inflation for central bankers. Federal Reserve Bank of St. Louis 79, 143-155.

Blanchard O., Summers L., 1993. The stock market, profit, and investment. Quarterly Journal of Economics 108, 115-136.

Blot, C., Creel, J., Hubert, P., Labondance, F., Saraceno, F., 2015. Assessing the link between price and financial stability. Journal of Financial Stability 16, 71-88.

Boivin, J., Giannoni, M- P., Mihov, I., 2009. Sticky prices and monetary policy: Evidence from disaggregated US data. American Economic Review 99, 350-384.

Borio, C., Lowe, P., 2002. Asset prices, financial and monetary stability: Exploring the nexus. Working Paper 114, Bank of international Settlements, Basel.

Carlstrom, C. T,, Fuerst, T. S., 2007. Asset prices, nominal rigidities, and monetary policy. Review of Economics Dynamics 10, 256–275.

Case, K., Quigley, J., Shiller, R., 2001. Comparing wealth effects: The stock market versus the housing market. Working Paper 8606, National Bureau of Economic Research, Cambridge.

Castelnuovo, E., 2007. Taylor rules and interest rate smoothing in the euro area. The Manchester School 75, 1–16.

Cecchetti, S. G., Genberg, H., Wadhwani, S., 2003. Asset prices in a flexible inflation targeting framework. In: Hunter, W.C, Kaufman, G.G, Pomerleano, M. (Eds.), Asset Price Bubbles: The Implication for Monetary Regulatory, and International Policies, MIT Press, Cambridge, 427-444.

Cecchetti, S., Genberg, H., Lipsky, J., Wadhwani, S., 2000. Asset prices and central bank policy. Geneva Reports on the World Economy 2, International Center for Monetary and Banking Studies, Geneva.

Center for Economic Policy Research, 2015. Euro area business cycle dating committee: Euro area out of recession, in unusually weak expansion. Centre for Economic Policy Research, London.

Chamberlin, G., 2009. Core inflation. Economic and Labour Market Review 3, 48-57.

Charemza, W., Shah, I. H., 2013. Stability price index, core inflation and output volatility. Applied Economics Letters 20, 737-741.

Charemza, W., Makarova, S., Shah, I., 2015. Making the most of high inflation. Applied Economics 47, 3723-3739.

Chatziantoniou, I., Filis, G., Floros, C., 2017. Asset prices regime-switching and the role of inflation targeting monetary policy. Global Finance Journal 32, 97-112.

Chen, S., Ranciere, R., 2016. Financial information and macroeconomic forecasts. Workimg Paper 16/251, International Monetary Fund, Washington D. C.

Collard, F., Dellas, H., Diba, B., Loisel, O., 2017. Optimal monetary and prudential policies. American Economic Journal: Macroeconomics 9, 40-87

Corradin, S., Fontana, A., 2013. House price cycles in Europe. Working Paper 1613. European Central Bank, Frankfurt am Main.

Corradin, S., Fillat, J,, Vergara-Alert, C., 2014. Optimal portfolio choice with predictability in house prices and transaction costs. Review of Financial Studies 27, 823-880.

Debortoli, D., Kim, J., Lindé, J., Nunes, R., 2017. Designing a Simple Loss Function for Central Banks: Does a Dual Mandate Make Sense? Working Paper 958, Barcelona Graduate School of Economics, Barcelona.

Dhyne, E., Álvarez, L. J., Le Bihan, H., Veronese, G., Dias, D., Hoffmann, J., Jonker, N., Lünnemann, P., Rumler, F., Vilmunen, J., (2006. Price changes in the Euro Area and the United States: Some facts from individual consumer price data. Journal of Economic Perspectives 20, 171-192.

ECB, 2010. The “Great Inflation”: Lessons for monetary policy. Monthly Bulletin May, 99-110.

ECB, 2013. Are sub-indices of the HICP measures of underlying inflation? Monthly Bulletin December, 63-67

ECB, 2014. House prices and the rent component of the HICP in the euro area Monthly Bulletin August, 43-47.

ECB, 2015. The state of the house price cycle in the euro area, Economic Bulletin September, 58-73.

Farmer, R. E., 2009. What Keynes should have said. VOX, February 4. http://voxeu.org/article/government-should-target-stock-market

Fischer S., 1977. Long-term contracts, rational expectations, and the optimal money supply rule. Journal of Political Economy 85, 191-205.

Gerlach, S., 2010. Asset prices and monetary policy: Some sceptical observations. In: Balling, M, Berk, J. M., Strauss-Kahn, M. O. (Eds.), The Quest for Stability: The Macro View, SUERF, Vienna, 45–60.

Goodhart, C., 2001. What weight should be given to asset prices in the measurement of inflation? The Economic Journal 111, 335-356.

Goodhart, C., Hofmann, B., 2007a. Overview. In: Goodhart, C., Hofmann, B. (Eds.), House prices and the macro economy: Implications for banking and price stability, Oxford University Press, Oxford, 5-16.

Goodhart, C., Hofmann, B., 2007b. Financial conditions indices. In: Goodhart, C., Hofmann, B. (Eds.), House prices and the macro economy: Implications for banking and price stability, Oxford University Press, Oxford, 35-54.

Greenspan, A., 2007, The Age of Turbulence: Adventures in a New World. Penguin Books, London.

Hansen, L. P., 1982. Large sample properties of generalized method of moments estimators. Econometrica 50, 1029-1054.

Hodrick R. J., Prescott, E. C., 1997, Post-war US business cycles: An empirical investigation. Journal of Money, Credit and Banking 29, 1-16

IMF-BIS-Financial Stability Board, 2011. Macroprudential policy tools and frameworks, Progress report to G20, October.

Ivanov, V., Kilian, L., 2005. A practitioner's guide to lag order selection for var impulse response analysis. Studies in Nonlinear Dynamics and Econometrics 9, Article 2.

Kaufmann, D., Lein, L., 2011. Sectoral inflation dynamics, idiosyncratic shocks and monetary policy. Working Paper 2011-7. Swiss National Bank, Zurich.

Kent, C., Low, P., 1997. Asset-price bubbles and monetary policy. Research Discussion Paper 9709, Reserve Bank of Australia, Sydney

Kiley, M., 2000. Endogenous price stickiness and business cycle persistence. Journal of Money, Credit and Banking 32, 28-53.

Kimball, M., 2013. How paper currency is holding the US recovery back. Quartz January 3, https://qz.com/21797/the-case-for-electric-money-the-end-of-inflation-and-recessions-as-we-know-it/

Kontonikas, A., Montagnoli, C., 2005. Should monetary policy respond to asset price misalignments? Economic Modelling 22, 1105- 1121.

Lütkepohl, H., 2005. Introduction to multiple time series analysis. Springer, Berlin.

MacDonald, G., Mullineux, A., Sensarma, R., 2011. Asymmetric effects of interest rate changes: The role of the consumption-wealth channel. Applied Economics 43, 1991-2001.

Mackowiak, B., Wiederholt, M., 2009. Optimal sticky prices under rational inattention. American Economic Review 99, 769-803.

Mankiw, N., Reis, R., 2002. Sticky information versus sticky prices: A proposal to replace the new Keynesian Phillips curve. The Quarterly Journal of Economics 117, 1295-1328.

Mankiw, N., Reis, R., 2003. What measure of inflation should a central bank target? Journal of the European Economic Association 1, 1058-1086.

Meyler, A., 2009. The pass through of oil prices into euro area consumer liquid fuel prices in an environment of high and volatile oil prices. Energy Economics 31, 867-881.

Mumtaz, H., Zabczyk, P., Ellis, C., 2009. What lies beneath: What can disaggregated data tell us about the behaviour of prices? Working Paper 364, Bank of England, London.

Nutahara, K., 2017. Asset prices, nominal rigidities, and monetary policy: Case of housing price. Working Paper 17-001E, Canon Institute for Global Studies, Tokyo

Ogaki, M., 1993. Generalized method of moments: Econometric applications. In: Maddala, G. S., Rao, C. R., Vinod, H. D. (Eds.), Handbook of Statistics, Volume 11, Elsevier Science, Amsterdam, 455-486.

Schwartz, A. J., 2003. Asset price inflation and monetary policy. Atlantic Economic Journal 31, 1-14.

Shah, I.H., Ahmad, A. H., 2017. How important is the financial sector to price indices in an inflation targeting regime? An empirical analysis of the UK and the US. Review of Quantitative Finance and Accounting 48, 1063-1082.

Shiratsuka, S., 1999. Asset price fluctuation and price indices. Monetary and Economic Studies 17, 103-128.

Svensson, L. E., 2012. The relation between monetary policy and financial policy. International Journal of Central Banking 8, 293-295.

Taylor, J. B., 1993. Discretion versus policy rules in practice. Carnegie-Rochester Series on Public Policy 39, 195-214.

Woodford M., 2012. Inflation targeting and financial stability. Working Paper 17967, National Bureau of Economic Research, Cambridge.

Wooldridge, J., 2001. Applications of generalized method of moments estimation. Journal of Economic Perspectives 15, 87-100.

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