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Abstract

The recent financial crisis has been characterized by unprecedented monetary policy interventions of central banks with the intention to stabilize financial markets and the real economy. This paper sheds light on the actual impact of monetary policy on stock liquidity and thereby addresses its role as a determinant of commonality in liquidity. To capture effects both at the micro and macro level of stock markets, we apply panel estimations and vector autoregressive models. Our results suggest that an expansionary monetary policy of the European Central Bank leads to an increase of stock market liquidity in the German, French and Italian markets. These findings are robust for seven proxies of liquidity and two measures of monetary policy.

JEL classification: E44, E51, E52, G12
Keywords: Stock liquidity, monetary policy, euro zone

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1 Introduction

The liquidity of financial markets, defined as "the ease of trading" (Amihud et al., 2005), has attracted a lot of attention, as the recent financial crisis highlighted its role as a precondition for well-functioning and efficient markets. Although central banks all over the world tried to ease financial markets during the recent crisis period by means of massive monetary policy interventions, we know surprisingly little so far about the actual relationship of monetary policy on stock liquidity.

Since Amihud & Mendelson (1986) suggested that stock returns are an increasing function of illiquidity, numerous successive studies investigated this relationship. Indeed, the empirical literature generally confirms the theoretical proposition that investors demand higher gross returns as compensation for holding less liquid stocks.[1] Another well-established strand of the academic literature on asset liquidity documents that the liquidity of individual stocks exhibits significant co-movement, which is usually referred to as commonality in liquidity.[2] Covariation in the liquidity of stocks implies that the illiquidity risk cannot be diversified and therefore illiquidity should be regarded as a systematic risk factor.[3] Furthermore, the observed commonality suggests the assumption that there needs to be at least one common factor that simultaneously determines the liquidity of all stocks in a market, which might be monetary policy.

The hypothesis we test in this paper is that the monetary policy of central banks is a common determinant of stock liquidity. In particular we examine the relationship between the European Central Bank's (ECB) monetary policy interventions and stock liquidity. Anecdotal evidence suggests that the ECB itself seems to be well aware of the necessity to actively take care of market liquidity, since the ECB executive board member José Manuel González-Páramo stated: "This environment poses challenges for central banks, as addressing funding liquidity shortages may require supporting market liquidity".[4] Indeed, our results indicate that an expansionary (contractionary) monetary policy leads to an increase (decrease) in the liquidity of stocks. We observe this relationship at the microeconomic level for individual stocks by applying panel estimations and at the macroeconomic level for aggregate liquidity by using vector autoregressive (VAR) models.

1 For a comprehensive overview of the literature about asset pricing and liquidity see Amihud et al. (2005).

2 See Chordia et al. (2000), Hasbrouck & Seppi (2001) or Huberman & Halka (2001) for the U.S. and Kempf & Mayston (2008) for the German market.

3 See for example Pástor & Stambaugh (2003) and Acharya & Pedersen (2005).

4 Fundación Caixa Galicia, Santiago de Compostela (Galicia, Spain), October 16, 2008. The full speech is available at http://www.ecb.int/press/.

Interestingly, we find only few theoretical approaches that address a possible relationship between stock market liquidity and the monetary policy. The inventory paradigm of the market microstructure literature suggests that inventory turnover and inventory risk affect stock market liquidity.[5] In a nutshell, this paradigm proposes that stocks are expected to be more liquid if market participants can cheaply finance their holdings and perceive low risk of holding assets. Since the monetary policy influences both the costs of financing and the perceived risk of holding securities (e.g., through its impact on the general economic environment), it follows that the monetary policy should also affect stock market liquidity. Similarly, Brunnermeier & Pedersen (2009) develop a model that addresses the interaction between funding liquidity and asset market liquidity. Their model suggests that traders facing capital constraints experience difficulties to meet margin requirements and therefore fail to provide liquidity to the market. Moreover, a deterioration of market liquidity reduces traders' funding liquidity through higher margin requirements. This may lead to a loss spiral and a lower liquidity, higher margin equilibrium. Following this reasoning, monetary policy may influence stock market liquidity, since an expansionary (restrictive) policy eases (exacerbates) constraints for margin borrowing and thus, facilitates (impedes) the funding liquidity of market participants.

Few academic studies empirically examine the relationship between monetary policy and stock liquidity, and their results are to some extent ambiguous. Goyenko & Ukhov (2009) document strong evidence for the U.S. American market (NYSE and AMEX) that monetary policy predicts liquidity for the period 1962 to 2003. A tightening of the monetary policy, as indicated by positive shocks to the federal funds rate and negative shocks to non-borrowed reserves, is shown to decrease stock market liquidity. Moreover, the bond market seems to serve as a transmitter that forwards monetary policy shocks to the stock market. On the contrary, Chordia et al. (2005) report only modest predictive power of monetary policy for stock market liquidity. For a sample of NYSE traded stocks they find that an expansionary monetary policy is associated with a contemporaneous increase in aggregated liquidity only during periods of crisis. The authors measure monetary policy by means of net-borrowed reserves and the federal funds rate. Söderberg (2008) studies the influence of 14 macroeconomic variables on the market liquidity of three Scandinavian stock exchanges between 1993 and 2005 and also provides mixed evidence. He finds that the policy rate is able to predict market liquidity on the Copenhagen stock exchange, whereas broad money growth plays a major role on the Oslo stock exchange

[5] Market microstructure theory deals with the determinants of the liquidity of individual stocks by focusing on stock characteristics and trade mechanisms. For an overview see O'Hara (1998) and Hasbrouck (2007).

and short-term interest rates and mutual fund flows predict liquidity on the Stockholm stock exchange. However, no variable is able to forecast liquidity for all three exchanges. Also Fujimoto (2003) studies the relationship between macroeconomic variables and liquidity for NYSE and AMEX stocks. For the period ranging from 1965 to 1982, a positive shock to non-borrowed reserves increases liquidity, whereas an increase in the federal funds rate decreases liquidity. However, for the period from 1983 to 2001, neither shocks to non-borrowed reserves nor to the federal funds rate are able to predict stock market liquidity.

We contribute to the existing literature in three ways. First of all, while previous research focuses primarily on the U.S. American stock market, this study investigates European data from three major countries of the euro zone. We are not aware of any study analyzing in depth the impact of ECB monetary policy interventions on stock liquidity for major markets of the euro zone, including the German, French and Italian stock exchanges. Further investigation is of great interest, because the effect of monetary policy on stock market liquidity might differ between currency areas and across countries, particularly when taking the differences in the statutes and policy aims between central banks into account. Moreover, the results of the few existing studies are to a large extent ambiguous. Secondly, while prior studies only consider effects of monetary policy on stock liquidity at an aggregated-market level, we extend the analysis to the individual stock level. From a methodological point of view, the application of panel-fixed-effects gives much stronger evidence as some effects could be canceled out at an aggregated level due to (unobserved) heterogeneity among assets. Our panel approach, on the contrary, controls implicitly even for unobserved time-invariant characteristics at the individual stock level. To our knowledge, this is the first study applying both panel and VAR models to this specific research question. Finally, we add additional insights by employing in this respect untested, but generally well-acknowledged measures for both the monetary policy and asset (il)liquidity.

Noteworthy, our findings are robust for three different markets (Germany, France, and Italy), seven measures of (il)liquidity and two variables of monetary policy. The employed (il)liquidity measures capture the aspects trading activity (i.e., turnover rate and trading volume), price impact (i.e., Amihud (2002) illiquidity ratio, turnover price impact and Roll impact) and transaction costs (i.e., relative Roll proxy and relative bid-ask spread). Monetary policy is approximated either by the twelve-month growth rate of the monetary base or by the difference between the actual policy rate and the target rate derived from an estimated Taylor (1993) rule.

The paper is structured as follows. Section 2 describes the data set and the applied variables, including the measures of monetary policy and (il)liquidity. Empirical results at the micro and macro level with respect to the German stock market are illustrated in detail in sections 3 and 4. Section 5 presents evidence from the French and Italian markets. Finally, section 6 summarizes the results and draws conclusions.

2 Data and hypotheses

2.1 Data set

For our analysis we consider data of three major markets of the euro zone, namely Germany, France and Italy. The sample period spans from the introduction of the euro in January 1999 to December 2009 (132 months). The considered stock universe includes all German stocks traded at the Xetra trading system, all French stocks traded at the Euronext Paris and all Italian stocks traded at the Milan stock exchange. For each stock we use the daily total return index, the number of shares traded and outstanding, and the end-of-day price as well as bid and ask prices. The source of the data for the three considered stock markets is *Thomson Reuters Datastream*. For reasons of plausibility we exclude all negative observations from our sample. In order to remove the most thinly traded stocks we require from every stock more than 100 trading days per year as well as a share price greater than one euro. Moreover, in our analysis we only include a stock if it has at least 15 observations of the respective (il)liquidity measures described in Section 2.2.2 per month. In order to eliminate outliers and erroneous data, we also exclude the highest and lowest 1% of the computed returns and of the monthly (il)liquidity measures.[6] All macroeconomic variables of the euro zone such as the rolling twelve-month inflation rate, the base money growth rate, and the ECB policy rate and monthly industrial production figures are available from the *ECB Statistical Data Warehouse*.

[6] The monthly observations of the Roll impact ratio and the relative Roll measure are winsorized only by the most illiquid 1%, since the estimation procedure of the Roll measure exhibits an implicit trimming of the most liquid securities. The Roll estimate is set to zero whenever the autocovariance of daily stock price changes is positive.

2.2 Explanatory variables

2.2.1 Central bank policy measures

Prior literature commonly uses either monetary aggregates or interest rates to approximate the monetary policy. Accordingly, we apply a measure of each of the two categories in order to investigate its impact on stock liquidity. Firstly, we use the rolling twelve-month growth rate of base money. Base money is defined as currency (banknotes and coins) in circulation plus the reserves credit institutions hold with the Eurosystem. We choose base money because it represents the monetary aggregate that is most easily influenced by the central bank. In this respect, an expansionary monetary policy is characterized by a higher growth rate of the monetary base. Defining BM_t as base money in month t, we can formally define the twelve-month base money growth as

$$base\ money\ growth_t = \frac{BM_t - BM_{t-12}}{BM_{t-12}} \cdot 100 \tag{1}$$

Secondly, the monetary stance of the ECB is measured by applying a simple Taylor (1993) rule to the European policy rate for main refinancing operations. Thereby, we model the ECB target policy rate as a function of inflation and the output gap, which entails the presumed following model

$$i_t^{TR} = \alpha + \beta_1 \pi_t + \beta_2 y_t + \varepsilon_t, \tag{2}$$

where i_t^{TR} denotes the target policy rate of the ECB, π_t labels the inflation rate, and y_t stands for the output gap of the euro zone in month t.[7] We estimate the parameters of (2) for the sample period from January 1999 to December 2009. The following expression (3) displays the estimated coefficients, all of which are significant at the 1% level.[8]

[7] The output gap is computed as the deviation of industrial production from its long-run trend, which is calculated by applying the Hodrick & Prescott (1997) filter.

[8] Estimation of the regression coefficients for inflation and industrial production was carried out by means of simple Ordinary Least Squares (OLS) regression methods. We also estimated two forward-looking specifications including a smoothing parameter to consider the fact that policy makers have the problem of incomplete information when taking decisions (see, for instance, Clarida et al. (1998)) and the fact that the ECB faces uncertainties when deciding about the policy rate as the ex-post realized contemporaneous variables are not known at the time of the decision. In those cases OLS estimates seem inapplicable. When the decision-makers base their actions on information which includes only lagged variables, it is common practice in the literature to use a Generalized Method of Moments (GMM) approach which is basically an instrument variables estimation of equation (2). Although these alternative approaches might yield more consistent estimates for the Taylor rule (e.g., a regression coefficient for inflation which is larger than one, which would mean that the ECB is following a stabilizing policy), all results described below remained qualitatively the same, and thus, we report the most simple specification by using OLS methods.

$$i_t^{TR} = 2.258 + 0.327\pi_t + 0.184y_t \quad (3)$$

Subsequently, the fitted values $\hat{i}_t^{TR}$ from the estimated model in (3), which serve as the estimated target policy rate, and the observed policy rate i_t are used to compute the monetary stance - the deviation of the actual policy rate from that estimated corresponding (equilibrium) Taylor rule interest rate. Thus, we use this difference $monetary\ stance_t = i_t - \hat{i}_t^{TR}$ as a measure for the monetary policy by arguing that it indicates whether the current interest rate is below or above the equilibrium level as suggested by the Taylor rule. The higher the monetary stance, the higher the actual policy rate in comparison to the estimated target rate of the ECB. A higher monetary stance therefore indicates a tighter monetary policy. Descriptive statistics of the two described monetary policy measures are depicted in Table 1.

	Monetary policy measures	
Descriptive statistics	*Base money growth* (in %)	*Monetary stance* (in %)
Mean	9.750	0.016
Standard deviation	9.373	0.700
Skewness	0.179	0.092
Median	10.757	0.075
Max	39.404	1.577
Min	-12.423	-1.652

Table 1: Descriptive statistics of the two monetary policy measures

2.2.2 (Il)liquidity measures

Since stock market liquidity is a very broad concept with various facets, we employ seven different measures that capture the aspects of trading activity, price impact and transaction costs. Most applied (il)liquidity variables are well-established in the finance literature and all of them can be computed from daily stock market data.

Trading activity is considered as an indirect measure of a stock's liquidity. According to Amihud & Mendelson (1986), in equilibrium, liquid stocks should be held by investors with short investment horizons and, therefore, exhibit a higher trading activity than less liquid stocks. Similarly, Constantinides (1986) predicts that investors reduce their trading frequency for illiquid assets. In other words, theoretical models suggest that stocks exhibiting a high trading frequency should be considered as more liquid. The first proxy of trading activity is the turnover rate as was proposed, for example, by Datar et al. (1998). The stock turnover can be interpreted as the reciprocal of the average holding period, implying that stocks with higher turnover are on average held for shorter time periods and thus, exhibit an increased trading frequency. We compute the stock turnover rate of stock i in month m of year y (TO_{iym}) by summing up the daily number of shares traded (VO_{iymd}) in each month and dividing it by the number of shares outstanding ($NOSH_{iym}$)

$$TO_{iym} = \frac{\sum_{d=1}^{D_{iym}} VO_{iymd}}{NOSH_{iym}} \tag{4}$$

The second trading activity variable employed is the traded volume in euro. We assume that a higher traded volume implies more liquid stocks, following Brennan et al. (1998) who argue that the traded volume is a suitable measure of trading activity and liquidity. Thereby, trading volume in euro of stock i in month m of year y (TV_{iym}) is proxied by taking the natural logarithm of the monthly sum of the daily product of the number of shares traded (VO_{iymd}) and the respective prices (P_{iymd})

$$TV_{iym} = ln(\sum_{d=1}^{D_{iym}} (VO_{iymd} P_{iymd})) \tag{5}$$

It should be noted that the two above-mentioned trading activity variables can be interpreted as liquidity proxies since higher trading activity, which implies more liquid stocks, is associated with higher values for turnover and trading volume. All the other measures that are described in the rest of this section can be considered as illiquidity proxies, since an increase in these variables is associated with less liquid stocks.

Besides measures of trading activity, we employ proxies for the price impact of order flow. Firstly, the Amihud (2002) illiquidity ratio of security i on day d of year y ($ILLIQ_{iyd}$) quantifies the response of returns to one euro of trading volume. This illiquidity measure is very well established, particularly since Hasbrouck (2009) and Goyenko et al. (2009) report its adequacy as a measure of price impact. $ILLIQ_{iyd}$ is computed as the absolute return of security i on day d of year y ($|R_{iyd}|$) divided by the respective traded volume in euro (TV_{iyd})

$$ILLIQ_{iyd} = \frac{|R_{iyd}|}{TV_{iyd}} \tag{6}$$

We also apply a related price impact measure which was proposed by Florackis et al. (2010) and gives the turnover price impact of security i on day d of year y (TPI_{iyd})

$$TPI_{iyd} = \frac{|R_{iyd}|}{TO_{iyd}}, \tag{7}$$

where $|R_{iyd}|$ and TO_{iyd} are the absolute return and the turnover rate of security i on day d of year y. It is a variant of the Amihud (2002) price impact measure that gives the return impact of a one percent stock turnover. Since TPI_{iyd} ratio makes use of the stock turnover rate instead of the traded volume in euro, it should be, by construction, less related to market capitalization or inflation than Amihud´s (2002) illiquidity ratio. The third price impact proxy is based on the work of Goyenko et al. (2009), who have proposed a new form of price impact measures by dividing proxies for the bid-ask-spread by the traded volume in euro. We follow their approach and include the Roll impact of stock i on day d of year y (R_IMP_{iyd})

$$R\_IMP_{iyd} = \frac{ROLL_{iyd}}{TV_{iyd}}, \tag{8}$$

where $ROLL_{iyd}$ is the Roll (1984) estimate of stock i on day d of year y, and TV_{iyd} is the traded volume in euro. Goyenko et al. (2009) conclude that the Roll impact variable estimated from daily data is a qualified measure for price impact.[9]

Finally, in order to measure transaction costs, we employ two variables that proxy the relative difference between the bid and ask prices of stocks. We use the Roll (1984) estimate as the first measure of transaction costs, as it can sensibly be interpreted as a proxy for the bid-ask-spread. Therefore, we define the relative Roll estimate of stock i on day d of year y (R_REL_{iyd}) as the ratio

$$R\_REL_{iyd} = \frac{ROLL_{iyd}}{P_{iyd}}, \tag{9}$$

where $ROLL_{iyd}$ is the Roll (1984) estimate and P_{iyd} the end-of-day price of stock i on day d of year y. Secondly, in line with Amihud & Mendelson (1986), we use the relative

[9] Roll (1984) assumes that the fundamental value of an asset at period t (m_t) follows a random walk, with innovation u_t that are independent and identically distributed (iid) with zero mean and σ standard deviation. Each transaction causes transaction costs $\frac{1}{2}S$ (i.e., half the bid-ask-spread) and the probability of a buy and sell order equals 0.5 and is also iid. The observed price at time t depends on whether a buy or sell order occurs and thus equals $P_t = m_t + Q_t\frac{1}{2}S$, where $Q_t = 1$ ($Q_t = -1$) if the asset is bought (sold). Computing the covariance of consecutive price changes yields $Cov(\Delta P_t, \Delta P_{t-1}) = -\frac{1}{4}S^2$. Inverting this relation gives the following proxy for the spread $S = 2\sqrt{-Cov(\Delta P_t, \Delta P_{t-1})}$ (see, for example, Hasbrouck, 2007 or Harris, 2002, for further explanations of the Roll´s (1984) measure). For its empirical estimation, we compute the serial covariance of daily price changes each month. Whenever this covariance is negative $ROLL_{iyd} = 2\sqrt{-Cov(\Delta P_t, \Delta P_{t-1})}$, $ROLL_{iyd} = 0$ otherwise.

bid-ask-spread of stock i at the end of trading day d of year y (S_REL_{iyd}) - the difference between the quoted end-of-day ask (PA_{iyd}) and bid prices (PB_{iyd}), divided by the mid price of stock i at the end of trading day d of year y

$$S\_REL_{iyd} = \frac{PA_{iyd} - PB_{iyd}}{\left(\frac{PA_{iyd}+PB_{iyd}}{2}\right)} \tag{10}$$

In sections 3 and 4 we will carry out panel regressions and time series analysis at a monthly frequency with the aim of analyzing whether the European common monetary policy influences the liquidity of individual stocks and the aggregate stock market, respectively. Therefore, the monthly averages of the individual daily (il)liquidity measures of each stock i (LIQ_{iym}) and the (equally weighted) average of the (il)liquidity measures across all stocks (LIQ_{ym}) in month m of year y are computed as

$$LIQ_{iym} = \frac{1}{D_{iym}} \sum_{d=1}^{Diym} LIQ_{iymd}, \tag{11}$$

$$LIQ_{ym} = \frac{1}{N_{ym}} \sum_{i=1}^{N_{ym}} LIQ_{iym}, \tag{12}$$

where the replacement characters LIQ_{yimd} in (11) and LIQ_{iym} in (12) are alternatively each of the above described (il)liquidity measures, D_{iym} in (11) is the number of daily observations of stock i in month m of year y, and N_{ym} is the number of observed stocks in month m of year y in (12).

2.2.3 Control variables

In the panel regressions in Section 3 we control for individual stock characteristics that are known to determine stock liquidity, and for macroeconomic variables that may be related to the monetary policy or to stock market liquidity. The individual stock characteristics are one-month lagged and include the monthly return, the monthly standard deviation of daily returns and the natural logarithm of market capitalization. We include the return of the previous month (RET_{iym-1}) as a control variable, since, amongst others, Brunnermeier & Pedersen (2009) have shown theoretically that past returns may influence stock liquidity and Hameed et al. (2010) have provided confirming empirical evidence about that. The inclusion of the monthly standard deviation of daily stock returns ($STDV_{iym}$) is motivated by the findings of Copeland & Galai (1983) who showed theoretically that the volatility of stock returns should be negatively related to liquidity (in their model the bid-ask-spread). To take into account the argument of Amihud (2002) that liquidity is negatively related to a stock's market value, we include the (log of the) market capitalization of stocks ($lnMV_{iym}$). We also control for the potential effect of macroeconomic variables on stock market liquidity, by explicitly considering the vast amount of literature in this field of research. For instance, the relationship between liquidity and macroeconomic factors was theoretically demonstrated by Eisfeldt (2004) and empirically investigated, amongst others, by Fujimoto (2003), Söderberg (2008) and Naes et al. (2010). In order to control for potential effects of macroeconomic variables we follow Goyenko & Ukhov (2009) and include the rolling twelve-month growth rate of euro zone industrial production (IP_{ym}) and the twelve-month inflation rate in the euro zone (IR_{ym}). To account for an interdependence of liquidity and cyclical movements in the stock market we include in the panel analysis the MSCI stock market index (IDX_{ym}) for each stock market under consideration.

In the time series analysis of Section 4 we follow Chordia et al. (2001), Chordia et al. (2005) and Goyenko & Ukhov (2009) and account for monthly market returns and the monthly volatility of daily market returns. In order to control for returns, we compute the monthly market return as the equally weighted average of individual monthly stock returns. Similarly, the market's monthly volatility of returns is computed as the monthly standard deviation of the equally weighted average of daily stock returns. In addition to this, we follow Goyenko & Ukhov (2009) and include the twelve-month growth rate of euro zone industrial production and the twelve-month inflation rate of the euro zone as computed in the panel regressions.

2.3 Tested hypotheses

Table 2 depicts the expected influence of monetary policy on each liquidity variable. The first column lists the defined (il)liquidity measures, whereas the second and third columns report the expected sign of the impact of both the base money growth and the monetary stance on each (il)liquidity proxy. On the one hand, the stock turnover rate (TO) and trading volume in euro (TV) are interpreted as liquidity measures and are associated with increased liquidity. On the other hand, the price impact measures including the illiquidity ratio ($ILLIQ$), the turnover price impact ratio (TPI) and the Roll impact measure (R_IMP), as well as the transaction cost measures, which comprise the relative Roll estimate (R_REL) and the relative bid-ask spread (S_REL), are considered as proxies for illiquidity. Intuitively, higher values of those figures indicate lower liquidity.

As can be inferred from the second column of Table 2, we expect base money growth to

	Expected signs	
Liquidity variable	Base money growth	Monetary stance
TO	+	-
TV	+	-
ILLIQ	-	+
TPI	-	+
R_IMP	-	+
R_REL	-	+
S_REL	-	+

Table 2: Expected impact of base-money growth and the monetary stance on each liquidity variable

affect turnover (TO) and trading volume (TV) positively, since we hypothesize that an expansionary monetary policy (i.e., a higher base money growth) will imply more liquid stock markets. Moreover, we expect that base money growth has a negative impact on the illiquidity measures ($ILLIQ$, TPI, R_IMP, R_REL and S_REL). The monetary stance measure, which quantifies the deviation of the actual policy rate from the central bank's target rate as modeled by the Taylor rule in (3), is expected to have the opposite signs compared to the base money growth variable, because a loose monetary policy indicated by low (negative) values of the monetary stance measure is assumed to increase stock liquidity.

3 The micro level - Individual stock liquidity and central bank policy

In a first step, we investigate whether monetary policy as exercised by the ECB determines the liquidity of individual stocks. For that purpose, we estimate panel regressions in which the liquidity of stock i in month t ($LIQ_{i,t}$) is modeled as a function of the (one-month lagged) ECB´s monetary policy and other lagged control variables:

$$\begin{aligned} LIQ_{i,t} &= c + b_1 LIQ_{i,t-1} + b_2 MP_{t-1} + b_3 RET_{i,t-1} + b_4 STDV_{i,t-1} + b_5 lnMV_{i,t-1} \\ &\quad + b_6 IP_{t-1} + b_7 IR_{t-1} + b_8 IDX_{t-1} + c_i + u_{i,t} \end{aligned} \tag{13}$$

where the dependent variable $LIQ_{i,t}$ is a replacement character for the seven above-described (il)liquidity measures (stock turnover, trading volume, Amihud (2002) illiquidity ratio, turnover price impact, Roll impact, relative Roll and relative bid-ask spread). To account for autocorrelation induced by a dynamic relationship in stock liquidity, we include the one-month lagged (il)liquidity measures $LIQ_{i,t-1}$ as a regressor. MP_{t-1}

stands for the monetary policy as exercised by the ECB and is thus the exogenous variable of main interest. As mentioned above, we measure the monetary policy either by the rolling twelve-month growth rate of base money or by the Taylor-rule based monetary stance variable. The other control variables considered include firm specific characteristics as well as macroeconomic variables. On the stock level, we control for each stock's lagged value of monthly return ($RET_{i,t-1}$), monthly standard deviation of daily stock returns ($STDV_{i,t-1}$) and the natural logarithm of market capitalization ($lnMV_{i,t-1}$). The employed macroeconomic variables include the twelve-month growth rates of industrial production (IP_{t-1}), the twelve-month inflation rate (IR_{t-1}) and the MSCI Germany stock market index (IDX_{t-1}). In order to account for time-invariant stock specific determinants of liquidity we use the within (fixed-effects) estimator. Thus, c_i in (13) stands for fixed-effects in the cross-section, which basically can be interpreted as a dummy variable for each firm i.

Descriptive statistics and the correlation matrix for the variables employed in the panel estimations are presented in Tables 3 and 4. Of particular interest are the average monthly bivariate correlations between the seven (il)liquidity measures. As one would expect, the cross-sectional correlations between the trading activity measures (i.e., TO and TV) and the measures of price impact (i.e., $ILLIQ$, TPI and R_IMP) or transaction costs (i.e., R_REL and S_REL) are negative. This observation is intuitive, since higher trading activity translates into more liquid stocks, whereas higher levels of price impact or transaction costs indicate less liquid assets. Moreover, the positive (negative) correlation between the market value of firms and liquidity (illiquidity) suggests that stocks of larger firms tend to be more liquid. Besides that, the monthly standard deviation of daily returns is negatively related to liquidity for all variables, except for the stock turnover rate which implies that turnover increases during more volatile periods.

We estimate (13) for each of the seven (il)liquidity measures and the two monetary policy variables. This entails a total of 14 estimations for every market under consideration, including the German, French and Italian markets. In this section we focus on the German stock market, whereas evidence from the French and Italian markets is presented in section 5. In Tables 5 and 6 we present the estimation results for the base money growth and the monetary stance measures, respectively. We report standardized coefficients and, in order to account for heteroscedasticity, all p-values are based on robust standard errors.[10]

[10] We test for stationarity applying the panel unit root test developed by Levin et al. (2002). Because the Amihud (2002) illiquidity ratio appears non-stationary for the German market, we employ its first differences in the panel regressions.

Panel variables	Mean of monthly means	Mean of monthly σ	Mean of monthly skewness	Median of monthly means	Min. monthly mean	Max. monthly mean
TO	4.482	4.963	1.911	4.503	1.578	8.542
TV	8.406	2.466	0.890	8.371	7.644	9.522
ILLIQ	0.178	0.338	3.213	0.159	0.029	0.535
TPI	8,716.097	13,590.580	3.465	8,530.118	2,980.804	16,940.220
R_IMP	0.002	0.004	2.852	0.002	0.001	0.005
R_REL	0.017	0.021	1.452	0.016	0.010	0.036
S_REL	0.018	0.012	0.740	0.017	0.012	0.035
RET	-0.043	12.911	0.466	0.805	-20.351	20.184
MV	2,159.542	8,193.870	0.006	2,022.399	1,272.181	4,599.777
STDV	2.862	1.242	0.429	2.669	1.765	6.103
Time variables	Mean	σ	Skewness	Median	Min.	Max.
IP	-0.004	6.186	-1.933	1.203	-22.047	7.773
IR	2.013	0.815	-0.611	2.100	-0.700	4.000
IDX	109.867	28.722	0.148	106.902	50.311	170.717

Table 3: Descriptive statistics of the variables employed in the panel for the Xetra trading system

Table 5 depicts the estimation results when measuring monetary policy by the rolling twelve-month growth rate of base money. The second row of Table 5 (labeled $Base\ money\ growth_{t-1}$) shows that the monetary policy significantly determines the liquidity of individual stocks. As hypothesized, an increase in the twelve-month growth rate of base money leads to a rise in turnover and trading volume, the two employed liquidity proxies. Furthermore, the signs of the coefficients of the five illiquidity measures are significantly negative. This implies that an expansionary monetary policy - as measured by an increase in the growth rate of base money - triggers an increase (decrease) in individual stocks' liquidity (illiquidity). The coefficients of the growth rate of base money are significant at the one percent level in each of the seven specifications. Noteworthy is the large variation in the R^2. Our model explains large part of the variation in stocks' trading volume and relative spread (as the R^2 amounts to 68.6% and 58.4%). However, only a small fraction of the variation is explained in the case of liquidity proxies that are based on the Roll measure (as the R^2 of the model amounts to 3.8% and 4.4%, respectively).

In Table 6 we present the estimation results for the models in which the central bank policy is approximated by the monetary stance as based on the Taylor rule given in (3). Again, the first column lists the one-month lagged independent variables, while the results of the seven estimated specifications for each (il)liquidity variable are shown in columns two to eight. From the second row, labeled $Monetary\ stance_{t-1}$, it can be inferred that an interest rate above the target rate leads to a decline in the two liquidity variables (stock

	TO	TV	ILLIQ	TPI	R_IMP	R_REL	S_REL	RET	lnMV	STDV
TO	1	0.582	-0.226	-0.402	-0.285	-0.026	-0.340	0.064	0.240	0.244
TV		1	-0.526	-0.430	-0.437	-0.193	-0.788	0.084	0.890	-0.142
ILLIQ			1	0.561	0.394	0.228	0.672	-0.058	-0.489	0.188
TPI				1	0.340	0.132	0.425	-0.038	-0.171	0.019
R_IMP					1	0.536	0.422	-0.059	-0.331	0.060
R_REL						1	0.272	-0.081	-0.233	0.291
S_REL							1	-0.049	-0.771	0.344
RET								1	0.088	0.053
lnMV									1	-0.343
STDV										1

Table 4: Correlation matrix of time-series means of the monthly bivariate cross-sectional correlations for the Xetra trading system

turnover and trading volume). Moreover, such a restrictive monetary policy tends to be followed by an increase in the other illiquidity measures. These results are well in line with our hypotheses and all coefficients of the monetary stance variable appear significant at meaningful levels. The R^2 is again quite high for the specification explaining trading volume (69.1%), and rather low for the Roll impact measure and the relative Roll variable.

With respect to the influence of the control variables on the (il)liquidity of individual stocks we find robust results that are in line with economic intuition. Concerning the stock specific control variables, one may expect a positive relationship between past stock returns and liquidity, since Chordia et al. (2005) and Goyenko & Ukhov (2009) report that aggregated returns and liquidity are positively related. From the third row in the tables 5 and 6 ($Return_{i,t-1}$) it can be inferred that the negative signs of the coefficients in the specifications explaining stocks' illiquidity mostly confirm such a hypothesis. Surprisingly, the impact of lagged stock returns on the turnover rate and trading volume is negative and significant, implying that trading activity decreases as stock prices increase. Besides that, nine of the fourteen panel estimations indicate that an increase in the standard deviation of stock returns forecasts a decline in liquidity. This finding is in line with the results of Goyenko & Ukhov (2009). Interestingly, the Amihud (2002) illiquidity ratio seems to decline as the volatility of returns increases. Concerning the expected positive relationship of a firm's market value and liquidity, the signs of all fourteen coefficients of $ln(Market\ value)_{i,t-1}$ support such a hypothesis.

Regarding the macroeconomic control variables, Eisfeldt (2004) shows in a theoretical model that positive shocks to productivity increase the returns of risky assets and consequently lead to more trading and higher liquidity. According to this, the sixth row of Tables 5 and 6 corresponding to $Industrial\ production_{t-1}$ indicates in most cases that

	Dependent variable ((il)liquidity measure)						
	TO	TV	$d(ILLIQ)$	TPI	R_IMP	R_REL	S_REL
$Dependent\ variable_{i,t-1}$	0.611***	0.705***	-0.415***	0.468***	0.163***	0.022***	0.634***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)
$Base\ money\ growth_{t-1}$	0.032***	0.014***	-0.035***	-0.056***	-0.041***	-0.053***	-0.054***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Return_{i,t-1}$	-0.033***	-0.005***	-0.078***	-0.012***	0.009*	-0.011*	-0.041***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.060)	(0.085)	(0.000)
$Standard\ deviation_{i,t-1}$	-0.063***	-0.033***	-0.017***	0.010**	0.040***	0.171***	0.002
	(0.000)	(0.000)	(0.008)	(0.021)	(0.000)	(0.000)	(0.474)
$ln(Market\ value)_{i,t-1}$	0.028**	0.206***	-0.018	-0.129***	-0.103***	-0.204***	-0.307***
	(0.013)	(0.000)	(0.297)	(0.000)	(0.000)	(0.000)	(0.000)
$Industrial\ production_{t-1}$	-0.028***	0.007***	-0.041***	-0.063***	-0.041***	-0.079***	-0.065***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Inflation_{t-1}$	0.029***	-0.006***	0.038***	0.033***	0.028***	0.045***	0.044***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Stock\ market\ index_{t-1}$	0.038***	0.002	0.025***	-0.009*	-0.008	0.037***	0.008***
	(0.000)	(0.260)	(0.000)	(0.060)	(0.140)	(0.000)	(0.002)
N	42,084	42,176	39,850	41,306	37,948	37,845	41,843
R^2	0.379	0.686	0.174	0.256	0.038	0.044	0.584

Table 5: Panel estimations for the Xetra trading system measuring monetary policy by the growth rate of the monetary base
Note: All coefficients are standardized. P-values are given in parentheses and *, **, *** denote 10%, 5% and 1% significance levels.

higher growth rates in industrial production lead to more liquid assets. The only exception is the negative coefficient in the specifications explaining turnover, which implies that an increase in industrial production decreases stock turnover. The explanatory power of industrial production for the investigated (il)liquidity variables is somehow contradicting to the findings of Söderberg (2008) and Goyenko & Ukhov (2009), who conclude that industrial production does not help predict stock liquidity. Similarly, in all estimated models except for the one explaining turnover (see the row of $Inflation_{t-1}$ in the tables 5 and 6), a higher inflation rate is found to imply lower stock liquidity, which is in line with evidence reported by Goyenko & Ukhov (2009). Finally, it is expected that stocks are more liquid in bull markets than in bear markets. As can be inferred from the eighth row ($Stock\ market\ index_{t-1}$), trading activity, measured by turnover and trading volume, is positively related to the (lagged) value of the MSCI German stock market index. However, the relationship between the different illiquidity measures and the market index is ambiguous across the estimated models.

4 The macro level - Market liquidity and central bank policy

In a second step, we examine the influence of central bank policy on the aggregated liquidity of stock markets. Even though the main objective of the ECB is to maintain

	Dependent variable ((il)liquidity measure)						
	TO	TV	$d(ILLIQ)$	TPI	R_IMP	R_REL	S_REL
$Dependent\ variable_{i,t-1}$	0.627***	0.722***	-0.412***	0.485***	0.161***	0.009	0.637***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.587)	(0.000)
$Monetary\ stance_{t-1}$	-0.020***	-0.004***	0.014**	0.058***	0.045***	0.055***	0.076***
	(0.000)	(0.006)	(0.011)	(0.000)	(0.000)	(0.000)	(0.000)
$Return_{i,t-1}$	-0.030***	-0.003**	-0.077***	-0.007**	0.010**	-0.008	-0.033***
	(0.000)	(0.040)	(0.000)	(0.027)	(0.041)	(0.172)	(0.000)
$Standard\ deviation_{i,t-1}$	-0.064***	-0.034***	-0.015**	-0.003	0.030***	0.137***	-0.013***
	(0.000)	(0.000)	(0.022)	(0.523)	(0.000)	(0.000)	(0.000)
$ln(Market\ value)_{i,t-1}$	0.032***	0.196***	-0.020	-0.124***	-0.029	-0.182***	-0.311***
	(0.003)	(0.000)	(0.244)	(0.000)	(0.118)	(0.000)	(0.000)
$Industrial\ production_{t-1}$	-0.042***	0.001	-0.029***	-0.036***	-0.014**	-0.045***	-0.042***
	(0.000)	(0.492)	(0.000)	(0.000)	(0.013)	(0.000)	(0.000)
$Inflation_{t-1}$	0.031***	-0.005***	0.044***	0.038***	0.015**	0.042***	0.057***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.010)	(0.000)	(0.000)
$Stock\ market\ index_{t-1}$	0.044***	0.004***	0.020***	-0.036***	-0.042***	0.009	-0.024***
	(0.000)	(0.008)	(0.003)	(0.000)	(0.000)	(0.107)	(0.000)
N	45,306	45,412	42,716	44,482	40,834	40,723	44,234
R^2	0.400	0.691	0.171	0.267	0.034	0.030	0.592

Table 6: Panel estimations for the Xetra trading system measuring monetary policy by the monetary stance from a Taylor rule.
Note: All coefficients are standardized, except for the intercept term. P-values are given in parentheses and *, **, *** denote 10%, 5% and 1% significance levels.

price stability, it may also care about the aggregate liquidity of financial markets and other macroeconomic variables. In this respect, Garcia (1989) outlines that central banks try to ease market liquidity during periods of crisis by means of monetary policy. If this is the case, we would expect an endogenous relationship between the liquidity of stock markets, central bank interventions and other macroeconomic factors. Thus, on the one hand, stock market liquidity may be a function of the central bank policy and macro variables while, on the other hand, central bank actions and macroeconomic variables may be influenced by stock market liquidity as well.

In order to take that potential endogeneity into account we investigate the relationship between stock market liquidity and monetary policy by specifying the following VAR model:[11]

$$\mathbf{z}_t = \mathbf{c} + \mathbf{A}\mathbf{z}_{t-1} + \mathbf{u}_t, \tag{14}$$

where $\mathbf{z}_t$ is the vector of endogenous variables (LIQ, MP, RET, $STDV$, IP, IR), $\mathbf{c}$ is the vector of intercepts, $\mathbf{A}$ is a 6×6 matrix representing the estimated coefficients of the lagged endogenous variables, and $\mathbf{u}_t$ labels the vector of residuals. For our

[11] This approach is also employed by Chordia et al. (2005) and Goyenko & Ukhov (2009).

purposes, the variables of main interest are LIQ, which represents alternatively the seven market (il)liquidity proxies, and MP, which labels alternatively the two monetary policy measures. The control variables include the equally weighted monthly stock return RET, the monthly standard deviation of equally weighted daily stock returns $STDV$, the twelve-month relative growth rate of industrial production IP and the twelve-month inflation rate IR. Since the ordering of the variables is relevant for the impulse response analysis, we follow Chordia et al. (2005) and Goyenko & Ukhov (2009) by placing variables according to the order in which they may influence other variables. Therefore, we place the macroeconomic variables IP, IR and MP first, followed by $STDV$, RET and LIQ. A lag length of one was set according to the Schwarz (1978) information criterion.[12]

In order to interpret the estimated VAR models for the German stock market we report the Granger-causality tests (see Granger (1969) and Sims (1980)) and the impulse response functions based on such VAR models. In Table 4 we present the Granger-causality tests in the context of the above-described VAR model.[13] Thereby, we test the null hypothesis that the estimated coefficient of the lagged endogenous variable of interest (either monetary policy or stock market liquidity in panels (a) and (b) of Table 4, respectively) does not Granger-cause the dependent variable of interest (again, either stock market liquidity or monetary policy, in panels (a) and (b) of Table 4, respectively).

The results of the Granger-causality tests depicted in panel (a) of Table 4 indicate some evidence that the monetary policy Granger-causes stock market liquidity. In particular, the base money growth and the monetary stance significantly Granger-cause some of the price impact measures and most of the transaction cost variables. However, the two trading activity proxies turnover TO and trading volume TV as well as the first differences of the turnover price impact TPI are not significantly Granger-caused by the monetary policy. Interestingly, the results of the Granger-causality test in panel (b) of Table 4 show only little evidence of a bidirectional relationship between stock market liquidity and the central bank policy in the German stock market. Apart from the exceptions that the relative spread S_REL and the turnover price impact $d(TPI)$ Granger-cause base money growth and the monetary stance respectively, no other significant causation

[12] The Augmented Dickey & Fuller (1979) test was used to check for stationarity of the variables. To ensure that the (il)liquidity variables of the German stock market are of the same order of integration we employ the first differences of the illiquidity ratio $ILLIQ$, the turnover price impact TPI and of the relative spread S_REL.

[13] We estimated such a VAR model for each of the seven (il)liquidity measures and the two monetary policy variables considered in our analysis. This entails a total of 14 different VAR estimates, each of which allows for 30 pairwise Granger-causality tests. Since reporting the results of all the Granger-causality tests would exceed the scope of this paper, Table 4 only presents the causality-tests between the two monetary stance measures and the seven different (il)liquidity proxies.

monetary policy measure	TO	TV	d(ILLIQ)	d(TPI)	R_IMP	R_REL	d(S_REL)
	(il)liquidity measure						
Panel (a): monetary policy (row) → liquidity (column)							
H_0: The central bank policy (row) does not Granger-cause the liquidity (column)							
Base money growth	2.040	2.627	3.687*	1.254	3.619*	5.248**	1.696
	(0.153)	(0.105)	(0.055)	(0.263)	(0.057)	(0.022)	(0.193)
Monetary stance	2.431	0.829	2.337	0.276	4.505**	16.509***	5.895**
	(0.119)	(0.363)	(0.126)	(0.599)	(0.034)	(0.000)	(0.015)
Panel (b): liquidity (column) → monetary policy (row)							
H_0: The liquidity (column) does not Granger-cause the central bank policy (row)							
Base money growth	2.091	0.755	2.037	2.156	1.307	1.681	7.580***
	(0.148)	(0.385)	(0.154)	(0.142)	(0.253)	(0.195)	(0.006)
Monetary stance	0.445	0.276	1.897	3.436*	1.201	1.528	1.927
	(0.505)	(0.599)	(0.168)	(0.064)	(0.273)	(0.216)	(0.165)

Table 7: Pairwise Granger-causality tests between liquidity and monetary policy for the Xetra trading system
Note: χ^2 statistics and p-values in parenthesis. *, ** and *** denote 10%, 5% and 1% significance levels.

of market liquidity for the ECB policy is found. Overall, the results in Table 4 indicate evidence that the ECB policy causes the aggregate stock market (il)liquidity, but only little evidence for the reverse is occurring.

To get a deeper understanding of the interactions between the variables in the VAR system we also report impulse response functions. Thereby, we are able to investigate the dynamic reaction of the stock market (il)liquidity measures due to a unit standard deviation innovation in the monetary policy variable.[14] Since we are primarily interested in the influence of the central bank policy on stock market liquidity, we only report the accumulated twelve-month responses of the seven different (il)liquidity measures to shocks in base money growth (see Figure 1) and in the monetary stance (see Figure 2).

Figure 1 illustrates the twelve-month responses of the seven (il)liquidity measures to a unit standard deviation innovation in base money growth. Given base money growth increases by one standard deviation, the VAR model predicts a positive accumulated response of the trading activity variables trading volume (TV) and turnover (TO). Moreover, a positive impulse in base money growth translates into an accumulated reduction in the aggregated price impact as shown by a negative response of the illiquidity ratio $d(ILLIQ)$, the turnover price impact $d(TPI)$ or the Roll impact (R_IMP). Also

[14] In order to orthogonalize innovations we use the Cholesky decomposition.

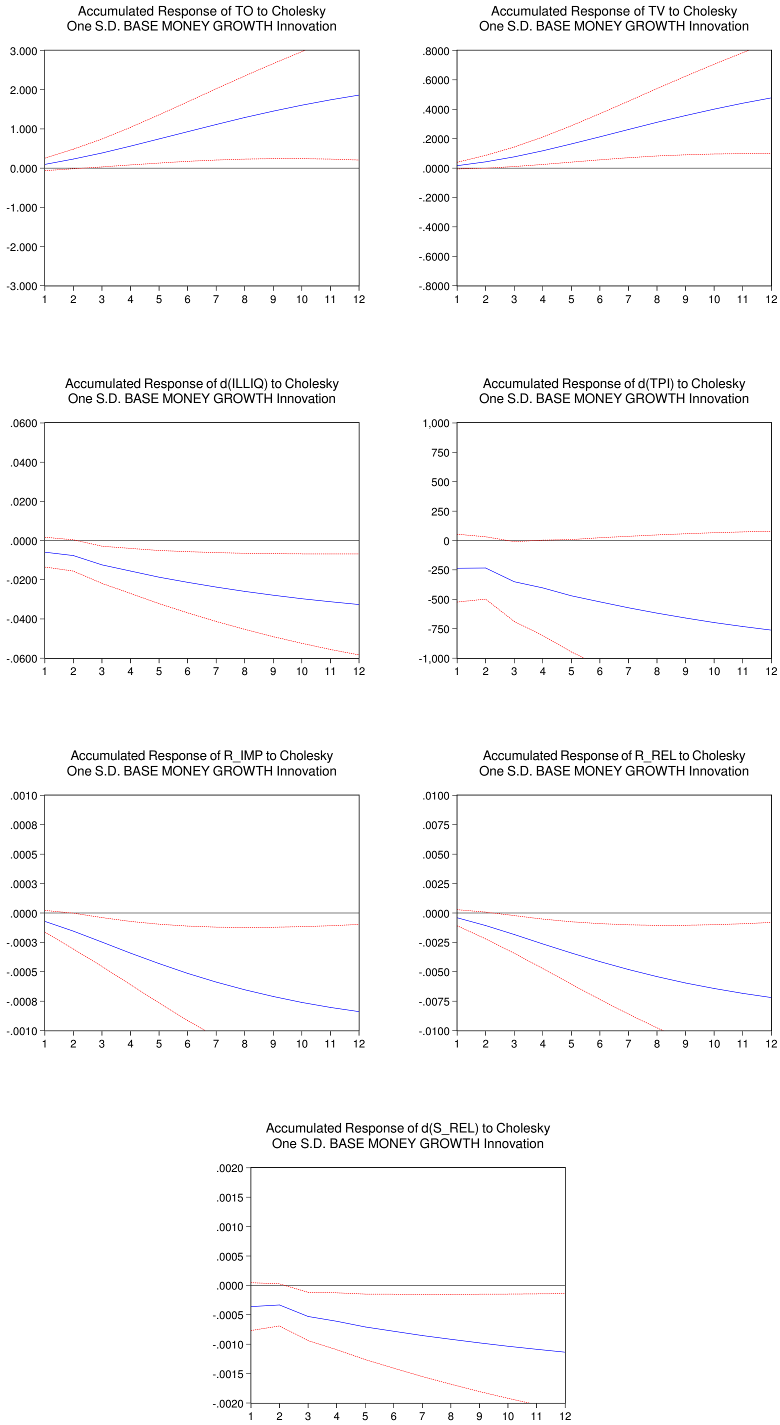

Figure 1: Response of the Xetra trading system to a unit standard deviation innovation in the base money growth

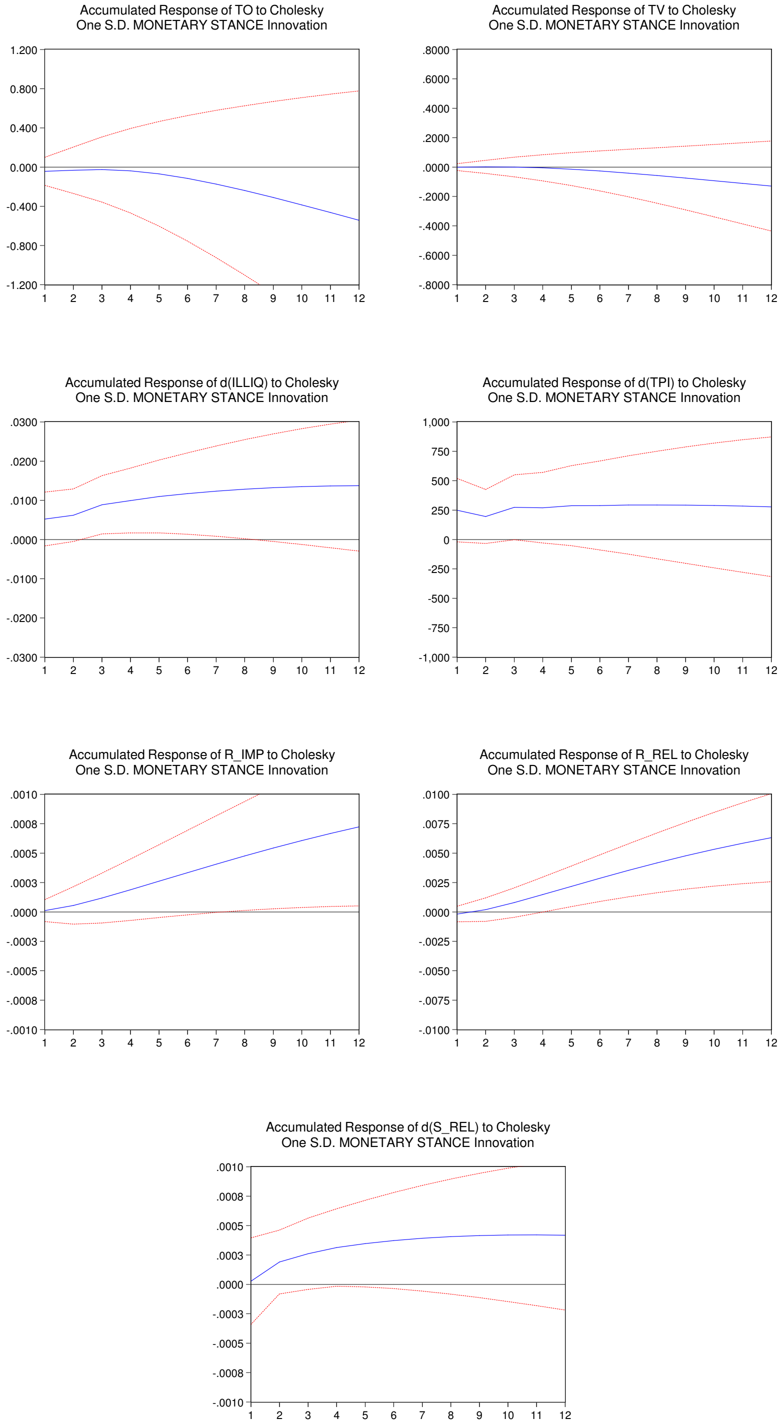

Figure 2: Response of the Xetra trading system to a unit standard deviation innovation in the monetary stance

transaction costs seem to decrease in response to a shock to base money growth as indicated by the negative reaction of the relative Roll measure (R_REL) and the relative spread $d(S\_REL)$. Since all the signs of the responses of aggregated market (il)liquidity to a one-time shock in base money growth are in line with the hypotheses outlined in Section 2.3, we conclude that stock market liquidity (illiquidity) tends to rise (decline) as base money growth increases. The impulse responses in Figure 2 show the accumulated reaction of the seven (il)liquidity measures to a one-time shock in the monetary stance variable. Indeed an increase in the deviation of the actual policy rate from the ECB's target rate by one standard deviation leads to a decrease in trading activity in the German stock market, as indicated by trading volume (TV) and turnover (TO). Furthermore, the increase in all the other variables (i.e., $d(ILLIQ)$, $d(TPI)$, R_IMP, R_REL and $d(S\_REL)$) illustrates that the impulse in the monetary stance leads to a rise in both price impact and transaction costs. These results suggest again that the aggregated stock market liquidity (illiquidity) decreases (increases) in response to a tightening of the monetary policy. However, though the signs of the illustrated responses are all well in line with our hypotheses, the two-standard-error bands indicate that the response of the (il)liquidity measures is in general not statistically significant for all specifications.[15]

Overall, the time-series analysis shows that the relationship between monetary policy and liquidity found at the micro level is also applicable to the macro level of stock markets. The estimated VAR models suggest that monetary policy, as measured by base money growth and the monetary stance, indeed influences aggregated market (il)liquidity, which is in agreement with the findings of Goyenko & Ukhov (2009).

5 Evidence from the French and Italian markets

In order to check for robustness of the results, we also carry out the above-presented panel and time-series investigation for French and Italian stock markets. Thereby, we compute for French and Italian stocks traded at the Euronext Paris and at the Milan stock exchange the seven (il)liquidity measures outlined in Section 2.2.2 as well as the stock-specific control variables presented in Section 2.2.3. Macroeconomic variables such as inflation, industrial production and the monetary policy measures are the same as those applied for the German market since these variables approximate euro zone-specific properties. Overall, the Italian and French stock markets seem to be comparable to the Xetra trading system. The distributions of the cross-sectional (il)liquidity measures have

[15] As mentioned in Section 2.2.1, this might also be due to the simplified specification of the Taylor Rule for the computation of the monetary stance.

very similar properties and almost all average bivariate correlations not only have equal signs, but are also similar in magnitude across the markets.

Table 8 summarizes the results of the panel estimations of the model outlined in (13) in order to examine the impact of the monetary policy on the (il)liquidity of French and Italian stocks. For reasons of brevity, we only report the standardized coefficients and the respective p-values for the base money growth and the monetary stance. Panel (a) of Table 8 presents the results for the French stock market, which suggest that the influence of both monetary policy variables on the (il)liquidity of individual stocks is significant and in line with the hypotheses outlined in Section 2.3. To a great extent, the coefficients of the other control variables (not reported) are qualitatively similar to those reported for the German stock sample. Panel (b) of Table 8 presents the estimation results for the Italian stock market. With respect to the relationship between base money growth and the (il)liquidity of stocks we find a significant positive influence on traded volume (TV) and turnover (TO), as well as a significant negative influence on the Roll impact measure (R_IMP) and the relative Roll variable (R_REL). While these findings are in line with our hypotheses, the impact of base money growth on the illiquidity ratio ($ILLIQ$), the turnover price impact (TPI) and the relative bid-ask spread (S_REL) are not significant for the Italian stock market. In contrast, the relationship between the monetary stance and (il)liquidity at the Milan stock exchange is highly significant in all tested specifications and all of them confirm our expectations. In addition, the control variables (not shown) offer similar results to the German case, and would not change our conclusions in this regard. Overall, we argue that our panel estimation results from the French and Italian stock markets confirm the hypothesis that the monetary policy interventions of the ECB determine the liquidity of stocks traded at the Euronext Paris and Milan stock exchange.

We also implement the VAR estimation in order to test the influence of the ECB on the aggregated liquidity of the Euronext Paris and the Milan stock exchange. Thereby, we computed the seven aggregated (il)liquidity measures for the Italian and French markets as each month's equally weighted average of individual stocks' (il)liquidity. In the VAR, which remains as in (14), we employ the same ordering of the variables as for the German stock market and set the lag length equal to one month according to the Schwarz (1978) information criterion. Given the estimated VAR models, we also investigate the response of the seven (il)liquidity variables to a unit standard deviation shock in the monetary policy proxies. Instead of reporting the graphs of the 14 impulse response functions for each market we qualitatively summarize the results in Table 9.

	Dependent variable ((il)liquidity measure)						
monetary policy measure	TO	TV	ILLIQ	TPI	R_IMP	R_REL	S_REL
(a) Euronext Paris							
$Base\ money\ growth_{t-1}$	0.039***	0.017***	-0.026***	-0.047***	-0.063***	-0.028***	-0.062***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Monetary\ stance_{t-1}$	-0.032***	-0.014***	0.038***	0.073***	0.088***	0.040***	0.090***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
(b) Milan stock exchange							
$Base\ money\ growth_{t-1}$	0.044***	0.022***	0.002	-0.001	-0.051***	-0.048***	0.015
	(0.000)	(0.000)	(0.862)	(0.912)	(0.000)	(0.000)	(0.124)
$Monetary\ stance_{t-1}$	-0.044***	-0.017***	0.024***	0.038***	0.060***	0.049***	0.057***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Table 8: Summarized panel estimates for the Euronext Paris and the Milan stock exchange
Note: All coefficients are standardized. P-values are given in parentheses and *, **, *** denote 10%, 5% and 1% significance levels.

The impulse response functions for the Euronext Paris stock exchange, summarized in panel (a) of Table 9, show that the central bank interventions indeed influence the aggregated stock market liquidity. All signs of the impulse responses confirm our expectations and most of them are significant at the 5% level. However, for the Milan stock exchange we only find moderate evidence for an influence of the ECB policy interventions on the aggregated stock market liquidity. From panel (b) of Table 9 we can infer that most signs of the impulse response functions are in line with our hypotheses. The only exception is the response of the illiquidity ratio ($ILLIQ$) due to an innovation in the monetary stance. However, with regard to the statistical significance only the response of the relative Roll measure is significantly different from zero.

All in all, empirical evidence from stocks traded at the Euronext Paris and Milan stock exchange allow us to conclude that the monetary policy similarly determines liquidity in the three most important stock markets of the euro zone. We find robust results in all three markets at the micro level for individual stocks' (il)liquidity, and also at the macro level where we detect an influence of the monetary policy on the aggregated market liquidity.

6 Summary and conclusion

This study examines the role of monetary policy as a potential determinant of stock liquidity. Our hypothesis is that an expansionary (restrictive) monetary policy of the ECB increases (decreases) the liquidity of stocks. In particular, we address this relationship

monetary policy measure	TO	TV	ILLIQ	TPI	R_IMP	R_REL	S_REL
	(il)liquidity measure						
(a) Euronext Paris							
$Base\ money\ growth_{t-1}$	++	++	−−	−−	−−	−	−
$Monetary\ stance_{t-1}$	−	−	+	++	++	++	+
(b) Milan stock exchange							
$Base\ money\ growth_{t-1}$	+	+	−	−	−	−−	+
$Monetary\ stance_{t-1}$	−	−	−	+	+	++	+

Table 9: Summary of the impulse response functions for the Euronext Paris and the Milan stock exchange

Note:
− (+) indicates a negative (positive) response of the seven aggregate (il)liquidity measures to a unit standard deviation innovation in the monetary policy variables. −− (++) marks responses of which both corresponding bands representing plus/minus two standard errors are less than (exceed) zero.

both at the micro and macro level for stocks traded at the Xetra trading system, Euronext Paris and Milan stock exchange. The sample period spans from the introduction of the euro in January 1999 until December 2009. In order to measure (il)liquidity we employ seven variables that capture the aspects trading activity, price impact and transaction costs. The monetary policy of the ECB is approximated either by the twelve-month growth rate of the monetary base or by the monetary stance, which is defined as the deviation of the actual policy rate from the target rate derived from a simple Taylor rule.

By means of monthly panel estimations with stock-fixed effects we find that an expansionary (restrictive) monetary policy leads to an increase (decrease) in the liquidity of individual stocks. The coefficients of the lagged monetary policy variables exhibit the hypothesized sign and are significant in the majority of the estimated models. To examine the relationship between the monetary policy and the aggregated market liquidity we use VAR models in order to take potential endogeneities into account. Firstly, the Granger-causality tests favor the conclusion that the central bank policy is Granger-causal for stock market liquidity, while evidence for a reversed relationship is rather weak. These observations are consistent with the fact that the ECB clearly focuses on inflation control, thereby being less activist with regard to other objectives. However, this result does not necessarily contradict the hypothesis that, for instance in crisis periods, in which European stock markets may show synchronization towards less liquidity, the ECB will condition its decisions to accommodate markets' needs. Secondly, the estimated impulse response functions confirm that an expansionary monetary policy entails more liquid stock markets. Most signs of the responses of the aggregated market (il)liquidity measures due to a unit standard deviation impulse in the monetary policy variables are well in line with our hypotheses. Though, the statistical significance of the monetary stance variable is in some cases only moderate. Overall, we conclude that the monetary policy of the ECB determines the liquidity of major stock markets in the euro zone. As hypothesized, an expansionary (restrictive) monetary policy leads to an increase (decrease) in liquidity. This implies that monetary interventions of central banks should be considered as a determinant of individual stock liquidity. This insight may help to explain observed commonality in liquidity, as well as variations in liquidity at the aggregated-market level. Our results are robust for seven (il)liquidity measures, two proxies of monetary policy, panel as well as time-series approaches and three different markets.

Our study leaves several doors open to further research. An extension of our essay could, for instance, take the bond market into consideration. As suggested by Keynesian arguments, the final effect of monetary policy on liquidity depends on the relative attractiveness of other asset markets (i.e., the bond market). A tightening (easing) of the monetary policy would for instance make bonds relatively more attractive compared to equities and part of the effect of monetary policy on stock market liquidity would be channeled through the bond market (flight-to-quality or flight-to-liquidity episodes). Noteworthy, existing literature supports this conclusion as shown by Goyenko & Ukhov (2009). However, this effect does not change the causation direction observed in our study (from monetary policy to stock market liquidity), but solely concerns the transmission mechanism of monetary policy shocks to the stock market (potentially through the bond market). Moreover, studying cross-market information could also turn out to be an interesting research question. Specifically, information across countries could play a role in determining to what extent comovements towards low-liquidity levels across countries (for example in periods of global crisis) would determine the conduct of common monetary policy in the euro area. Such an extension would add information about a potential reverse causality in those periods.

References

Acharya, V. V. & Pedersen, L. H. (2005), 'Asset pricing with liquidity risk', *Journal of Financial Economics* **77**(2), 375–410.

Amihud, Y. (2002), 'Illiquidity and stock returns: Cross-section and time-series effects', *Journal of Financial Markets* **5**(1), 31–56.

Amihud, Y. & Mendelson, H. (1986), 'Asset pricing and the bid-ask spread', *Journal of Financial Economics* **17**(2), 223–249.

Amihud, Y., Mendelson, H. & Pedersen, L. H. (2005), *Liquidity and asset prices (foundations and trends in finance)*, Now Publishers Inc.

Brennan, M. J., Chordia, T. & Subrahmanyam, A. (1998), 'Alternative factor specifications, security characteristics, and the cross-section of expected stock returns', *Journal of Financial Economics* **49**(3), 345–373.

Brunnermeier, M. K. & Pedersen, L. H. (2009), 'Market liquidity and funding liquidity.', *Review of Financial Studies* **22**(6), 2201 – 2238.

Chordia, T., Roll, R. & Subrahmanyam, A. (2000), 'Commonality in liquidity', *Journal of Financial Economics* **56**(1), 3–28.

Chordia, T., Roll, R. & Subrahmanyam, A. (2001), 'Market liquidity and trading activity.', *Journal of Finance* **56**(2), 501 – 530.

Chordia, T., Sarkar, A. & Subrahmanyam, A. (2005), 'An empirical analysis of stock and bond market liquidity', *Review of Financial Studies* **18**(1), 85 – 129.

Clarida, R., Gali, J. & Gertler, M. (1998), 'Monetary policy rules in practice some international evidence', *European Economic Review* **42**(6), 1033–1067.

Constantinides, G. M. (1986), 'Capital market equilibrium with transaction costs', *The Journal of Political Economy* **94**(4), 842–862.

Copeland, T. E. & Galai, D. (1983), 'Information effects on the bid-ask spread', *The Journal of Finance* **38**(5), 1457–1469.

Datar, V. T., Y. Naik, N. & Radcliffe, R. (1998), 'Liquidity and stock returns: An alternative test', *Journal of Financial Markets* **1**(2), 203–219.

Dickey, D. A. & Fuller, W. A. (1979), 'Distribution of the estimators for autoregressive time series with a unit root.', *Journal of the American Statistical Association* **74**(366), 427.

Eisfeldt, A. L. (2004), 'Endogenous liquidity in asset markets.', *Journal of Finance* **59**(1), 1 – 30.

Florackis, C., Gregoriou, A. & Kostakis, A. (2010), 'Trading frequency and asset pricing: Evidence from a new price impact ratio', *SSRN eLibrary* .

Fujimoto, A. (2003), 'Macroeconomic Sources of Systematic Liquidity', *Working Paper, Yale University* .

Garcia, G. (1989), 'The lender of last resort in the wake of the crash.', *American Economic Review* **79**(2), 151 – 155.

Goyenko, R. Y., Holden, C. W. & Trzcinka, C. A. (2009), 'Do liquidity measures measure liquidity?', *Journal of Financial Economics* **92**(2), 153–181.

Goyenko, R. Y. & Ukhov, A. D. (2009), 'Stock and bond market liquidity: A long-run empirical analysis.', *Journal of Financial and Quantitative Analysis* **44**(1), 189 – 212.

Granger, C. W. J. (1969), 'Investigating causal relations by econometric models and cross-spectral methods.', *Econometrica* **37**(3), 424 – 438.

Hameed, A., Kang, W. & Viswanathan, S. (2010), 'Stock market declines and liquidity.', *Journal of Finance* **65**(1), 257 – 293.

Hasbrouck, J. (2007), *Empirical market microstructure: The institutions, economics, and econometrics of securities trading*, Oxford University Press, USA.

Hasbrouck, J. (2009), 'Trading costs and returns for U.S. equities: Estimating effective costs from daily data', *Journal of Finance* **64**(3), 1445–1477.

Hasbrouck, J. & Seppi, D. (2001), 'Common factors in prices, order flows, and liquidity', *Journal of Financial Economics* **59**, 383–411.

Hodrick, R. J. & Prescott, E. C. (1997), 'Postwar u.s. business cycles: An empirical investigation.', *Journal of Money, Credit and Banking (Ohio State University Press)* **29**(1), 1 – 16.

Huberman, G. & Halka, D. (2001), 'Systematic liquidity', *Journal of Financial Research* **24**(2), 161–178.

Kempf, A. & Mayston, D. (2008), 'Liquidity commonality beyond best prices', *Journal of Financial Research* **31**(1), 25–40.

Levin, A., Chien-Fu Lin, A. & Chu, C.-S. J. (2002), 'Unit root tests in panel data: asymptotic and finite-sample properties.', *Journal of Econometrics* **108**(1), 1 – 24.

Naes, R., Skjeltorp, J. A. & Ødegaard, B. A. (2010), 'Stock Market Liquidity and the Business Cycle', *forthcoming: The Journal of Finance* .

O'Hara, M. (1998), *Market Microstructure Theory*, Wiley.

Pástor, L. & Stambaugh, R. (2003), 'Liquidity risk and expected stock returns', *Journal of Political Economy* **111**(3), 642–685.

Roll, R. (1984), 'A simple implicit measure of the effective bid-ask spread in an efficient market', *The Journal of Finance* **39**(4), 1127–1139.

Schwarz, G. (1978), 'Estimating the dimension of a model', *The Annals of Statistics* **6**(2), pp. 461–464.

Söderberg, J. (2008), 'Do macroeconomic variables forecast changes in liquidity? An out-of-sample study on the order-driven stock markets in Scandinavia', *CAFO Working Paper, Växjö University* .

Sims, C. (1980), 'Macroeconomics and reality', *Econometrica* **48**(1), 1 – 48.

Taylor, J. B. (1993), 'Discretion versus policy rules in practice', *Carnegie-Rochester Conference Series on Public Policy* **39**(1), 195–214.

7 Appendix: Tables for France and Italy

Panel variables	Mean of monthly means	Mean of monthly σ	Mean of monthly skewness	Median of monthly means	Min. monthly mean	Max. monthly mean
TO	3.449	4.079	2.215	3.397	2.146	5.509
TV	8.145	2.667	0.719	8.120	7.584	8.812
ILLIQ	0.150	0.300	3.481	0.128	0.034	0.473
TPI	6,714.872	9,794.229	3.469	6,080.066	2,723.612	14,358.630
R_IMP	0.006	0.013	3.421	0.005	0.002	0.015
R_REL	0.012	0.015	1.641	0.012	0.007	0.025
S_REL	0.018	0.015	1.760	0.017	0.009	0.040
RET	0.599	10.775	0.493	1.133	-18.964	16.568
MV	2,157.182	8,780.206	0.008	2,120.580	1,362.832	3,035.125
STDV	2.292	1.043	0.474	2.137	1.448	4.488
Time variables	Mean	σ	Skewness	Median	Min.	Max.
IP	-0.004	6.186	-1.933	1.203	-22.047	7.773
IR	2.013	0.815	-0.611	2.100	-0.700	4.000
IDX	130.4323	29.381	0.177	126.899	73.104	192.405

Table 10: Descriptive statistics of the variables employed in the panel for the Euronext Paris

	TO	TV	ILLIQ	TPI	R_IMP	R_REL	S_REL	RET	lnMV	STDV
TO	1	0.605	-0.207	-0.388	-0.273	-0.007	-0.320	0.066	0.295	0.281
TV		1	-0.526	-0.370	-0.407	-0.147	-0.701	0.073	0.903	-0.068
ILLIQ			1	0.370	0.338	0.271	0.683	-0.064	-0.534	0.304
TPI				1	0.288	0.165	0.397	-0.033	-0.127	0.080
R_IMP					1	0.451	0.351	-0.051	-0.290	0.020
R_REL						1	0.265	-0.096	-0.175	0.295
S_REL							1	-0.049	-0.695	0.373
RET								1	0.073	0.058
lnMV									1	-0.256
STDV										1

Table 11: Correlation matrix of the time-series means of the monthly bivariate cross-sectional correlations for the Euronext Paris

	Dependent variable ((il)liquidity measure)						
	TO	TV	$ILLIQ$	TPI	R_IMP	R_REL	S_REL
$Dependent\ variable_{i,t-1}$	0.549***	0.581***	0.510***	0.515***	0.149***	0.041***	0.600***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Monetary\ stance_{t-1}$	-0.032***	-0.014***	0.038***	0.073***	0.088***	0.040***	0.090***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Return_{i,t-1}$	-0.015***	0.005***	-0.043***	-0.023***	-0.002	-0.008	-0.032***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.694)	(0.204)	(0.000)
$Standard\ deviation_{i,t-1}$	-0.039***	-0.016***	-0.009**	-0.019***	0.022***	0.153***	-0.011***
	(0.000)	(0.000)	(0.038)	(0.000)	(0.000)	(0.000)	(0.003)
$ln(Market\ value)_{i,t-1}$	-0.025**	0.291***	-0.371***	-0.047***	-0.168***	-0.200***	-0.239***
	(0.045)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Industrial\ production_{t-1}$	-0.038***	0.002	-0.025***	-0.028***	0.047***	-0.034***	-0.003
	(0.000)	(0.259)	(0.000)	(0.000)	(0.000)	(0.000)	(0.384)
$Inflation_{t-1}$	0.008***	-0.018***	0.052***	0.065***	0.017***	0.054***	0.056***
	(0.007)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Stock\ market\ index_{t-1}$	0.061***	0.025***	-0.043***	-0.072***	-0.085***	0.006	-0.073***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.303)	(0.000)
N	57,926	58,125	56,801	56,620	51,897	51,664	51,333
R^2	0.312	0.582	0.352	0.308	0.045	0.036	0.500

Table 12: Panel estimations for the Euronext Paris measuring monetary policy by the monetary stance from a Taylor rule
Note: All coefficients are standardized, except for the intercept term. P-values are given in parentheses and *, **, *** denote 10%, 5% and 1% significance levels.

	Dependent variable ((il)liquidity measure)						
	TO	TV	$ILLIQ$	TPI	R_IMP	R_REL	S_REL
$Dependent\ variable_{i,t-1}$	0.542***	0.576***	0.507***	0.513***	0.151***	0.031***	0.623***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
$Base\ money\ growth_{t-1}$	0.039***	0.017***	-0.026***	-0.047***	-0.063***	-0.028***	-0.062***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Return_{i,t-1}$	-0.018***	0.004***	-0.048***	-0.030***	-0.007	-0.007	-0.040***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.121)	(0.325)	(0.000)
$Standard\ deviation_{i,t-1}$	-0.049***	-0.021***	-0.003	-0.002	0.046***	0.165***	0.000
	(0.000)	(0.000)	(0.464)	(0.653)	(0.000)	(0.000)	(0.919)
$ln(Market\ value)_{i,t-1}$	-0.046***	0.282***	-0.371***	-0.051***	-0.158***	-0.194***	-0.215***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Industrial\ production_{t-1}$	-0.028***	0.005***	-0.030***	-0.045***	0.025***	-0.038***	-0.038***
	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Inflation_{t-1}$	0.018***	-0.011***	0.034***	0.041***	-0.003	0.034***	0.038***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.478)	(0.000)	(0.000)
$Stock\ market\ index_{t-1}$	0.049***	0.021***	-0.030***	-0.041***	-0.048***	0.017***	-0.028***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.000)
N	51,137	51,299	50,129	49,975	45,885	45,685	45,357
R^2	0.302	0.580	0.347	0.299	0.043	0.034	0.506

Table 13: Panel estimations for the Euronext Paris measuring monetary policy by the growth rate of the monetary base
Note: All coefficients are standardized. P-values are given in parentheses and *, **, *** denote 10%, 5% and 1% significance levels.

	(il)liquidity measure						
monetary policy measure	TO	TV	d(ILLIQ)	TPI	R_IMP	R_REL	d(S_REL)
(a) Central bank policy (row) → liquidity (column)							
H_0: Central bank policy (row) does not Granger cause the liquidity (column)							
Base money growth	2.533	3.176*	2.836*	4.895**	3.947**	2.785*	2.029
	(0.112)	(0.075)	(0.092)	(0.027)	(0.047)	(0.095)	(0.154)
Monetary stance	0.543	0.001	0.777	3.146*	5.350**	10.749***	1.287
	(0.461)	(0.974)	(0.378)	(0.076)	(0.021)	(0.001)	(0.257)
(b) Liquidity (column) → central bank policy (row)							
H_0: The liquidity (column) does not Granger cause the central bank policy (row)							
Base money growth	0.228	0.682	1.207	1.190	0.363	1.509	0.506
	(0.633)	(0.409)	(0.272)	(0.275)	(0.547)	(0.219)	(0.477)
Monetary stance	0.087	0.001	0.530	0.016	0.064	0.177	3.195*
	(0.768)	(0.971)	(0.467)	(0.900)	(0.801)	(0.674)	(0.074)

Table 14: Pairwise Granger-causality tests between liquidity and monetary policy for the Euronext Paris
Note: χ^2 statistics and p-values in parenthesis. *, ** and *** denote 10%, 5% and 1% significance levels.

Panel variables	Mean of monthly means	Mean of monthly σ	Mean of monthly skewness	Median of monthly means	Min. monthly mean	Max. monthly mean
TO	5.872	6.664	2.522	5.410	2.529	13.889
TV	9.339	2.227	0.447	9.291	8.229	10.560
ILLIQ	0.037	0.077	3.943	0.025	0.006	0.193
TPI	3,408.601	6,088.971	4.262	2,718.502	658.732	13,649.260
R_IMP	0.001	0.001	4.068	0.000	0.000	0.001
R_REL	0.011	0.011	0.997	0.010	0.004	0.018
S_REL	0.012	0.009	1.878	0.009	0.004	0.063
RET	0.273	8.088	0.611	0.771	-18.070	20.633
MV	1,921.728	6,912.630	0.008	1,875.621	1,173.883	2,798.944
STDV	1.839	0.713	0.463	1.679	1.075	4.302
Time variables	Mean	σ	Skewness	Median	Min.	Max.
IP	-0.004	6.186	-1.933	1.203	-22.047	7.773
IR	2.013	0.815	-0.611	2.100	-0.700	4.000
IDX	111.036	25.189	0.405	104.901	66.183	166.661

Table 15: Descriptive statistics of the variables employed in the panel for the Milan stock exchange.

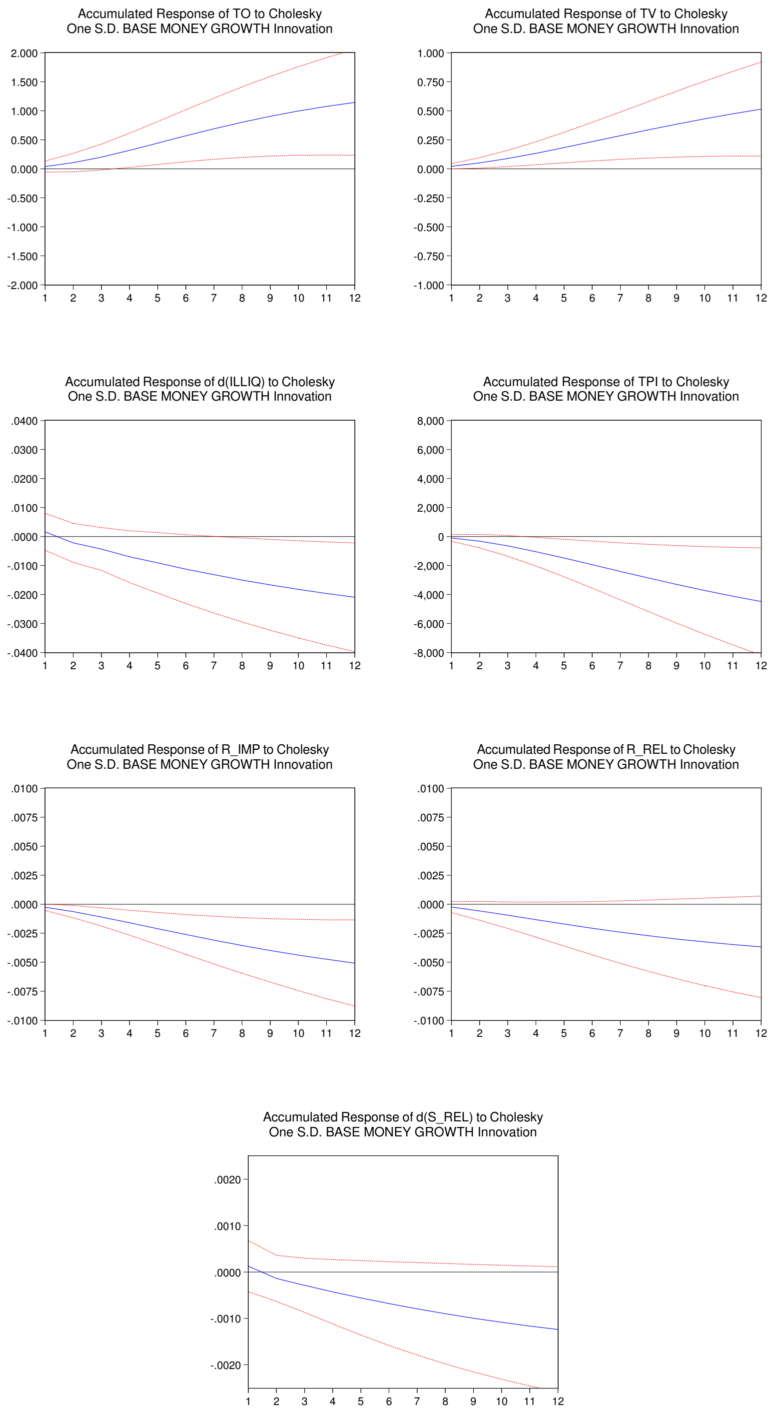

Figure 3: Response of the seven (il)liquidity measures to a unit standard deviation innovation in the base money growth (Euronext Paris stock exchange)

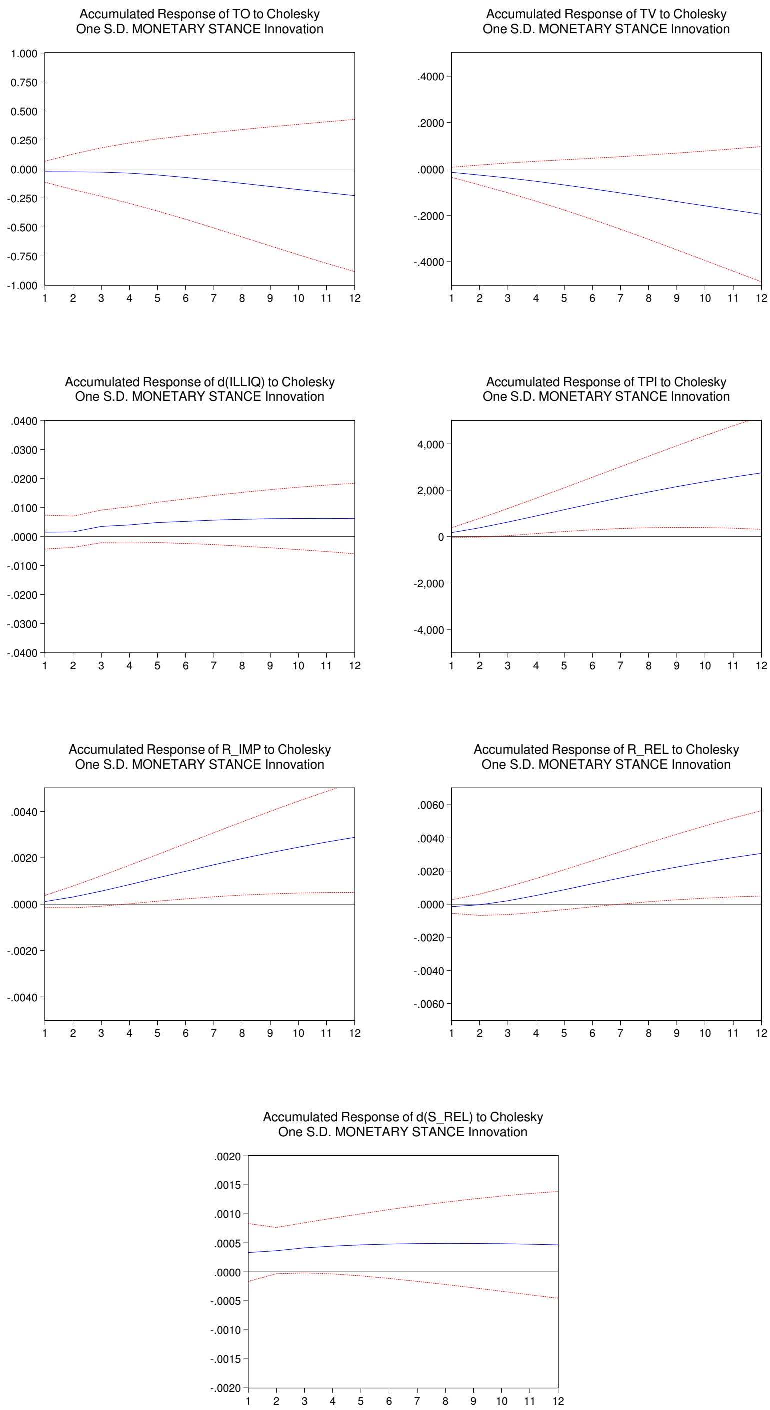

Figure 4: Response of the seven (il)liquidity measures to a unit standard deviation innovation in the monetary stance (Euronext Paris stock exchange)

	TO	TV	ILLIQ	TPI	R_IMP	R_REL	S_REL	RET	lnMV	STDV
TO	1	0.537	-0.232	-0.370	-0.216	0.001	-0.270	0.157	0.164	0.391
TV		1	-0.554	-0.453	-0.436	-0.118	-0.659	0.115	0.873	0.160
ILLIQ			1	0.597	0.460	0.169	0.624	-0.037	-0.485	0.054
TPI				1	0.329	0.132	0.459	-0.043	-0.187	-0.014
R_IMP					1	0.399	0.378	-0.078	-0.357	-0.020
R_REL						1	0.150	-0.056	-0.137	0.214
S_REL							1	-0.004	-0.599	0.088
RET								1	0.071	0.139
lnMV									1	-0.047
STDV										1

Table 16: Correlation matrix of the time-series means of the monthly bivariate cross-sectional correlations for the Milan stock exchange

	Dependent variable ((il)liquidity measure)						
	TO	*TV*	*ILLIQ*	*TPI*	*R_IMP*	*R_REL*	*S_REL*
$Dependent\ variable_{i,t-1}$	0.470***	0.625***	0.507***	0.456***	0.221***	0.008	0.568***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.367)	(0.000)
$Monetary\ stance_{t-1}$	-0.044***	-0.017***	0.024***	0.038***	0.060***	0.049***	0.057***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Return_{i,t-1}$	0.016*	0.009***	-0.027***	-0.025***	-0.016***	-0.003	-0.039***
	(0.052)	(0.000)	(0.000)	(0.000)	(0.005)	(0.766)	(0.000)
$Standard\ deviation_{i,t-1}$	-0.008	-0.017***	-0.005	-0.021***	0.008	0.167***	0.038***
	(0.320)	(0.000)	(0.366)	(0.001)	(0.272)	(0.000)	(0.000)
$ln(Market\ value)_{i,t-1}$	-0.093***	0.204***	-0.196***	0.032*	-0.054*	-0.114***	-0.154***
	(0.000)	(0.000)	(0.000)	(0.067)	(0.074)	(0.001)	(0.000)
$Industrial\ production_{t-1}$	-0.014**	0.003	-0.091***	-0.092***	-0.019**	-0.028**	-0.182***
	(0.035)	(0.270)	(0.000)	(0.000)	(0.040)	(0.010)	(0.000)
$Inflation_{t-1}$	-0.030***	-0.028***	0.072***	0.102***	0.049***	0.020**	0.031***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.017)	(0.000)
$Stock\ market\ index_{t-1}$	0.113***	0.048***	-0.019**	-0.067***	-0.092***	-0.005	-0.002
	(0.000)	(0.000)	(0.015)	(0.000)	(0.000)	(0.603)	(0.701)
N	24,418	24,499	24,195	24,085	23,759	23,681	22,657
R^2	0.260	0.590	0.323	0.265	0.076	0.036	0.518

Table 17: Panel estimations for the Milan stock exchange measuring monetary policy by the monetary stance from a Taylor rule

Note: All coefficients are standardized, except for the intercept term. P-values are given in parentheses and *, **, *** denote 10%, 5% and 1% significance levels.

	Dependent variable ((il)liquidity measure)						
	TO	*TV*	*ILLIQ*	*TPI*	*R_IMP*	*R_REL*	*S_REL*
$Dependent\ variable_{i,t-1}$	0.475***	0.616***	0.504***	0.452***	0.217***	0.006	0.571***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.510)	(0.000)
$Base\ money\ growth_{t-1}$	0.044***	0.022***	0.002	-0.001	-0.051***	-0.048***	0.015
	(0.000)	(0.000)	(0.862)	(0.912)	(0.000)	(0.000)	(0.124)
$Return_{i,t-1}$	0.016*	0.011***	-0.031***	-0.031***	-0.020***	-0.001	-0.046***
	(0.062)	(0.000)	(0.000)	(0.000)	(0.001)	(0.956)	(0.000)
$Standard\ deviation_{i,t-1}$	-0.022***	-0.020***	0.002	-0.010	0.019***	0.171***	0.052***
	(0.007)	(0.000)	(0.764)	(0.129)	(0.007)	(0.000)	(0.000)
$ln(Market\ value)_{i,t-1}$	-0.102***	0.211***	-0.194***	0.031*	-0.027	-0.114***	-0.147***
	(0.000)	(0.000)	(0.000)	(0.093)	(0.417)	(0.002)	(0.000)
$Industrial\ production_{t-1}$	-0.003	0.007**	-0.095***	-0.099***	-0.040***	-0.082***	-0.193***
	(0.724)	(0.038)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Inflation_{t-1}$	-0.015***	-0.019***	0.064***	0.093***	0.030***	0.037***	0.033***
	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Stock\ market\ index_{t-1}$	0.098***	0.044***	-0.009	-0.053***	-0.069***	0.037***	0.024***
	(0.000)	(0.000)	(0.244)	(0.000)	(0.000)	(0.000)	(0.000)
N	21,963	22,018	21,760	21,662	21,366	21,297	20,319
R^2	0.261	0.596	0.319	0.257	0.073	0.038	0.516

Table 18: Panel estimations for the Milan stock exchange measuring monetary policy by the growth rate of the monetary base
Note: All coefficients are standardized. P-values are given in parentheses and *, **, *** denote 10%, 5% and 1% significance levels.

	(il)liquidity measure						
monetary policy measure	TO	d(TV)	d(ILLIQ)	TPI	d(R_IMP)	R_REL	S_REL
(a) Central bank policy (row) → liquidity (column)							
H_0: Central bank policy (row) does not Granger cause the liquidity (column)							
Base money growth	3.874**	1.099	0.635	0.124	0.660	3.304*	0.116
	(0.049)	(0.294)	(0.425)	(0.725)	(0.416)	(0.069)	(0.734)
Monetary stance	0.013	0.064	0.009	0.900	0.792	6.879***	5.541**
	(0.910)	(0.801)	(0.923)	(0.343)	(0.373)	(0.009)	(0.019)
(b) Liquidity (column) → central bank policy (row)							
H_0: The liquidity (column) does not Granger cause the central bank policy (row)							
Base money growth	1.326	3.499*	4.237**	4.819**	3.325*	0.427	0.005
	(0.250)	(0.061)	(0.040)	(0.028)	(0.068)	(0.514)	(0.941)
Monetary stance	0.004	0.110	2.346	3.817*	0.095	0.095	3.291*
	(0.952)	(0.741)	(0.126)	(0.051)	(0.758)	(0.758)	(0.070)

Table 19: Pairwise Granger-causality tests between liquidity and monetary policy for the Milan stock exchange.
Note: χ^2 statistics and p-values in parenthesis. *, ** and *** denote 10%, 5% and 1% significance levels.

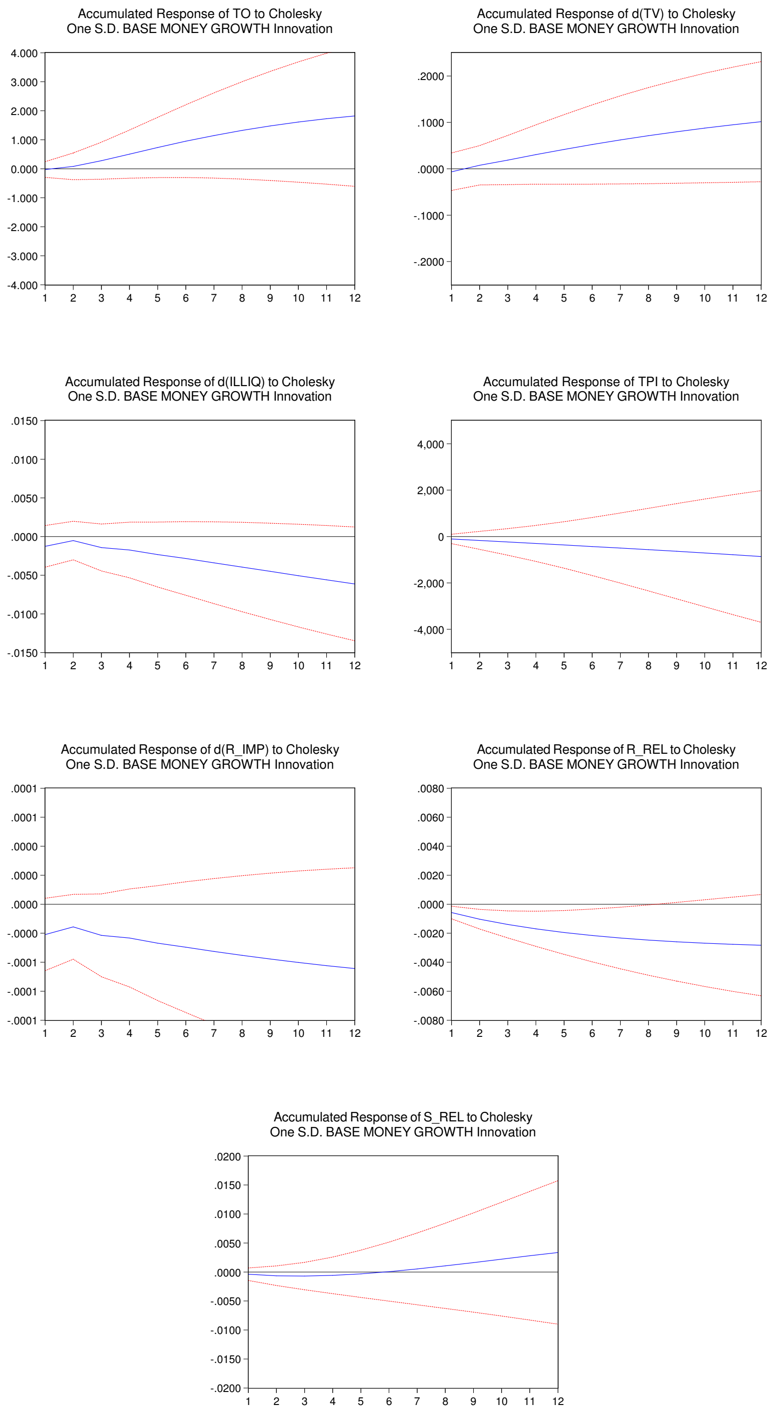

Figure 5: Response of the seven aggregate (il)liquidity measures to a unit standard deviation innovation in base money growth (Milan stock exchange)

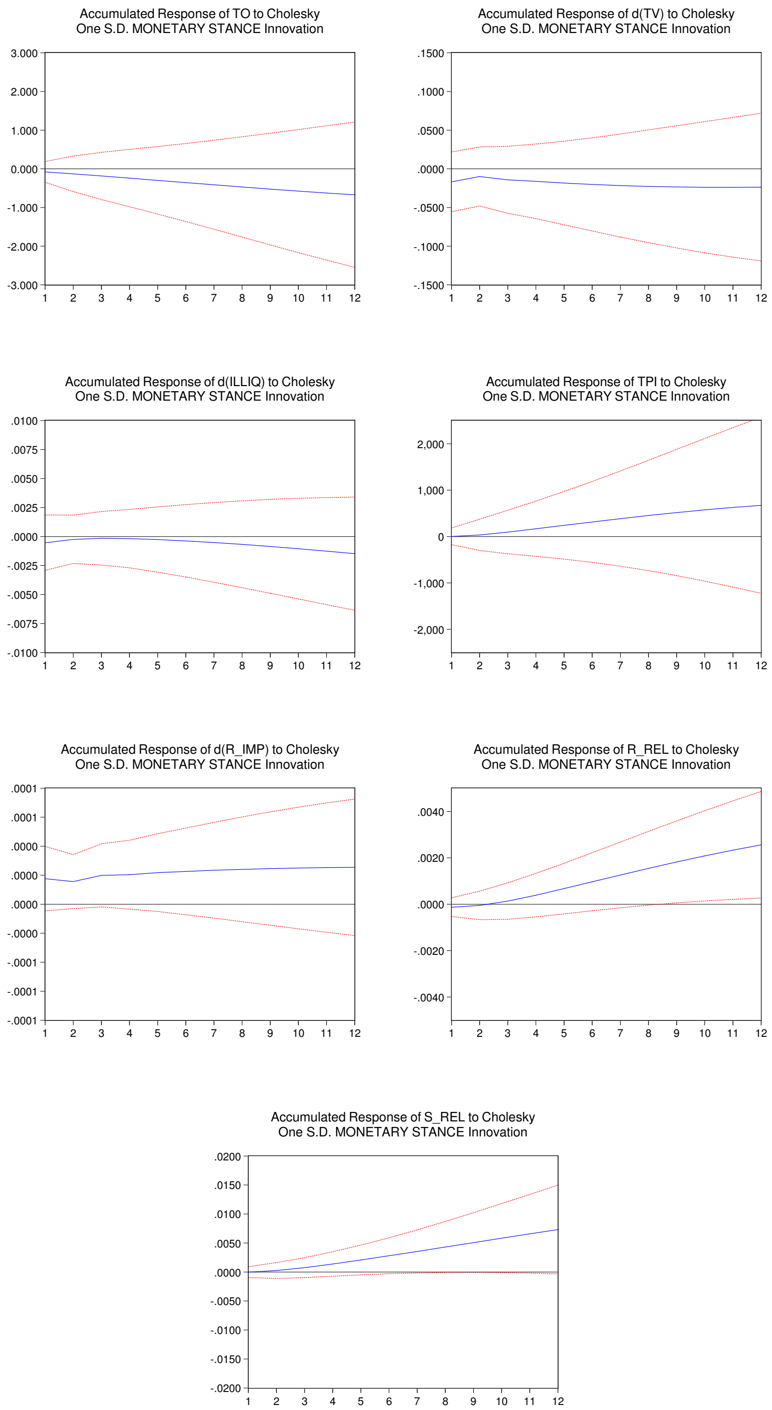

Figure 6: Response of the seven aggregate (il)liquidity measures to a unit standard deviation innovation in the monetary stance (Milan stock exchange)