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Abstract

A key problem facing monetary policy makers is determining whether serious financial instability is present. Periods of financial instability are linked with low investors' risk appetite (or in other words high risk aversion). Two different measures of investors' risk aversion are used: (a) the implied volatility from the Eurostoxx 50 index (VSTOX) and (b) an index based on principal component analysis applied to risk premia of several stock portfolios in the eurozone area (12 countries) with different fundamental and size characteristics. By using an unrestricted VAR model and impulse response analysis for the period January 1999 to August 2007, our results show that a shock in the risk aversion indicator affects negatively future real activity in the eurozone in a similar way to an exchange rate shock. The ECB reacts significantly to a risk aversion shock by reducing the interest rate in order to provide liquidity. Moreover, assuming rational expectations and using a forward-looking specification of the Taylor rule, we found that investors' risk aversion affects the ECB behavior as the leading indicator of future economic activity but not as an independent argument for the monetary policy. It views price stability and economic and financial stability as highly complementary and mutually consistent objectives to be pursued within a unified policy framework.

JEL classification: E44, E52, G0

Keywords: European Central Bank, monetary policy; Taylor rule; transmission mechanism; VAR model; GMM

1. Introduction

Since the introduction of the common currency in 1999 the degree of financial market integration has increased dramatically among the members of the eurozone. Moreover, global stock indices have been constructed including companies from countries belonging to the eurozone and international investors direct their interest to these indices.

Equity markets are an active alternative source of corporate finance compared with traditional lending via banks. These days, more and more companies raise funds via equity markets to finance their investment projects, which affect real economic activity. If managers of risky firms are cognizant of their investors' required compensation for risk, an increase in the risk premium should raise the "hurdle rate" that managers use to evaluate new investments. This can lead to quashing many investments already planned and reducing the number of feasible projects, with significant consequences for the real economy. As a consequence the study of investors' risk behavior in stock markets could provide possible signals about future real economic activity.

Broad literature originating in the 1990s documents, using mainly U.S. data, that there is a link between risk premia in stock market and macroeconomic variables. Among others Kandel and Stambaugh (1990), Chen (1991) and Pastor and Stambaugh (2001) indicate that expected excess returns vary countercyclically with current business conditions.

Recently, Liew and Vassalou (2000) and Fuerst (2006) measured risk premia implied by the Fama–French asset pricing model and found that innovations in some of these premia are informative about future real economic activity in the U.S. Fuerst focused on size-related premia without providing arguments for the poor information contained in other premia about economic activity. Each risk premium in these studies reflects the attitude toward risk of a specific category of investors.

However, according to Kumar and Persaud (2002), investors share a common but changing appetite for risk. All theses implying that information about economic activity containing investors' appetite for risk greater than the risk premia in general should be investigated.

In our study risk premia on indices portfolios are decomposed within the framework of asset pricing models into a "price of risk," which is common to all assets, and a "quantity of risk," which is specific to each asset.[1] The relation between "price of risk" and economic activity is investigated within the well-established framework of monetary policy vector autoregression.

Risk aversion is often considered to correspond to the "price of risk" obtained in this way and has a dual use in the literature. On the one hand, in its narrow sense, the term refers to the risk aversion coefficient present in the consumer's utility function. This parameter depends on the economic agent profile and it is constant over time. On the other hand, in its broader view – which is the one adopted in this paper – it is a significant factor in the formation of asset prices and makes it possible to reflect investor sentiment with regard to risk in an ever-changing environment.[2] This definition has the advantage that it constitutes the opposite of the concept of "risk appetite" frequently mentioned by market operators (Kumar and Persaud, 2002; Gai and Vause, 2004). Goudert and Gex (2006) find that risk aversion tends to increase before stock market crises. In light of these findings and the fact that there is significant correlation between

[1] See Cochrane (2001).
[2] Kumar and Persaud (2002) developed an analytical framework for defining investor risk appetite based on the price of risk.

stock market crises and economic activity, we investigate the relation between risk aversion measures and economic activity, which is not given particular attention in academic literature.

The paper's contribution to the literature is twofold. It is the first study to our knowledge that investigates the relationship between measures of investors' risk aversion and economic activity for eurozone aggregate data. Moreover, it compares the effect on economic activity of shocks in risk aversion indices with monetary policy shocks. It therefore provides useful implications for policy makers about the significance of investors' risk perception in conducting economic policy in the broad eurozone. More specifically, the role of investors' risk aversion in the ECB reaction function is investigated.

Over the recent years there has been an increasing amount of literature that investigates empirically the ECB reaction function (see among others Fourcans and Vranceanu, 2002; Gerdesmeier and Roffia, 2004; Ullrich, 2003; Sauer and Sturm, 2007). However, none of these researchers mentioned the importance of financial stability in conducting monetary policy. This paper tries to shed light in this direction. The Central Bank's liquidity may be the answer to the increased level of risk aversion from investors in the name of financial stability. However, the recent financial crisis teaches us that the magnitude and the duration of this provided liquidity may have negative effects on the economy depending on commercial banks' behavior.

The rest of the paper is organized as follows. In Section 2 there is a literature review. Section 3 provides information about the data and the main methodology of our research. In the fourth Section, estimation results are presented and discussed. Finally, the last Section concludes with some general comments.

2. Literature Review

At the beginning of the 1990s Kandel and Stambaugh provided empirical evidence of the countercyclical and leading behavior of the risk premium. They argue that, at business cycle peaks, when current consumption and output are high, investors have a relatively lower marginal utility for consumption and therefore require less compensation for bearing risk. At business cycle troughs, the risk premium is at its greatest due to the fact that investors suffer from lower consumption and anticipate higher future consumption levels and volatility.

Two years later, Fama and French (1992) initiated one of the main research topics in asset pricing in the 1990s. They state that the Capital Asset Pricing Model (CAPM) should be extended by including two more risk premium factors related to size and relative distress. More specifically, in a series of their papers (1995, 1996, 1998), they argue that a risk factor related to book-to-market called High Minus Low (HML) and a risk factor related to size called Small Minus Big (SMB) act as state variables in the context of Merton's (1973) Intertemporal Capital Asset Pricing Model (ICAPM). In such a case, risk premia related to these two factors should capture information about fundamental risk in the economy that affects the investment opportunity set.

According to Fama and French (1992, 1996) and Lakonishok et al. (1994), U.S. firms that have a high book-to-market equity ratio, earnings-to-price ratio or cash flow-to-price ratio, known as value stocks, present a strong premium in average returns. This value premium is associated with relative distress. This premium arises because the market undervalues distressed (value) stocks and overvalues growth stocks (Haugen, 1995). When these pricing errors are corrected value stocks have high returns and growth stocks low returns. In other words, value stocks are usually undervalued due to the persistent low future earnings they tend to have and the great optimism about economic conditions that leads investors to buy growth stocks. However, in periods of high economic uncertainty, all investors sell growth stocks and buy value stocks, resulting in an increase in the HML risk factor.

Hardouvelis and Wizman (1992) find that the risk premium for size shows strong countercyclical variation, implying that this size effect may be a significant propagation mechanism of business cycles. Moreover, Fuerst (2006) argues that this small firm risk premium, indicating small firm access to capital, plays a crucial role in the monetary transmission mechanism to the real economy. Liew and Vassalou (2000) find that SMB and HML portfolios do well in good times and poorly in bad times. This is exactly the opposite of what a consumption risk-averse investor desires and justifies risk premia on these factors. Fuerst (2006) indicates that shocks to the premium related to small firms induce responses in the real economy similar to those from monetary policy disturbances.

Other studies focusing on the relationship between investment decisions and risk premia are those by Lamont (2000) and Lettau and Ludvigson (2002). The former use Q theory and a consumption–wealth ratio to proxy for the future risk premium and then analyze the link between this proxy and future long-term investment. The latter argues that actual investing occurs with a lag following a change in the discount rate and induces a negative correlation between risk premia and investments.

Another interesting area in the literature is the one referring to the relation between risk aversion indices and financial crises. According to Goudert and Gex (2006), risk aversion tends to increase before a financial crisis. However, the measure of risk aversion is a good leading indicator of stock market crises, but is less so for currency crises.

According to Bernanke and Gertler (1999), asset price crashes in the U.S. have inflicted sustained damage on the economy only in cases where the monetary policy remained unresponsive to actively reinforced deflationary pressures. Therefore, one development that has already concentrated the minds of policy makers is an apparent increase in financial stability, of which one important dimension is the increased volatility of asset prices. Central banks should view price stability as highly complementary and mutually consistent objectives, to be pursued within a unified policy framework.

The inflation targeting implies that interest rates will tend to increase during (inflationary) asset price booms and fall during (deflationary) asset price busts, and reduces the potential for financial panics produced from trying to stabilize the asset price per se.

Moreover, Mishkin and White (2002) argue that stock market crashes that may be attributed to expectations of an economic decline or a loss of "irrational exuberance" have an independent effect on economic activity. The financial shock is transmitted via the effect that a large loss in wealth has on consumer spending and through effects on the cost of capital on investment. Monetary authorities should follow an expansionary policy by increasing liquidity in order to reduce the financial instability that produces additional stress on the economy. However, the recent financial crisis provides evidence that increased liquidity lasting a long time in the market may affect the risk perception of banks and have serious implications concerning systemic risk.

3. Theoretical Underpinnings: Price and Quantity of Risk

Based on asset pricing theory, the risk premium can be decomposed into the quantity and the price of risk. The latter is common across assets or portfolios and is frequently related in the literature to investors' behavior to risk.

By considering the CCAPM framework in a very simple form, we assume that there is a single risky asset, two periods, constant consumer prices and a utility function that is separable over time. The investor must therefore maximize his utility by choosing an optimal quantity of assets to buy in the first period. The optimization program to be solved is as follows:

$$\begin{cases} \max_{\xi} \quad u(c_t) + E_t[\delta \cdot u(c_{t+1})] \\ c_t = y_t - p_t \cdot \xi \\ c_{t+1} = y_{t+1} + x_{t+1} \cdot \xi \end{cases} \tag{1}$$

We denote consumption as c_t in t, non-financial revenue as y_t, the price of the asset as p_t, gross income from the asset x_{t+1} and the quantity of the asset bought in t as ξ, and δ is the intertemporal discount factor, which captures the consumer's preference the present. Then the price of the asset is deduced from the first-order conditions:

$$p_t = E_t[\delta \frac{u'(c_{t+1})}{u'(c_t)} x_{t+1}]. \tag{2}$$

The asset price expressed in Eq. (2) can be interpreted as the expected income x_{t+1}, discounted by a discount factor, denoted as m_{t+1} and referred to as the "stochastic discount factor":

$$p_t = E_t[m_{t+1}x_{t+1}],\ m_{t+1} = \delta \frac{u'(c_{t+1})}{u'(c_t)}. \tag{3}$$

To express the risk premia, it is necessary to derive the gross return on the asset. To do so we divide the income by the price:

$$1 = E_t[m_{t+1}R_{t+1}]. \tag{4}$$

By definition the risk-free asset (R^f) does not vary with the states of the world and it follows that:

$$1 = E_t[m_{t+1}R^f_{t+1}] = E_t[m_{t+1}]R^f_{t+1} \Rightarrow R^f_{t+1} = 1/E_t[m_{t+1}]. \tag{5}$$

By using Eq. (4) and (5) the risk premium can be written as follows:[3]

$$E_t(R_{t+1}) - R^f_{t+1} = -\operatorname{cov}[m_{t+1}, R_{t+1}]R^f_{t+1}. \tag{6}$$

Assuming that there are n assets or portfolio indices in our case (i=1 to n), the risk premium can be decomposed as follows:

$$E_t(R^i_{t+1}) - R^f_{t+1} = \left(\frac{-\operatorname{cov}[m_{t+1}, R_{t+1}]}{\operatorname{var}(m_{t+1})}\right) \cdot \left(\frac{\operatorname{var}(m_{t+1})}{E_t(m_{t+1})}\right). \tag{7}$$

The risk premium can be written in the form:

$$E_t(R^i_{t+1}) = R^f_{t+1} + \beta_{i,m} \cdot \lambda_m \tag{8}$$

$$\beta_{i,m} = \left(\frac{-\operatorname{cov}[m_{t+1}, R_{t+1}]}{\operatorname{var}(m_{t+1})}\right),\ \lambda_m = \left(\frac{\operatorname{var}(m_{t+1})}{E_t(m_{t+1})}\right).$$

We can consider that λ_m is the price of risk, which is common to all assets, and that $\beta_{i,m}$ is the specific quantity of risk associated with each asset. Often, the price of risk λ_m is regarded as corresponding to risk aversion.

[3] We also use the definition of covariance $\operatorname{cov}[m_{t+1}, R_{t+1}] = E(m_{t+1}, R_{t+1}) - E(m_{t+1})E(R_{t+1})$.

4. Data and Methodology

In the first step of our methodology we construct indices portfolios based on fundamental characteristics of firms in the eurozone. Secondly, by adopting principal component analysis on the risk premia of these indices portfolios, we estimate a measure of risk aversion. Thirdly, within a VAR framework, we compare the effects of monetary policy on industrial production with the effects of our risk aversion indicators on this same measure. Finally, we investigate the role of this risk aversion indicator in the Central Bank's setting of the interest rate in a Taylor-rule framework.

Risk Aversion Measures

The sample size begins with the introduction of the European Union unit. Monthly stock market data for the broad eurozone[4] area, during the period 1999M1–2007M8, are taken from "Stoxx Limited,"[5] a joint venture between Deutsche Börse AG, Dow Jones & Company and SWX Group (Swiss Exchange) providing special style and sector indices.

The DJ STOXX Total Market Index (TMI) for the eurozone covers 95 percent of the free float market capitalization of the respective investable stock universe. The size classification groups companies of this index into three different size ranges: Large, Medium and Small. The companies belonging to each size index are grouped further by investment styles into growth or value, producing the following indices portfolios of our main concern: Large Cap

[4] Eurozone: companies incorporated and listed in the eurozone (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain) that are trading in euros.
[5] www.stoxx.com

Growth (LG), Mid Cap Growth (MG), Small Cap Growth (SG) and Large Cap Value (LV), Mid Cap Value (MV), Small Cap Value (SV).

The Dow Jones STOXX style classification process groups together companies with similar value and growth style characteristics. The style characteristics of each stock are determined by analyzing six factors – two projected and four historical: projected and trailing P/E ratios, projected and trailing earnings growth, price/book (P/B) ratio and dividend yield.[6]

The common trend in the risk premia of indices portfolios can be interpreted as the price of risk if certain conditions are met: notably that it increases with each risk premium and it is correlated with other measures of investor risk tolerance such as the volatility indices from the stock markets.

The search for common sources of variation has a long history in the asset pricing literature. Ross's (1976) APT model, which is based on the no-arbitrage argument, shows that the systematic portion of equity returns can be expressed as a linear function of a set of "factors." However, APT specifies neither their number nor their nature. This leads to the use of statistical methods, such as principal component analysis (PCA), to identify them.

In order to estimate a risk aversion measure principal component analysis is applied to the risk premia of our equity portfolios in order to identify a common factor in their variations. More specifically, an indicator referred to hereafter as "Comp1" is constructed exactly like a weighted average of risk premia, the weighting being given by the PCA on the risk premia of indices portfolios (LG, MG, SG, LV, MV, SV). The risk premia have been chosen so as to be representative of the changes observed across the stock market as a whole.

[6] The style indices are reviewed on a semi-annual basis in March and September. Details concerning the construction of style indices can be found at the website www.stoxx.com.

Sløk and Kennedy (2004) use principal component analysis to identify a common trend in the risk premia on stock and bond markets in developed and emerging countries. They argue that the variance explained weighted average of the first two common factors is strongly correlated with the OECD's leading indicator of industrial production and a measure of global liquidity, and can be used as a measure of risk aversion. McGuire and Schrijvers (2003) find similar results for 15 emerging market countries.

As an alternative measure of risk aversion we use a volatility index constructed from the option market. Volatility is a measure of the level of uncertainty prevailing in certain markets. Implied volatility represents the estimates and assumptions of market participants involved in a trade, on the basis of a given option price.

Market analysts usually try to estimate changes in investors' perception of risk by looking at gold prices and the Swiss franc exchange rate, which increase over periods of uncertainty. However, in 1993 a more direct measure of fear, a new volatility index (VIX), was created by the Chicago Board Options Exchange (CBOE), which equals the implied volatility on the S&P 500. Over the last years, a similar measure for the eurozone has been presented, known as the DJ EURO STOXX 50 Volatility Index (VSTOXX).

The underling asset is the DJ EURO STOXX 50 index that measures the performance of the eurozone equity market. It covers the 50 largest sector leaders in the eurozone based on free float market capitalization. The options contract on this index is one of the products of Eurex with the highest trading volume. The VSTOXX is calculated on the basis of 8 expiry months with a maximum time to expiry of 2 years.[7] Since we have 2 measures of risk aversion we proceed to the second step of our methodology by investigating the relation between these measures and economic activity.

<u>*Risk Aversion Measures within a VAR Framework*</u>

By following the previous findings of Patelis (1997), Thorbecke (1997, 2000) and Fuerst (2006), which show a link between monetary policy and stock returns, we cast our analysis within the well-established framework of monetary policy vector autoregressions.

The benefit of this approach is the direct comparability of the effects of monetary policy on industrial production with the effects of our risk aversion indicators on this same measure. Monetary models analyze the impact on the economy of changes in the cost of borrowing. Similarly, we analyze the impact on the economy of changes in the risk aversion indicator, which makes raising funds through the capital market not an easy task.

Our system is essentially a standard monetary model augmented with a risk aversion indicator. As with many common monetary models, we achieve identification by assuming a lower triangular matrix for the contemporaneous interactions among the variables (i.e., we use a Choleski decomposition). We estimate the following system as vector autoregressions in levels and analyze its impulse responses:

$$\mathbf{y}_t = \boldsymbol{\mu} + \sum_{i=1}^{k} \boldsymbol{\Gamma}_i \mathbf{y}_{t-i} + \varepsilon_t, \tag{10}$$

where $\mathbf{y}_t$ is a p-vector of industrial production, the inflation variable, the risk aversion variable, the overnight interest rate (EONIA[8]) and the nominal effective

[7] This index, jointly developed by Goldman Sachs and Deutsche Börse, does not measure implied volatilities of at-the-money DJ EURO STOXX 50 options but the implied variance across all options of a given time to expiry (www.stoxx.com).

exchange rate of the euro[9]; $\boldsymbol{\mu}$ is a vector of drift constants; $\boldsymbol{\Gamma}$ is the $p \times p$ matrix of the coefficients at lag i; and $\varepsilon_t \sim nid(\mathbf{0}, \boldsymbol{\Sigma})$ is the vector of innovations. The number of three lags for the system is specified based on likelihood ratio tests.

The Taylor Rule and the Risk Aversion Measures

Price stability over the medium term is the main goal of the European Central Bank. Because monetary policy operates with a lag, a successful stabilization policy therefore needs to be forward looking. In order to investigate ECB interest rate setting we use a simple rule for monetary policy, building on the experience of Taylor (1993). The effectiveness of the Taylor rule in stabilizing open economies under exchange rate model uncertainty has been presented recently by Leitemo and Soderstrom (2005).

As an enhancement of the standard Taylor rule we follow Clarida et al. (1998) and use a forward-looking rule, where the target interest rate i_t^* is set in response to the expected inflation and output gap. At this point we should mention that many economists argue that central bankers focus their attention on core inflation more than on a broader measure of inflation. This is mainly due to their belief that energy shocks have a temporary character (see Figure 1).

[Insert Figure 1 here]

In line with Clarida et al. (1998) we take the industrial production index for the euro area, apply a standard Hodrick–Prescott filter[10] and calculate our measure of the output gap as the deviation of logarithm of the actual industrial

[8] We measure actual monetary policy by the Euro Overnight Index Average (EONIA) lending rate on the money market, which is the European equivalent of the Federal Funds rate for the United States.
[9] Monthly data for the period 1999M1–2007M8 obtained from Eurostat and the International Monetary Fund's International Financial Statistics database.
[10] The smoothing parameter set at λ=14400.

production from its trend. Expectations are based on the available information set Ω at time t and reach k and l periods into the future, respectively:

$$i_t = a + \beta_\pi \cdot E(\pi_{t+k} \mid \Omega_t) + \beta_y \cdot E(y_{t+l} \mid \Omega_t) + \varepsilon_t \,. \qquad (11)$$

However, it is commonly observed that, especially since the early 1990s, central banks worldwide tend to move policy interest rates in small steps without reversing direction quickly (see e.g. Amato and Laubach, 1999; Rudebusch, 2002). To capture this so-called interest rate smoothing, Eq. (11) is viewed as the mechanism by which the target interest rate i_t^* is determined. The actual interest rate partially adjusts to this target according to $i_t = (1-\rho)\cdot i_t^* + \rho \cdot i_{t-1}$, where ρ is the smoothing parameter. By following Eq. 11, interest rate smoothing and assuming rational expectations, the following equation is estimated using the generalized method of moments (GMM) for k=12:

$$i_t = (1-\rho)\cdot a + (1-\rho)\cdot[\beta_\pi \cdot E(\pi_{t+k} \mid \Omega_t) + \beta_y \cdot E(y_t \mid \Omega_t)] + \rho \cdot i_{t-1} + \varepsilon_t \,. \qquad (12)$$

Another way to include forward-looking elements in the analysis is to use survey data information to proxy business cycle movements. Survey data are available immediately and contain questions regarding the future development of economic activity. On the contrary GDP data are frequently revised data and they are published with a time lag. Orphanides (2001) shows that estimated policy reaction functions obtained using ex-post revised data can yield misleading descriptions of historical policy in the case of the United States. Central bankers take their decision based on real data. Sauer and Sturm (2007) show the stabilizing role of the ECB by using expectations as derived from survey results in Taylor rules. Similarly we estimate the following equations by using forward-looking survey measures:

$$i_t = a + \beta_\pi \cdot (\pi_t) + \beta_y \cdot (y_t) + \varepsilon_t \quad (13)$$

$$i_t = (1-\rho) \cdot a + (1-\rho) \cdot [\beta_\pi \cdot (\pi_k) + \beta_y \cdot (y_l)] + \rho \cdot i_{t-1} + \varepsilon_t \,. \quad (14)$$

Inflation forecasts (π_t) are used based on a poll of a group of forecasters provided every month by Reuters. Concerning economic activity measures in the eurozone, the economic sentiment indicator (ESIN- y_t), which is a monthly composite index based on business and consumer surveys, is used. This index is published one to two months before industrial production statistics become available.[11]

Within the GMM framework it is easy to check the importance of omitted variables in the policy rule. In fact, if there are such variables, then the orthogonality condition should be violated and the test for the validity of the instruments should then reject the null hypothesis. We concentrate on the importance of risk aversion or financial instability for the ECB explicitly related to its signalling role for future economic activity.

5. Empirical Results

In the first step of our methodology the principal components of the risk premia of the six composite size and style indices portfolios (LG, MG, SG, LV, MV, SV) are calculated for the whole period from January 1999 to August 2007. The analysis shows that the first principal component has an eigenvalue greater than 1 and explains about 85 percent of the variation among the series (Table 1). We construct an indicator exactly like a weighted average of risk premia, the weighting being given by the principal component analysis.

[11]It comprises an industrial confidence indicator, a consumer confidence indicator, a construction confidence indicator and a retail trade confidence indicator.

[Insert Table 1 and Table 2 here]

In order to assign an economic meaning to this indicator, Table 2 presents the correlation of this index with several economic variables like stock market returns, oil price changes, monetary aggregates changes and the implied volatility index from options. As can be easily indicated, there is a negative significant relation between this indicator and stock market returns and a positive relation with the volatility index. The latter relation is also presented clearly in Figure 2. There is also a negative relation with liquidity measures such as the change in monetary aggregates and a positive relation with the price of oil. All these can help us to interpret this indicator as the price of risk or in general as the investors' risk aversion index (a similar methodology has been adopted by McGuire and Schrijvers, 2003; Sløk and Kennedy, 2004; Goudert and Gex, 2006).

[Insert Figure 2 here]

Secondly, in order to estimate the VAR system of Eq. (10), unit root tests are performed on all the variables of interest. It is now well known that the augmented Dickey–Fuller and Phillips–Perron tests suffer from low power and size distortion, respectively. Based on the modified Z tests of Perron and Ng (1996), which have superior power and size properties, all the series are stationary in levels except the IPI index and the effective exchange rate.[12] A VAR in levels is estimated since cointegration can be established.[13]

We also calculate diagnostic tests on the residuals of the VAR. More specifically, the Jarque–Bera test about normality, the F statistic versions of the

[12] These results, not presented for economy of space, are available upon request from the authors.
[13] Sims (1980) and Enders (1995) recommend against differencing time series, even if they are non-stationary, in order not to throw away information concerning long-term relationships. In addition our work is comparable with VAR literature on monetary transmission in the U.S. and Europe (among others, Bernanke and Blinder, 1992; Peersman and Smets, 2001).

Breush–Godfrey test (LM) for autocorrelation and the ARCH test (Engle, 1982) are applied. Generally speaking, there is no evidence against the null hypotheses (Ho: normality, Ho: no autocorrelation, Ho: no heteroskedasticity).

The effect of changing risk aversion on the industrial production index is tested by applying impulse–response analysis. More specifically, the direction and the magnitude of this change are examined and compared with responses in the monetary policy variable. As can be seen in Figure 3, industrial production is very quick to respond to a 1 standard deviation increase in the risk aversion index, inducing a -0.25 percent drop in industrial production at the 3 month horizon. Moreover, this response has a magnitude similar to the response from a shock in the interest rate variable (EONIA). However, the latter response presents a delay and has a longer duration compared with the former. These days investors' perceptions about risk from the stock market have an immediate effect on economic activity compared with the monetary policy variable. This result implies that central bankers should focus on investors' risk aversion effects on economic activity and then apply a monetary policy in order to smooth these effects. So, investors' risk aversion can be used as an additional signal when conducting monetary policy in order to affect economic activity.

[Insert Figure 3 here]

Moreover, the response of industrial production to the risk aversion index is very similar in magnitude and duration to the response from shocks in the real exchange rate index. This similarity can also be explained by the fact that, these days, international investors play a crucial role in financial markets and consequently an important part of economic activity is funded by these investors.

By looking at the response of the monetary variable to shocks in the other variables of the system we can say that the EONIA is very quick to respond to a one-standard-deviation increase in the industrial production index. The Central Bank reacts significantly to a risk aversion shock by reducing the interest rate in order to provide liquidity. Concerning the exact time taken for this action it can be easily understood that the effect of investors' risk aversion on economic activity takes two to three months. This implies that the ECB cares about financial market stability and takes corrective actions in order to achieve it. This result is consistent with that of Mishkin and White (2002). The findings are similar when we estimate the VAR model by using the volatility index as an estimate of risk aversion (Figure 4).

[Insert Figure 4 here]

By keeping in mind the Taylor rule, the reaction of the interest rate to past economic activity is in the right direction; however, it is not of the same magnitude as that expected from the rule. Similarly, the response of the "EONIA" to a shock in inflation confirms previous studies' findings that the ECB's interest rate setting is based on forward-looking variables rather than past information.

In order to investigate further if the ECB takes into account shifts in investors' risk preferences, we estimate the ECB interest rate reaction function based on a forward-looking Taylor rule. Table 3 contains the results of estimating Eq. (12) (Model 1a) and Eq. 14 (Model 2a) by using GMM and as instruments the lagged inflation, output gap and yield slope defined as the difference between the long-term Government Bond yield and the three-month treasury bill yield. These are the baseline models.

[Insert Table 3 here]

However, the important effect of the risk aversion index on economic and financial activity indicates that there are serious theoretical and policy reasons for the Central Bank to monitor investors' risk aversion measures, and the omission of the risk aversion index from the rule seems an obvious candidate for putting our testing procedure to work. We then re-estimate the baseline models by including up to three lagged risk aversion indexes in the set of instruments and we obtain the results in Table 3 in the columns entitled model 1b and model 2b.

As can be seen from the estimates of these equations, the ECB follows a stabilizing policy concerning inflation since β_π is higher than 1 and statistically significant. The Central Bank cares about economic activity and the values of the relevant parameter β_y are near the Taylor rule suggestions. Moreover, it follows a smoothing interest rate setting, as can be concluded from the estimation of the ρ in all models. Models 2a,b present slightly higher adjusted R^2 compared with Models 1a,b, indicating the importance of survey data in estimating the ECB reaction function. The ECB bases its decisions on expectations and survey data can be very useful in the interest rate setting.

The point estimates of the parameters in Models 1b and 2b are slightly modified but the tests for validity of instruments do not reject the null, as can be seen in the J-statistic test results presented in the last row of Table 3. In the light of this evidence we can conclude that the shift in investors' risk aversion affects the ECB behavior as the leading indicator of future economic activity but not as an independent argument for the monetary policy.

5. Conclusions

Following recent studies on the important role of the risk premia in economic activity in the U.S., this paper, following an asset pricing framework, decomposes risk premia into the quantity and price of risk. Risk aversion is often considered to correspond to the "price of risk" obtained in this way.

Over the last years, there has been an increasing amount of literature that indicates an important relation between risk aversion indicators and financial instability. However, little attention is given to the relation between these indicators and real economic activity.

The results from impulse response analysis presented here suggest that a shock in the risk aversion index has a negative effect on the industrial production index after three months and is similar to the exchange rate shock effect. The effect of a risk aversion shock on economic activity is quicker but is of the same magnitude as the monetary policy effect. Impulse response analysis indicates that the ECB seems to react to the risk aversion shock from financial markets by reducing the policy rate and providing liquidity. However, the duration of this providing liquidity may hide significant risks, as implied by the last financial crisis.

Additionally, we provide evidence that, either assuming rational expectations and using a forward-looking specification or using expectations as derived from surveys, the ECB follows a stabilizing policy concerning inflation and economic activity. Investors' risk aversion affects the ECB behavior as a leading indicator of future economic activity but not as an independent argument for the monetary policy.

In conclusion, the Central Bank cares about financial stability mainly due to the increasing role of equity markets these days and the immediate effect of financial shocks on economic activity. In accordance with Bernanke and Gertler (1999) and Mishkin and White (2002), we provide evidence that the ECB views price stability and economic and financial stability as highly complementary and mutually consistent objectives to be pursued within a unified policy framework. However, the recent financial crisis indicates that offering significant liquidity may alter commercial bank perception of risk and thus increase systemic risk.

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Tables

Table 1 Principal component analysis of risk premia

	January 1999 - August 2007					
Components	1	2	3	4	5	6
Eigenvalue	5.12	0.47	0.22	0.08	0.07	0.05
Variance Prop.	0.85	0.08	0.04	0.01	0.01	0.01
Cumulative Prop.	0.85	0.93	0.97	0.98	0.99	1.00
Eigenvectors						
Variable	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5	Vector 6
LG	-0.40	0.54	0.30	0.48	-0.08	0.48
LV	-0.41	-0.15	0.67	-0.40	0.42	-0.13
MG	-0.42	0.35	-0.12	0.07	-0.26	-0.78
MV	-0.41	-0.45	0.03	-0.21	-0.73	0.24
SG	-0.41	0.25	-0.61	-0.48	0.29	0.29
SV	-0.40	-0.55	-0.27	0.57	0.37	-0.06

Table 2 Correlation between common factor and economic variables

1	DJ STOXX Total Market Index (TMI)	-0.98
2	DJ EURO STOXX 50 Volatility Index (VSTOXX)	0.47
3	Industrial Production Index	-0.07
4	Money growth (M3)	-0.08
5	Slope yield curve	-0.08
6	Price of Oil	0.11

All the variables are in first differences except variables 2 and 5.

Table 3 Estimated forward-looking Taylor rules using GMM

	Model 1a		**Model 1b**		**Model 2a**		**Model 2b**	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
ρ	0.910	0.00**	0.926	0.00**	0.955	0.00**	0.948	0.00**
constant	-0.876	0.10*	-1.193	0.07*	-4.449	0.17	-3.841	0.18
β_π	2.251	0.00**	2.456	0.00**	4.386	0.02**	4.000	0.01**
β_y	0.634	0.00**	0.534	0.00**	0.441	0.00**	0.393	0.00**
Obs. No.	74		74		101		101	
Adjusted R-squared	0.981		0.981		0.982		0.982	
Durbin-Watson stat	1.729		1.747		1.870		1.846	
J-statistic (p-value)	0.82		0.86		0.52		0.55	

Model 1a: Estimation of Eq. (12) using GMM with Newey–West heteroskedasticity and serial correlation. As instruments we use up to six months lagged inflation and up to three months lagged output gap, yield spread (ten-year Government Bonds; three-month Treasury Bills) and the interest rate corresponding to the data employed in the regression. **Model 1b**: Estimated as in Model 1a but as an additional instrument the up to three months lagged risk aversion index is used. **Model 2a**: Estimation of Eq. (14) using GMM with Newey–West heteroskedasticity and serial correlation. As instruments we use up to three months lagged inflation, output gap, yield spread (ten-year Government Bonds; three-month Treasury Bills), and the interest rate corresponding to the data employed in the regression. **Model 2b**: Estimated as in Model 2a but as additional instrument an up to three months lagged risk aversion index is used.

Figures

Figure 1 Inflation measures and oil prices

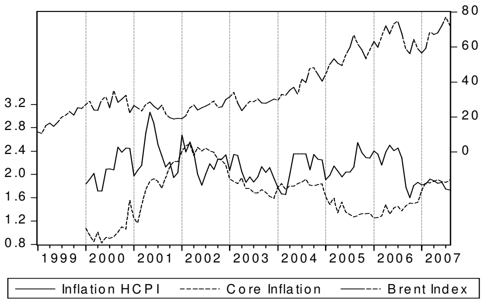


Figure 2 Risk aversion estimates

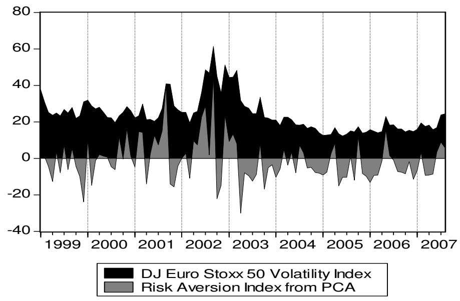
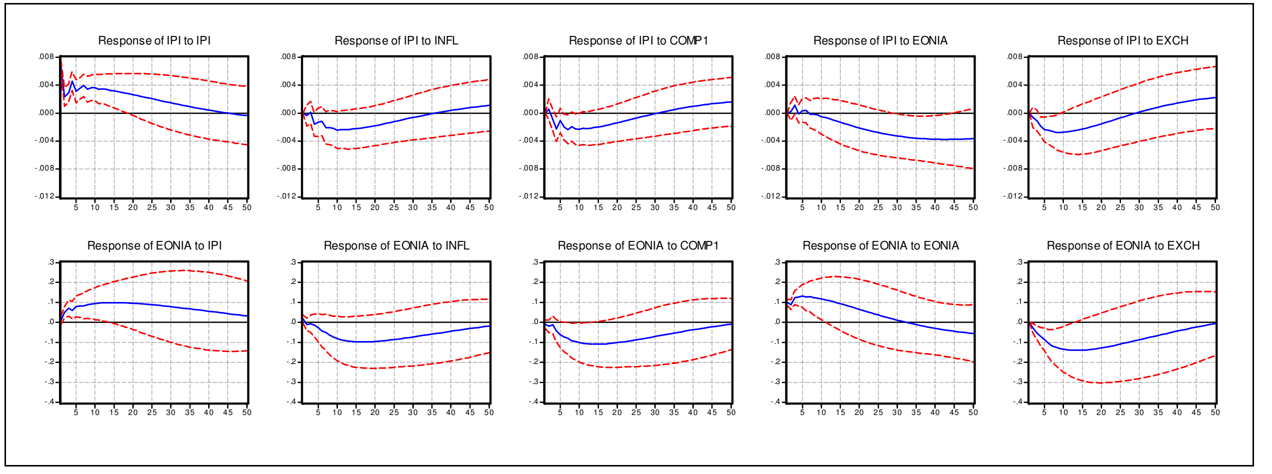
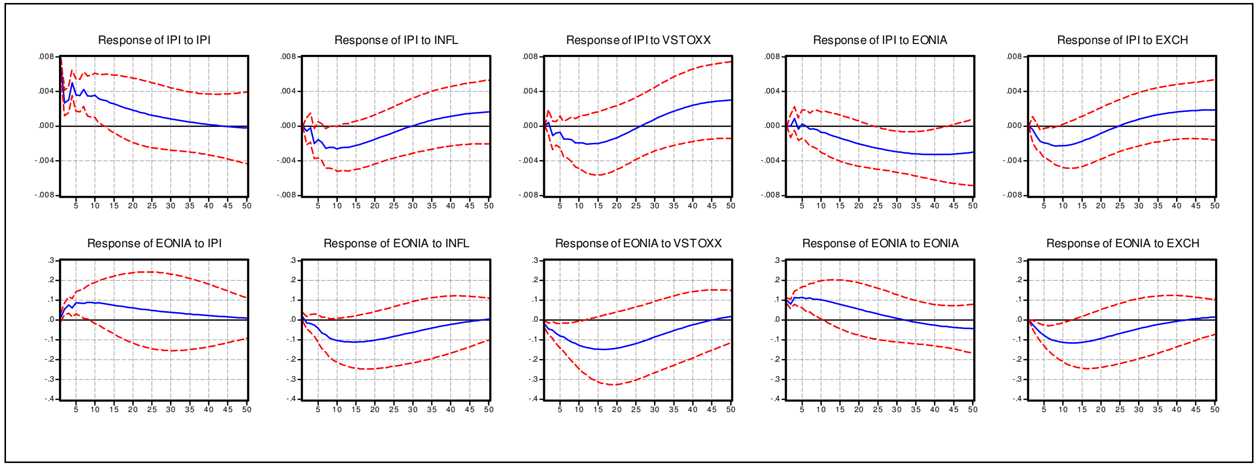


Figure 2 Response to Cholesky 1 S.D. innovations ± 2 S.E.



Note: We take the log levels of IPI, VSTOXX and the real exchange rate.

Figure 3 Response to Cholesky 1 S.D. innovations ± 2 S.E.



Note: We take the log levels of IPI, VSTOXX and the real exchange rate.