

DOES FINANCIAL STRESS HAVE AN IMPACT ON MONETARY POLICY?

AN ECONOMETRIC ANALYSIS USING NORWEGIAN DATA

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Abstract

This thesis investigates the impact of financial stress on monetary policy in Norway. Financial distress has a negative impact on the economy, and if the shocks are large enough, it may possibly lead to a recession in the economy with sustained deflationary pressure, low production and high unemployment rates. The manner and extent to which the central bank reacts to counteract the effects of financial stress may thus be key in avoiding longer spells of reductions in the economic growth of a country. This thesis will investigate the impact of financial stress on the monetary policy decisions in Norway—both how large the effect has been and whether the central bank has responded *ex ante* or *ex post* to financial stress.

The effect of financial stress on the monetary policy is estimated using an augmented Taylor rule using monthly data from 1998 to 2011. All regressors are treated as endogenous in a model framework where the parameter capturing the effect of financial instability is time varying. The results show a negative relationship between financial instability and monetary policy decisions. That is, the estimation results imply that an increase in the financial stress index contributes to lower interest rates. The effect is found to be larger in late 2008, when a full-blown financial crisis hit the global economy, than during the rest of the period covered by my sample. Furthermore, the estimates suggest that the central bank reacted more aggressively after an increase in financial stress had occurred than before such an increase.

Preface

This thesis marks the end of five years study in economics. I have spent these years at the Department of Economics, University of Oslo, except for the one semester I studied at Universidade NOVA de Lisboa.

First of all, I would like to thank my supervisor Farooq Akram, for his invaluable feedback and comments during the whole process. His insights became especially helpful during the later phases of the process. Moreover, I owe André Anundsen a special token of appreciation, as he has provided me with good and helpful advice. Special thanks also go to Matt Arens, for proofreading the thesis. My friends have earned a big “thank you” for keeping my spirits high. Finally, I would like to thank my family for their support throughout the years.

Any remaining errors and inaccuracies in this thesis are my own responsibility, and mine alone.

May 2012,

Michael W. Madsen

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1 Introduction

In recent years, especially in the wake of the recent financial crisis, interest in the impact of financial imbalances on monetary policy decisions has increased. The Norwegian central bank's core responsibilities include the promotion of price stability by the means of monetary policy, as well as promoting financial stability and contributing to robust and efficient financial infrastructures and payment systems¹. As an example of the latter, the Deputy Governor of Norges Bank, Jan F. Qvigstad, argued that increased financial turmoil abroad calls for a monetary ease, in a press release dated December 14th 2011². The authority has also taken extraordinary measures in order to cope with threats of financial stress in recent years, e.g. by the easing of collateral requirements³. The central bank also points to changes in the economic environment abroad that are needed to be taken into account when adjusting its interest rates (Norges Bank, 2012).

In light of this, this master thesis investigates the impact of financial distress on monetary policy decisions in Norway in recent years. Furthermore, I investigate the reaction from the Norwegian central bank when financial stress increases as well as the nature of the response, i.e. the size and timing of the central bank reaction. That is, the thesis examines whether the monetary authority in Norway has reacted to financial stress, and if this has been an *ex ante* or *ex post* response.

By applying an augmented Taylor rule in a time-varying parameter framework, I estimate the effect of financial stress on interest rates. I estimate a Taylor-type rule with endogenous regressors by first utilizing the two-stage least squares method. The model is later estimated by letting the coefficient in which the effect of financial instability is measured vary across time. The index measuring financial stress is based on an index developed by the International Monetary Fund, and uses different measures of financial stress in the bank sector, stock market and exchange rate market; see Cardarelli et al. (2011).

In recent years, there has been an increased interest in this field of research. Empirical findings imply that central banks in recent years have decreased their interest rates in cases of increased financial instability (Baxa et al., 2011). There is also evidence that points to the

¹ <http://www.norges-bank.no/en/about/mandate-and-core-responsibilities/>

² <http://www.norges-bank.no/en/about/published/press-releases/2011/key-rate-14-december/>

³ <http://www.norges-bank.no/en/about/financial-turbulence-and-norges-bank/steps-taken-by-norges-bank/>

central bank being asymmetric in its response towards financial stress, by decreasing its interest rates more in periods of stress than during normal times (Borio and Lowe, 2004). Additionally, in periods during which banks have difficulties in attaining credit, this can be counteracted by monetary policy easing (Cecchetti and Li, 2008).

The evidence apprehended in this thesis suggests that the Norwegian central bank has decreased its interest rates when financial stress has increased heavily. Specifically, there was a rather big decrease in interest rates as a response to the massive increase of financial stress following the financial turmoil in 2008.

The thesis is organized as follows. Section 2 gives an overview of literature in the field. Section 3 provides the modelling framework. Section 4 describes the data utilized in estimating the model. Section 5 presents the econometric results. Finally, section 6 concludes.

2 Literature

In recent years, there has been an increased interest in studying how monetary policy decisions are affected by financial imbalances. Results from Bernanke and Gertler (1995) and Bernanke et al. (1999) suggest that the financial sector may amplify shocks to the real economy – the so-called financial accelerator effect. There is, however, disagreement concerning the extent to which the central bank should include a measure of financial instability in its reaction function. Bernanke and Gertler (1999) claim that the central bank should not respond to asset prices, a finding that is supported by Bernanke and Gertler (2001). On the other hand, Akram et al. (2007) and Akram and Eitrheim (2008) find that there may be gains from responding to asset prices. There is also some evidence suggesting that the monetary authorities have decreased their interest rates after the occurrence of financial stress (Baxa et al., 2011; Bulíř and Čihák, 2008).

Bernanke et al. (1999) include credit-market frictions in a standard macroeconomic model, and show that the frictions propagate both nominal and real shocks to the economy, e.g. through a monetary contraction or expansion. Their findings suggest that even relatively small shocks to the economy will be amplified through the financial accelerator effect.

Bernanke and Gertler (1995) find that the effect of a monetary contraction tends to have an impact on the consumers demand quite rapidly, whereas the effect on the production side comes with a lag and is far more persistent. Furthermore, they show that the financial accelerator works through two channels– the balance sheet channel and the bank lending channel. A monetary tightening works directly through the balance sheet channel of the borrowers by decreasing their net cash flows and collateral values. For the firms, there is also an indirect effect with a longer lag than the direct effects. That is, a monetary contraction tends to reduce the consumers' spending, through their decreased budget balance, while the firms' short-term costs are rigid. This will over time decrease the net worth of firms. The other channel, through which the financial friction is affected, is the bank lending channel. An increase in the interest rates will increase financial friction through the decrease in the supply of loans from commercial banks.

According to Bernanke and Gertler (1999), inflation-targeting central banks should not respond to asset prices. This is further backed up in Bernanke and Gertler (2001), where they

found that the policy rules minimizing the volatility in output gap and inflation were so-called aggressive inflation targeting regimes. That is, by responding to increasing asset prices as well as inflation, the volatility in both output and inflation increased. Moreover, they found that the optimal policy never involved an interest rate response to stock prices.

Akram et al. (2007) show that there may be gains from pursuing financial stability for an inflation-targeting central bank. It is, however, highly dependent on the nature of the shock. By estimating an augmented Taylor rule, they find that the response to credit shocks yield higher volatility in both output gap, inflation and the interest rate than the simple Taylor rule. For house price shocks the results show that the augmented rule outperforms the simple Taylor rule when looking at the volatility in output gap and inflation.

Akram and Eitrheim (2008) expand the framework used in Akram et al. (2007). Their results show that an interest rate rule that responds to exchange rates, house prices, equity prices or credit growth lower the volatility of both inflation and the output gap compared to a Taylor-type rule with interest rate smoothing. They also find that including these variables in the interest rate rule tends to increase the interest rate volatility, which in turn might increase the degree of financial instability. Furthermore, their findings suggest that pursuing stability of the exchange rate tends to increase the interest rate volatility more than the other rules.

In Christiano et al.'s (2008) model, booms in asset prices are correlated with a strong growth in credit. They suggest that the monetary authority includes a measure for credit growth in their Taylor rule. That is, in their model there is a monetary tightening when credit growth is strong. Furthermore, they show that this will reduce the magnitude of the boom-bust cycle.

Baxa et al. (2011) estimate the effect of a financial stress index on the interest rate setting in five countries: the U.S, the U.K, Sweden, Canada and Australia. The authors estimate a modified Taylor rule with time-varying parameters. This approach allows them to look at the effect of the different variables on monetary policy rates through time. They find that there are significant reductions in the interest rate during periods of financial instability. Furthermore, the results show that the effect is larger in the most recent period of financial distress, i.e. during the global financial crisis of 2008- 2009.

Mishkin (2009) argues that aggressive monetary policy easing during financial distress is effective, as it tends to minimize the likelihood of adverse feedback loops. That is, since

negative shocks to the financial sector have a tendency to reduce the value of collateral and thereby increase credit frictions, an aggressive central bank may alleviate some of these frictions by cutting its policy rates.

Fuhrer and Tootell (2008) investigate whether the Federal Reserve explicitly targets stock prices in its interest rate decisions, and find little evidence that it has responded directly to stock values other than through its impact on the monetary policy goal variables.

Cecchetti and Li (2008) research the impact of capital requirements on monetary policy. They find that capital requirements are pro-cyclical in the case of a passive monetary authority. Furthermore, their results show that optimal monetary policy can counteract the pro-cyclical impact of capital requirements, i.e. a tightening of credit. In a model framework that includes loan supply, loan demand and bank deposits, the authors estimate the impact of capital requirements on monetary policy by minimizing a loss function subject to the model framework.

Buliř and Čihák (2008) use an augmented Taylor rule, with measures of financial sector vulnerability included, to see if the monetary authority responds to financial instability. They report some evidence in support of this hypothesis.

Chadha et al. (2004) find statistically significant, though small, effects of asset prices and exchange rate changes on monetary policy. They interpret the evidence in the direction of these effects being asymmetric in their impact on interest rate setting. That is, the central bank is likely to react quite aggressively on misalignments that might act to destabilize the economy.

Moreover, Borio and Lowe (2004) find evidence that point in the direction of asymmetric interest rate decision in the face of financial imbalances. That is, central banks generally loosen their policy beyond normal when bubbles burst, but do not tighten it in the build-up of these imbalances.

Siklos and Bohl (2008) include asset prices as instruments in monetary policy rules, and find that this improves the model fit. Their results suggest that asset prices are part of the information set used in the determination of policy responses to inflation and output gap.

3 Model of interest rate setting

In line with Clarida et al. (1998, 2000), I will assume that the central bank sets its nominal interest rate according to a forward-looking rule:

$$(1) \quad r_t^* = \bar{r} + \beta(E[\pi_{t+i}|\Omega_t] - \pi_{t+i}^*) + \gamma E[y_{t+j}|\Omega_t] + \mu(E[e_{t+k}|\Omega_t] - e_{t+k}^*)$$

where r_t^* is the target interest rate, \bar{r} is the policy neutral rate, π_{t+i} is the inflation rate at time $t+i$, π_{t+i}^* is the central bank's target inflation rate. y_{t+j} is the output gap, defined as the difference between the realized and potential output in period $t+j$. e_{t+k} is the exchange rate at time $t+k$, while e_{t+k}^* may be interpreted as a steady state level or desired level of the exchange rate. E is an expectation operator conditional on the information, Ω_t , available for the central bank when monetary policy decisions are made.

This model is an expansion of the interest rate rule presented by Clarida et al. (1998), since I have included the exchange rate in my model. In that respect, the model I use is somewhat similar to the one utilized in de Andrade and Divino (2005). The exchange rate variable is included since my data set includes a time period when the central bank aimed to stabilize the exchange rate. Thus, one would expect that the exchange rate has had an impact on the central bank's interest rate setting decision. Moreover, Norges Bank has often pointed out that they take the exchange rate into account when making their interest rate decision, even after the inflation targeting regime was implemented.

Goodfriend (1991) points to the tendency the central bank has in not adjusting its interest rate target immediately. Specifically, as argued by Clarida et al. (1998), a simple Taylor-type rule, e.g. Eq. (1), does not capture the central bank's propensity to smooth interest rates over time. That is, the central bank has a tendency to adjust its interest rate somewhat sluggishly to avoid highly volatile interest rates, which may act destabilizing on the real economy. Therefore, I assume that the interest rate adjusts gradually to the target rate in the following manner:

$$(2) \quad r_t = \varrho r_{t-1} + (1 - \varrho)r_t^*,$$

where $\varrho \in [0,1)$ is a measure of the central bank's degree of interest rate smoothing. Specifically, the parameter captures the tendency central banks have in adjusting the interest rate somewhat sluggishly toward their target.

Since one would expect the central bank to also adjust their policy rates in situations of financial turmoil, a variable measuring financial instability should be included. Insertion of (1) into (2) and including a term for financial instability, x_t , yields:

$$(3) r_t = (1 - \rho)[\bar{r} + \beta(E[\pi_{t+i}|\Omega_t] - \pi_{t+i}^*) + \gamma E[y_{t+j}|\Omega_t] + \mu(E[e_{t+k}|\Omega_t] - e_{t+k}^*)] + \rho r_{t-1} + \delta x_{t+m}$$

Due to the inclusion of unobservable future dated variables in the former expression, the policy rule is rewritten in order to eliminate these and instead include observable future dated variables. Imposing this assumption, and defining $\alpha = \bar{r} - \beta\pi_{t+i}^* - \mu e_{t+k}^*$, (3) can be rewritten in the following way:

$$(4) r_t = (1 - \rho)[\alpha + \beta\pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k}] + \rho r_{t-1} + \delta x_{t+m} + \varepsilon_t,$$

Where the error term is defined as: $\varepsilon_t \equiv -(1 - \rho)\{\beta(E[\pi_{t+i}|\Omega_t] - \pi_{t+i}^*) + \gamma(E[y_{t+j}|\Omega_t] - y_{t+j}) + \mu(E[e_{t+k}|\Omega_t] - e_{t+k}^*)\}$. Consequently, the error term is a linear combination of the forecast errors of inflation, output gap and the exchange rate, where it is assumed that $E[\pi_{t+i}|\Omega_t]$, $E[y_{t+j}|\Omega_t]$, and $E[e_{t+k}|\Omega_t]$ are the central bank's forecasts of the aforementioned variables.

However, the fact that the central bank's objective has changed through the years, in my sample from a stable exchange rate regime to the current inflation targeting regime, indicates that there are some difficulties by using the constant parameter rule described in (4). This can be overcome by dividing the sample into different sub-samples, as in Clarida et al. (2000). Valente (2003) argues that one should apply a more general, nonlinear model rather than a linear time-invariant model. His argument in favour of a nonlinear model is strengthened as the test for parameter stability is rejected. Nevertheless, one can estimate the policy rule under different regimes in two alternative ways. That is, one may use a state-dependent Markov-switching model as Valente (2003), or a state-space model with time-varying parameters as in Kim (2001), Kim and Nelson (2003) and Trecroci and Vassalli (2009).

Since the shifts in the central bank's regimes are more likely to follow a smooth transition rather than an abrupt and sudden change, I will employ a model where the parameters vary through time. In addition, the weights the central bank puts on its objectives are also likely to vary within each regime, which further strengthens the argument of using a time-varying

parameter model. That is, the central bank is likely to vary the emphasis it puts on its objectives, e.g. the inflation rate, both across regimes and within each regime. These shifts are likely to happen more smoothly rather than abruptly as in the Markov-switching model. In Norway, the transition from an exchange rate targeting regime to an inflation targeting regime was a gradual one. Furthermore, there might also be changes in the weights put on the variables in the objective function due to changes in the central bank management.

The inclusion of a measure for financial instability also points in the direction of having a model in which the parameters vary across time. One would expect that shocks stemming from financial instability would strike the economy with different power at different points in time. In that respect, a time-varying parameter model provides a viable alternative to the state-dependent Markov-switching model.

As in Kim (2006) I will consider a model where the coefficients are allowed to vary across time, and where the regressors are endogenous. In contrast to Kim (2006), however, I will use time-invariant parameters in the equations for the endogenous regressors.

I will use a model framework as presented by Baxa et al. (2011), which is found by rewriting (4) along the lines of Kim (2006), resulting in the following model in a state-space framework:

$$(5) \quad r_t = (1 - \varrho_t)[\alpha_t + \beta_t \pi_{t+i} + \gamma_t y_{t+j} + \mu_t e_{t+k}] + \varrho_t r_{t-1} + \delta_t x_{t+m} + \varepsilon_t$$

$$(6) \quad \alpha_t = \alpha_{t-1} + \vartheta_{1,t} \quad , \vartheta_{1,t} \sim i.i.d. N(0, \sigma_{\vartheta_1}^2)$$

$$(7) \quad \beta_t = \beta_{t-1} + \vartheta_{2,t} \quad , \vartheta_{2,t} \sim i.i.d. N(0, \sigma_{\vartheta_2}^2)$$

$$(8) \quad \gamma_t = \gamma_{t-1} + \vartheta_{3,t} \quad , \vartheta_{3,t} \sim i.i.d. N(0, \sigma_{\vartheta_3}^2)$$

$$(9) \quad \mu_t = \mu_{t-1} + \vartheta_{4,t} \quad , \vartheta_{4,t} \sim i.i.d. N(0, \sigma_{\vartheta_4}^2)$$

$$(10) \quad \delta_t = \delta_{t-1} + \vartheta_{5,t} \quad , \vartheta_{5,t} \sim i.i.d. N(0, \sigma_{\vartheta_5}^2)$$

$$(11) \quad \varrho_t = \varrho_{t-1} + \vartheta_{6,t} \quad , \vartheta_{6,t} \sim i.i.d. N(0, \sigma_{\vartheta_6}^2)$$

$$(12) \quad \pi_{t+i} = Z'_{t-n} \tau + \sigma_\varphi \varphi_t \quad , \varphi_t \sim i.i.d. N(0,1)$$

$$(13) y_{t+j} = Z'_{t-n}\kappa + \sigma_{\zeta}\zeta_t \quad , \zeta_t \sim i.i.d.N(0,1)$$

$$(14) e_{t+k} = Z'_{t-n}\psi + \sigma_v v_t \quad , v_t \sim i.i.d.N(0,1)$$

$$(15) x_{t+m} = Z'_{t-n}\chi + \sigma_{\xi}\xi_t \quad , \xi_t \sim i.i.d.N(0,1)$$

Equation (5) is the time-varying representation of the time-invariant policy rule, i.e. Eq. (4). Eqs. (6) – (11) show how the parameters are assumed to vary across time. The movements of the parameters are represented by random-walk processes without a drift, where unexpected movements in the parameter values are picked up by the error terms. Eqs. (12) – (15) demonstrate the relationship between the endogenous right-hand side variables in (5), π_{t+i} , y_{t+j} , e_{t+k} and x_{t+m} , and their instrumental variables, represented by the vector Z'_t . The instruments that will be used, are lagged values of the inflation rate, the output gap, the exchange rate, the interest rate and foreign interest rate, along with lagged values of oil price inflation, foreign interest rates, foreign output gap and foreign inflation.

The covariance between the error terms in (5) and the standardized errors in (12) – (15), are defined as $\rho_{\varphi\varepsilon}\sigma_{\varepsilon}$, $\rho_{\zeta\varepsilon}\sigma_{\varepsilon}$, $\rho_{v\varepsilon}\sigma_{\varepsilon}$ and $\rho_{\xi\varepsilon}\sigma_{\varepsilon}$, where $\rho_{i\varepsilon}$ denotes are the correlation coefficients between residual i and ε .

In the model framework above, the parameters in the equations for the endogenous regressors (equations 12 – 15) are assumed time-invariant. By contrast, Kim (2006) and Kim and Nelson (2006) assume time-varying parameters for the endogenous right-hand-side variable.

Consistent estimates of the coefficients in (5) are obtained by estimation in two steps. In the first step, (12) – (15) are estimated. In this step, standardized prediction errors of the residuals in the equations for the endogenous right-hand-side variables in the policy rule are found. Furthermore, as is done in Kim and Nelson (2006), the error terms in (5) and (12) – (15) are decomposed utilizing the Cholesky method. Hence, the error term in (5) is allowed to be rewritten as follows:

$$(16) \varepsilon_t = \rho_{\varphi\varepsilon}\sigma_{\varepsilon}\varphi_t + \rho_{\zeta\varepsilon}\sigma_{\varepsilon}\zeta_t + \rho_{v\varepsilon}\sigma_{\varepsilon}v_t + \rho_{\xi\varepsilon}\sigma_{\varepsilon}\xi_t + \zeta_t$$

$$, \zeta_t \sim N(0, (1 - \rho_{\varphi\varepsilon}^2 - \rho_{\zeta\varepsilon}^2 - \rho_{v\varepsilon}^2 - \rho_{\xi\varepsilon}^2)\sigma_{\varepsilon,t}^2)$$

Inserted into (5), the standardized residuals from (12) – (15) act as bias correction terms, thereby securing unbiased and consistent estimates. Specifically, the correction terms are included due to the endogeneity of the right-hand-side variables in (5).

Insertion of (16) into (5) yields the following equation to estimate:

$$(17) r_t = (1 - \varrho_t) [\alpha_t + \beta_t(\pi_{t+i}) + \gamma_t y_{t+j} + \mu_t e_{t+k}] + \varrho_t r_{t-1} + \delta_t x_{t+m} + \rho_{\varphi\varepsilon} \sigma_\varepsilon \varphi_t + \rho_{\zeta\varepsilon} \sigma_\varepsilon \zeta_t + \rho_{v\varepsilon} \sigma_\varepsilon v_t + \rho_{\xi\varepsilon} \sigma_\varepsilon \xi_t + \zeta_t$$

In the second stage of the estimation, I estimate (17) along with (6) – (11) by employing the Varying Coefficients (VC) method proposed by Schlicht (1981, 2005) and Schlicht and Ludsteck (2006). In contrast to Kim and Nelson (2006), who use the maximum likelihood estimator through the Kalman filter to estimate the parameters in (17), the VC method suggested by Schlicht and Ludsteck (2006) is a generalization of the ordinary least squares method. Rather than minimizing the sum of squares, $\sum_{t=1}^T \zeta_t^2$, their VC method minimizes the weighted sum of squares $\sum_{t=1}^T \zeta_t^2 + \theta_1 \sum_{t=1}^T \vartheta_1^2 + \theta_2 \sum_{t=1}^T \vartheta_2^2 + \dots + \theta_n \sum_{t=1}^T \vartheta_n^2$. The weights, θ_i , are defined as the inverse variance ratio of the residuals from eq. (5), ε_t , and the error terms of the time-varying parameters, ϑ_t , formally defined as $\theta_i = \frac{\sigma}{\sigma_i}$.

Moreover, the time-average of the parameters in (17) coincides with the GLS estimate of the fixed parameters, i.e. $(1/T) \sum_t \hat{a}_t = \hat{a}_{GLS}$, where a denotes the parameters in (17) that is to be estimated.

This method has several advantages when estimating the modified Taylor-rule. First, no initial values are needed, as the estimator uses an orthogonal parameterization (Schlicht & Ludsteck, 2006).

Schlicht and Ludsteck (2006) also compare the estimator generated by the VC-method with the corresponding estimator produced by estimation through utilization of the Kalman filter. The performance of the two estimation methods is quite similar. However, the ease of estimation through applying the VC-method is greater than the Kalman filter, as no initial values are needed. They conclude that the VC-method is preferable for estimating linear models with parameters that are following a random walk.

4 Data

All data are monthly observations, with the first observation being August 1998 and the last being December 2011. During this period, the central bank changed its objective from keeping a stable exchange rate to keeping a stable inflation rate. The era of the floating exchange rate regime was officially abandoned in 2001, from which the objective of the monetary authority has been to keep a stable inflation rate.

To represent the monetary policy interest rates, I use the three month Norwegian Interbank Offered Rate (NIBOR). In general, Norges Bank's liquidity policy is able to ensure that the money market interest rate stays close to the policy rate, which is its overnight deposit rate. However, during the recent financial crisis, there was occasionally relative large divergence between the policy rate and money market interest rates. Source: Norges Bank.

The inflation rate is measured as the 12-month percentage change in the consumer price index, excluding energy prices (CPI-AE). Starting in 2001, Norges Bank has had an explicit inflation target rate of 2.5 per cent, where the targeted inflation rate is the change in CPI adjusted for tax changes and excluding energy goods (CPI-ATE). Due to the limited number of observations based on this measure, I use CPI-AE as a proxy. Source: Statistics Norway.

The output gap is calculated as the log deviation of actual output from an estimated trend. The trend is calculated using an HP filter with the smoothing parameter set to 129 600. The output data consists of seasonally adjusted quarterly GDP in Norway⁴, and is measured in millions of Norwegian Kroner. As my data set consists of monthly data, I obtained monthly output data by linearly interpolating the quarterly data. Source: Statistics Norway.

The data from the last few quarters will typically be revised at a later point in time, and may thus not be alike for samples collected at different periods. To avoid this problem, the difference in the unemployment rate from its natural level could be used as a proxy for the output gap. There are some advantages from using the unemployment rate, such as the availability of monthly data and that the data will not be revised. That is, there are no uncertainties concerning the data gathered, as opposed to the use of the output gap. I will use

⁴ The data used are the Statistics Norway series called "Value added at basic prices. Current prices (NOK million), for Total Industry."

monthly data for the unemployment rate, and construct the proxy for the gap as the log unemployment rate divided by the log natural rate of unemployment, which is set to 3.5 per cent. Source: Statistics Norway.

As a measure of the exchange rate, I will use the monthly growth rate of the import weighted exchange rate, I44. It is the nominal effective exchange rate measured as a geometric average over Norway's 44 most important trading partners. Source: Norges Bank.

Finally, the set of instruments consists of monthly data for oil price inflation, average 12-month inflation rate for the G7 countries, the average nominal short term interest rate for the Euro economies and the output gap for the 27 European Union countries, measured as the deviation of the logged average gross production from its trend, where the trend is calculated using an HP filter with the smoothing parameter set to 129 600. Sources: FRED St. Louis Fed, OECD, EuroStat.

Financial Stress Index (FSI)

The variable measuring the degree of financial instability is based on the index created by Cardarelli et al. (2011). However, due to data availability the index presented in this thesis is somewhat different from the one constructed by them. All sub components of the index are demeaned and standardized. That is, I have subtracted the arithmetic mean and divided by the standard error. The financial stress index (FSI) is constructed as the sum of seven components, the beta for the banking sector, the spread between the NIBOR and the overnight lending rate, the inverted term spread, stock market return, stock market volatility and finally the exchange market volatility. The index itself is also demeaned and standardized.

The banking sector beta is a measure of the risk of the banking sector, and is defined as the covariance between the banking and market returns divided by the variance of the market. This measure gives an indication of how risky the banking sector is – the higher the value of beta the more risky is the banking sector stocks. As a proxy for the banking market performance in the Norwegian stock market I use the stock price of Norway's largest bank, DNB. The returns are measured as the twelve month growth in the DNB stock and the market index. Source: Oslo Børs.

As a proxy for the TED spread used by Cardarelli et al. (2011), I use the spread between the overnight lending rate and the three month NIBOR. Since the overnight lending rate is

considered to be safer than the interbank rate, this provides a measure of uncertainty in the interbank market as it captures the premium that banks charge over the overnight lending rate to lend out money in the interbank market. An increase in the spread corresponds to an increase in the premium and thus increased uncertainty in the interbank market. Source: Norges Bank.

The inverted term spread is calculated as the government overnight lending rate minus the NIBOR long term rate, the NIBOR 12-month rate. Hence, an increase in the term spread shows that there are increased difficulties in attaining short-term funding, indicating increased uncertainty in the banking sector. Source: Norges Bank.

The stock market returns are computed as the monthly change in the stock market index multiplied by minus one. By multiplying the returns with minus one, a drop in the stock prices corresponds to an increase in the index. Source: Oslo Børs.

Stock market volatility is measured as the six-month backward-looking moving average of the squared monthly returns of the stock market. An increase in the time-varying volatility measure corresponds to increased uncertainty in the stock market. Source: Oslo Børs.

The foreign-exchange market volatility is measured as the six-month backward-looking moving average of the squared monthly growth rate of the nominal effective exchange rate and captures the amount of stress in the foreign exchange rate market. Source: IMF.

Figure 1 below shows the evolution of the financial stress index, as well as bank related stress, stock market stress and instability in the exchange rate market. As seen from the figure, financial stress caused by negative shocks to the bank sector was the biggest contributor to the massive increase in the FSI in 2008. Moreover, it is clear that the stress was great during the latest financial crisis of 2008- 2009, for all the financial sectors covered by the index.

However, it is evident that the biggest shocks to the index came through the stock market, as well as the banking sector. There are two large shocks to the banking sector, resulting in a small, second shock to the index around 2010. The massive increase in the banking sector and stock market sub indexes illustrates the nature of the last financial crisis, which was initiated in the banking sector before it spilled over to the real economy. Furthermore, it is clear from looking at the figure that during what might be dubbed normal times, the index fluctuates around 0, in the interval of -1 to 1.

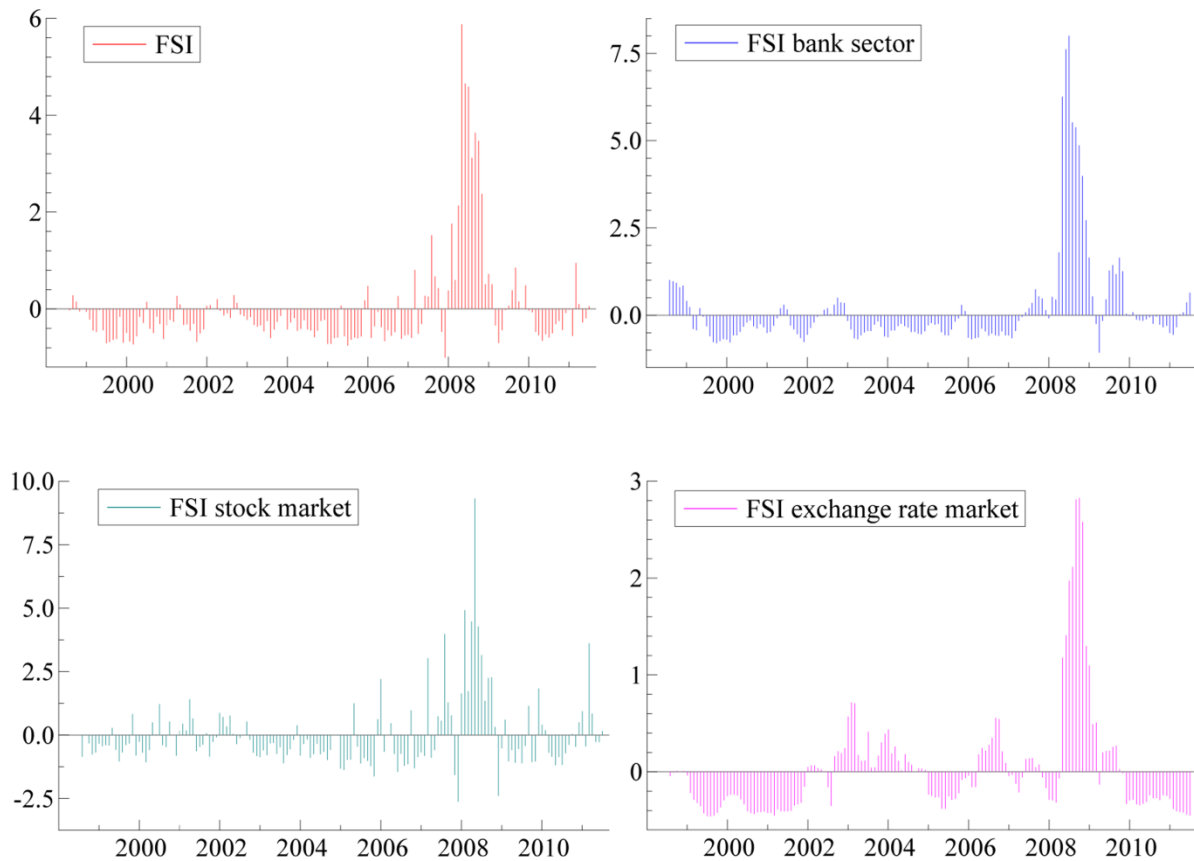


Figure 1: The evolution of the financial stress index (FSI) and its sub indexes. In the top left corner is the FSI, in the top right corner is the FSI for the bank sector, in the bottom left corner is the FSI for the stock market, and finally, in the bottom right corner is the FSI for the exchange rate. The bank sector FSI is defined as the sum of the banking beta, the TED spread proxy and the inverted term spread variables, the stock market FSI is defined as the sum of the stock market returns and stock market volatility variables, and the exchange rate market FSI is simply the exchange rate volatility variable. The sub indexes are demeaned and standardized.

Moreover, by having a glance at Figure 2 below, in which the evolution of the variables included in the stress index are depicted, it is easily seen that stress caused by shocks to the banking beta is the largest contributor to the stress seen in the most recent financial turmoil. This increase represents an amplification of the banking sector risk. Furthermore, the graph representing the TED spread, which is proxied by the spread between the overnight lending rate and the three month NIBOR, suggests that the increase in the interbank rate over the overnight lending rate in 2007 has been persistent. Together with the inverted term spread, the evolution of the interest rates suggests that short-term borrowing has been relatively harder to

receive and long-term borrowing relatively easier for the banks after 2007 than in the period up until 2007. That is, it seems as though the risk premium the banks charge each other in the interbank market has been persistent, even though the central bank has kept its interest rates low, ultimately resulting in a tougher climate in the interbank market. The graphs also show that the volatility in the stock market increased abruptly in 2008. Around the same time, the stock market returns measure increased heavily. Keeping in mind that this corresponds to a decrease in the actual returns, it is clear that these three graphs capture the increased risk and uncertainty in the securities market. Additionally, the volatility of the exchange rate increased rapidly in the same period, implying a higher degree of uncertainty in the exchange rate market.

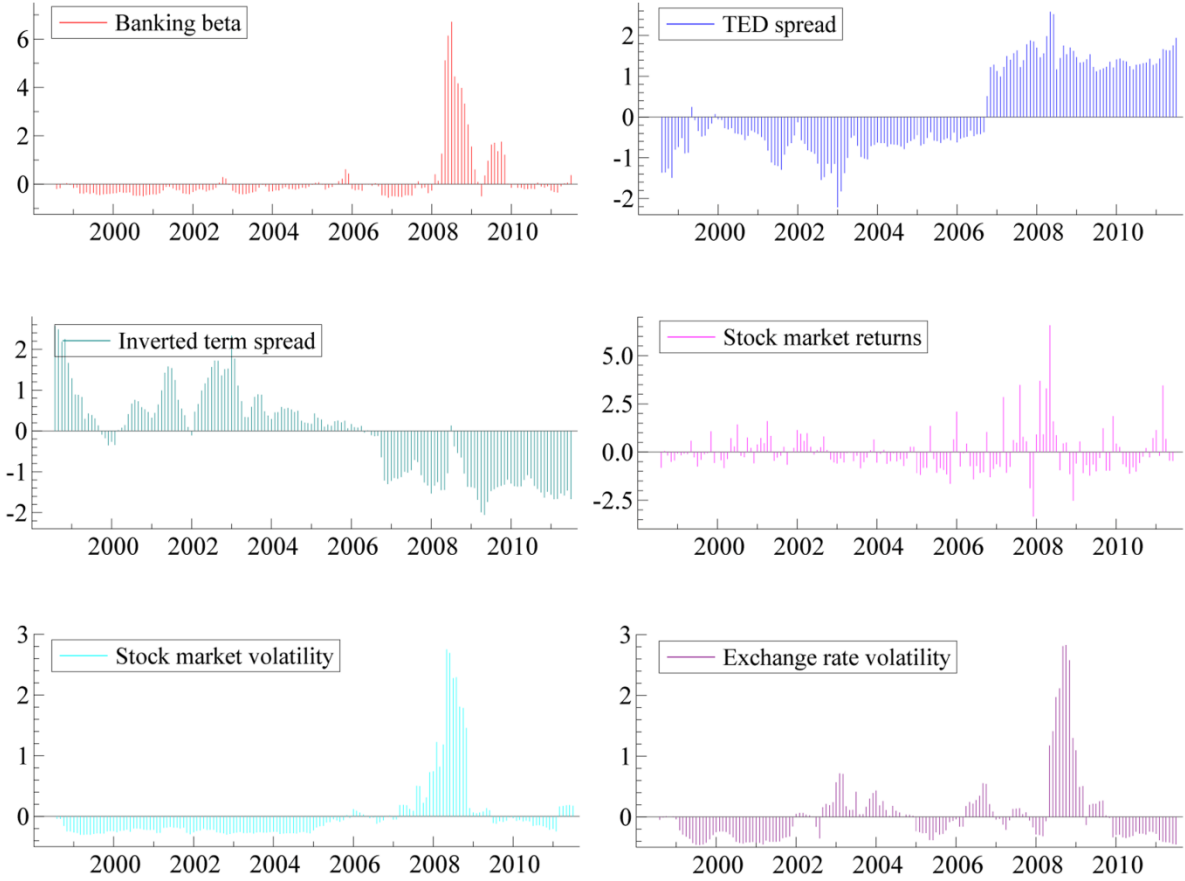


Figure 2: The evolution of the variables measuring financial stress in which the FSI is constructed from. In the upper left corner is the Banking beta, the upper right corner the TED spread proxy, to the left in the middle is the inverted term spread, to the right in the middle is the stock market returns, in the bottom left corner is the stock market volatility, and finally, in the bottom right corner is the exchange rate volatility.

5 Econometric Analysis

Based on the theoretical model, I anticipate that an increase in the expected rate of inflation results in an increase in the interest rate, due to the inflation target embedded in the Taylor rule. As Norway has had an inflation targeting regime the last decade, the effect of inflation on interest rates should be stable or even slightly decreasing, if the central bank is able to anchor inflation expectations, which in turn might diminish the central bank's need to act aggressively towards changes in the inflation rate. Moreover, the time horizon at which the central bank wants the inflation rate to approach its target has increased since the introduction of the inflation targeting regime. This effect might give results corresponding to a decrease in the aggressiveness towards inflation from the earlier parts of the inflation targeting regime to the more recent parts of the sample.

Through the effects that an increase in the output gap has on the inflation rate, one would expect an increase in the output gap to be followed by an increase in the interest rate. When using the deviation of the unemployment rate from its natural rate, it is expected that an increase in this measure will tend to have an expansionary effect on monetary authority.

As an increase in the exchange rate variable corresponds to a depreciation of the Norwegian Krone, one would expect that this would lead to an increase in the interest rate. Moreover, the response of an exchange rate depreciation should be larger during the period with a stable exchange rate regime than during the inflation targeting regime, when the exchange rate has been floating.

Moreover, by implementing a model with time-varying parameters, I am able to see whether the emphasis put on inflation and the exchange rate actually varies across time.

An interesting question in this study is how the financial stress index affects the interest rate. This variable is likely to have a negative effect on the interest rate. That is, as the degree of financial distress increases, I anticipate the central bank to decrease the interest rate in order to stabilize the financial side of the economy. As the degree of financial instability is likely to vary across time, the utilization of a time-varying parameter model will help capture the differing effect this variable has on the interest rate. Additionally, by employing this type of model, one could also explore if the central bank adjusts its interest rate in the build-up of financial instability. That is, the model exposition can be used to check whether the

interest rate is adjusted solely *ex post* or if there is an *ex ante* component in the interest rate adjustment to financial stress.

5.1 Estimation

I have estimated the model by utilizing different methods. The estimation procedures are repeated using both the output gap constructed from the production data and by using the deviation of the unemployment rate from its natural rate as an output gap proxy. The model is estimated in the three following ways:

- First, the estimation is carried out by running the regression as a two-stage least squares. In the first stage, the endogenous regressors in the Taylor rule, equations (12) – (15), are estimated. In the second stage, the Taylor rule, equation (4), is estimated. The estimation procedure has been implemented while applying different lags and leads for the right-hand-side variables in the final estimation step. That is, the interest rate was estimated by applying different lags and leads for the fitted values of the right-hand-side variables. Moreover, this procedure is executed using data from the official inflation targeting regime, i.e. from April 2001 until December 2011.
- Second, the process is repeated for the preferred lag-/lead structure by the means of recursive estimation so as to find the evolution of the coefficients in the final Taylor rule. This estimation is implemented using data from August 1998, using twelve observations for initialization.
- Finally, I estimate the Taylor rule by the means of the varying coefficients method, keeping the coefficients with a stable time path constant. That is, some of the coefficients in (17) are time-invariant, i.e. do not follow a random walk. Consistent estimates of the coefficients in (17) are provided by estimation in two steps. In the first, I estimate the endogenous right-hand side variables, given by eqs. (12) – (15), and store the standardized residuals, φ_t , ζ_t , v_t , ξ_t . In the second step, I estimate the model with time-varying parameters, i.e. equations (17) and (6) – (11), using the fitted values of the regressors. Estimation using time-varying coefficients is carried out in order to isolate the effect of financial stress on the interest rate setting over time. The estimation is carried out using observations from August 1998, as the estimation process does not work with fewer observations.

I will begin by turning to the case where the output gap is constructed as the deviation of the log production from its trend.

In estimating eq. (4) by employing the two-stage least squares method, I have chosen different lags and leads for the variables in order to find the structure that yields the best results. I estimated the model using 0, 6, 9 and 12 leads for the inflation rate and exchange rate variables, -3, -1, 0, 1, 3, 6, 9 and 12 leads for the output gap and finally -3, -2, -1, 0, 1 and 2 leads for the financial stress index, where -3, -2 and -1 leads refers to 1, 2 and 3 lags. That is, with reference to the model specification above, $i=k= 0, 6, 9, 12$, $j= -3, -1, 0, 1, 3, 6, 9, 12$ and $m= -3, -2, -1, 0, 1, 2$.

5.2 Estimation results

5.2.1 Estimating using output gap

Two stage least squares estimation

In the tables below, the results are presented, with the deviation of log production from its trend being used as the output gap. The rest of the right-hand side variables in the Taylor-type rule are the inflation rate, the per cent monthly growth in the nominal exchange rate and the financial stability index.

Table 1: Results from two-stage least squares estimation, with a lead of 1 period on the financial stress index.

$$r_t = (1 - \varrho) \left[\alpha + \beta \pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k} \right] + \varrho r_{t-1} + \delta x_{t+m} + \varepsilon_t$$

$i=k$	j	m		ϱ	α	β	γ	μ	δ
0	-3	1	Coefficient	0,98752	-0,00239	0,02361	1,70379	-0,03601	-0,14056
			<i>p-value</i>	0	0,8734	0,6145	0,0068	0,0898	0,0001
0	-1	1	Coefficient	0,98108	-0,00036	0,03107	1,97446	-0,03384	-0,14088
			<i>p-value</i>	0	0,9797	0,5022	0,0012	0,1046	0,0001
0	0	1	Coefficient	0,97894	0,00138	0,02885	2,08506	-0,04279	-0,13037
			<i>p-value</i>	0	0,9222	0,526	0,0003	0,0385	0,0001
0	1	1	Coefficient	0,97606	0,00394	0,02631	2,54234	-0,05369	-0,11962
			<i>p-value</i>	0	0,7734	0,5477	0	0,0083	0,0002
0	3	1	Coefficient	0,97622	0,01115	0,00051	3,40812	-0,06539	-0,07653
			<i>p-value</i>	0	0,3689	0,9896	0	0,0005	0,0059
0	6	1	Coefficient	0,99197	0,00320	-0,01466	2,75894	-0,04988	-0,04731
			<i>p-value</i>	0	0,8171	0,7353	0	0,0128	0,1317
0	9	1	Coefficient	1,00169	-0,01369	0,02097	2,21223	-0,03193	-0,07292
			<i>p-value</i>	0	0,3545	0,6502	0,0001	0,1383	0,0273
0	12	1	Coefficient	1,00360	-0,02011	0,03552	1,07810	-0,04214	-0,09843
			<i>p-value</i>	0	0,2282	0,4839	0,0619	0,0714	0,0051
6	-3	1	Coefficient	0,97956	-0,03626	0,16581	1,06593	-0,01673	-0,19369
			<i>p-value</i>	0	0,0164	0,0007	0,0926	0,4164	0
6	-1	1	Coefficient	0,97253	-0,03104	0,16348	1,66180	-0,02374	-0,19822
			<i>p-value</i>	0	0,0295	0,0005	0,0058	0,2339	0
6	0	1	Coefficient	0,97113	-0,03052	0,16493	1,62004	-0,02334	-0,19043
			<i>p-value</i>	0	0,0314	0,0003	0,0046	0,2278	0
6	1	1	Coefficient	0,97024	-0,02557	0,15011	1,91774	-0,02541	-0,17926
			<i>p-value</i>	0	0,0674	0,0008	0,0004	0,1791	0
9	-3	1	Coefficient	0,97394	-0,03152	0,16464	0,99521	0,04843	-0,16655
			<i>p-value</i>	0	0,0376	0,0003	0,1333	0,0209	0
9	-1	1	Coefficient	0,96885	-0,02596	0,15531	1,27006	0,04812	-0,16195
			<i>p-value</i>	0	0,0688	0,0004	0,0402	0,0175	0
9	0	1	Coefficient	0,96898	-0,02581	0,15408	1,17531	0,04779	-0,15467
			<i>p-value</i>	0	0,0707	0,0005	0,0476	0,0167	0
9	1	1	Coefficient	0,96817	-0,02119	0,13983	1,50250	0,04494	-0,14776
			<i>p-value</i>	0	0,1302	0,0014	0,0078	0,0212	0
12	-3	1	Coefficient	0,98978	-0,04506	0,17289	0,33160	-0,02617	-0,16154
			<i>p-value</i>	0	0,0048	0,0001	0,6384	0,2293	0
12	-1	1	Coefficient	0,98092	-0,03397	0,15318	0,82208	-0,01614	-0,15639
			<i>p-value</i>	0	0,0331	0,0005	0,249	0,46	0
12	0	1	Coefficient	0,98000	-0,03328	0,15208	0,78774	-0,01761	-0,15177
			<i>p-value</i>	0	0,0347	0,0006	0,2385	0,4088	0
12	1	1	Coefficient	0,97641	-0,02495	0,13124	1,32706	-0,01569	-0,14691
			<i>p-value</i>	0	0,0999	0,0026	0,0332	0,4469	0

Table 2: Results from two-stage least squares estimation, with a lag of 1 period on the financial stress index.

$$r_t = (1 - \varrho) \left[\alpha + \beta \pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k} \right] + \varrho r_{t-1} + \delta x_{t+m} + \varepsilon_t$$

$i = k$	j	m		ϱ	α	β	γ	μ	δ
0	-3	-1	Coefficient	0,96486	-0,01783	0,13898	2,60888	-0,03144	-0,25804
			<i>p-value</i>	0	0,1157	0,0004	0	0,0564	0
0	-1	-1	Coefficient	0,97236	-0,01922	0,12215	1,64398	-0,02977	-0,21731
			<i>p-value</i>	0	0,1109	0,0029	0,0007	0,0872	0
0	0	-1	Coefficient	0,97426	-0,01816	0,11334	1,50173	-0,03557	-0,20256
			<i>p-value</i>	0	0,1414	0,0062	0,0018	0,0464	0
0	1	-1	Coefficient	0,97333	-0,01505	0,10382	1,80389	-0,04394	-0,18757
			<i>p-value</i>	0	0,2187	0,0109	0,0002	0,0145	0
0	3	-1	Coefficient	0,97453	-0,00825	0,07586	2,69464	-0,05502	-0,14818
			<i>p-value</i>	0	0,4702	0,0461	0	0,0011	0
0	6	-1	Coefficient	0,98804	-0,02271	0,08967	1,95516	-0,03951	-0,15336
			<i>p-value</i>	0	0,0655	0,0312	0	0,0261	0
0	9	-1	Coefficient	0,99454	-0,03892	0,13338	1,93232	-0,02300	-0,18557
			<i>p-value</i>	0	0,0016	0,0013	0	0,2033	0
0	12	-1	Coefficient	0,99410	-0,04174	0,14119	0,87502	-0,03415	-0,20178
			<i>p-value</i>	0	0,0027	0,0019	0,0782	0,0825	0
6	-3	-1	Coefficient	0,95940	-0,03613	0,21632	1,59506	-0,02963	-0,26660
			<i>p-value</i>	0	0,0012	0	0,0013	0,0642	0
6	-1	-1	Coefficient	0,96488	-0,04234	0,22372	0,88108	-0,03720	-0,24840
			<i>p-value</i>	0	0,0003	0	0,059	0,0231	0
6	0	-1	Coefficient	0,96678	-0,04550	0,22997	0,56644	-0,03637	-0,24393
			<i>p-value</i>	0	0,0001	0	0,2177	0,0279	0
6	1	-1	Coefficient	0,96692	-0,04373	0,22349	0,65436	-0,03685	-0,23822
			<i>p-value</i>	0	0,0003	0	0,1586	0,0258	0
9	-3	-1	Coefficient	0,95984	-0,02156	0,16607	1,63181	0,03693	-0,22025
			<i>p-value</i>	0	0,0709	0	0,0036	0,0328	0
9	-1	-1	Coefficient	0,96507	-0,03309	0,19157	0,57752	0,03030	-0,20156
			<i>p-value</i>	0	0,0068	0	0,2592	0,0826	0
9	0	-1	Coefficient	0,96745	-0,03833	0,20381	0,16534	0,02891	-0,19986
			<i>p-value</i>	0	0,0023	0	0,7451	0,0993	0
9	1	-1	Coefficient	0,96699	-0,03625	0,19766	0,30816	0,02877	-0,19702
			<i>p-value</i>	0	0,0041	0	0,5452	0,099	0
12	-3	-1	Coefficient	0,97254	-0,02624	0,15154	1,29911	-0,01021	-0,21107
			<i>p-value</i>	0	0,0435	0	0,0353	0,571	0
12	-1	-1	Coefficient	0,97754	-0,03777	0,17735	0,25061	-0,01610	-0,19270
			<i>p-value</i>	0	0,0058	0	0,6706	0,3878	0
12	0	-1	Coefficient	0,98043	-0,04402	0,19176	-0,17318	-0,02004	-0,19237
			<i>p-value</i>	0	0,0014	0	0,7605	0,2723	0
12	1	-1	Coefficient	0,97855	-0,03947	0,18060	0,12716	-0,01791	-0,19064
			<i>p-value</i>	0	0,0039	0	0,8193	0,3191	0

Tables 1 and 2 above depict the cases where the central bank adjusts its interest rates in response to an expected increase in the financial stress index and in response to past shocks to the financial stress index, respectively. That is, Table 1 shows the effects on the different parameters in the Taylor-type rule when the central bank is assumed to have an *ex ante* approach toward adjusting its monetary policy following an increase in the financial stress index. Table 2 shows the results when the opposite is assumed – namely that the central bank has an *ex post* policy towards financial stress.

From Tables 1 and 2 above, it can be seen that the model specification which yields the most reasonable results is a structure where the inflation rate and exchange rate are led nine periods ($i=k=9$) ahead and the output gap is led one period ($j=1$); that is, when it is assumed that the central bank adjusts its interest rates in response to expected changes in the inflation rate and exchange rate nine periods ahead and the output gap one period ahead. Both for a one period lead ($m=1$; see Table 1) and a one period lag ($m=-1$; see Table 2) on the financial stress index, this yields significant results for the inflation rate, the exchange rate, the financial stress index and the interest rate smoothing parameter, and mostly significant results for the output gap.

For this specification, both Tables show that there is a positive relationship between the inflation rate and the interest rate, implying that a unit increase in the expected inflation rate results in an interest rate increase by the central bank. Conversely, a reduction in the expected inflation rate will cause the central bank to decrease its interest rates. Moreover, an increase in the expected exchange rate results in an increase in the interest rates. That is, an expected depreciation of the Norwegian Krone tends to yield a monetary contraction through increased interest rates. It can also be seen that there is a positive relationship between the expected output gap and interest rates. Thus, increased economic activity leads to higher interest rates. The interest rate smoothing parameter, ρ , is also positive and significant for all specifications.

Moreover, conferring Table 1, an increase in the financial stress index one period ahead yields a negative response by the central bank, in that it is found to reduce the interest rate when the financial stress index is expected to increase in the next period. That is, if the central bank expects the financial stress index to increase by one unit one period ahead, it decreases the interest rate by 0.148 percentage points. The same effect is evident when having a glance at Table 2, where it can be seen that an increase in the financial stress index last period results in a slashing of the interest rate by the central bank. Specifically, a unit increase in the stress

index one period ago brings about a decrease of the interest rate by the central bank of 0.197 percentage points in this period.

Hence, it can be seen that an *ex ante* policy towards financial stress yields a lower interest rate cut than with an *ex post* policy. That is, with reference to the tables above, if the central bank adjusts its interest rates to respond to past shocks to the financial stress index, it decreases interest rates by more than if it adjusts its interest rates due to an expected increase in the index. These results suggest that the central bank is more concerned with financial stress after it has occurred rather than being pre-emptive by adjusting its interest rates in order to minimize future financial stress.

These results could be intuitively explained, as financial stress stemming from the bank sector and stock market might be difficult to forecast and thus react to *ex ante*. Additionally, by loosening its policy during episodes of financial stress originating in the banking sector, the central bank adds liquidity to the bank market which in turn may reduce the likelihood of crisis that reach systemic proportions. The larger the stress to the financial sector, the higher the probability that the drainage of liquidity may spill over to the real economy and cause low inflation and weak economic growth.

Furthermore, Tables 1 and 2, as well as Tables A1 – A4 in Appendix A.1, show that an increase in the financial stress index yields an interest rate reduction. There are also similar results from applying different lags and leads to the financial stress index; suggesting that the central bank is more aggressive in its response toward financial stress *ex post* rather than *ex ante*.

Some of the specifications also yield somewhat counterintuitive results. First, the results show, in both tables, that for all but 9 leads on the exchange rate ($k=9$), for all other leads and lags in the output gap and the financial stress index, an increase in the variable leads to a decrease in the interest rate. This corresponds to the central bank lowering its interest rate if there is an expected depreciation of the exchange rate, thus further fueling the depreciation.

Second, in Table 1, with a specification of a one period lead on the financial stress index and a six period lead on the output gap, it is shown that an increase in the inflation rate today makes the central bank decrease its rate of interest. Hence, this result claims that the central bank fuels inflation by decreasing its interest rates in the case of growth in the inflation rate.

Moreover, the rather low values of the impact of the inflation rate on the interest rate, suggest that a unit increase in the inflation rate gives less than a unit increase in the real rate of interest, which in turn implies that the interest rate rule is destabilizing or accommodative to shocks to the economy. Table A1 also show similar results for a specification of 0 lags or leads on the inflation rate, different lag and lead structures of the output gap, as well as two leads on the financial stress index.

Third, from Table 2, if the central bank responds to an increase in the output gap this period as well as an expected increase in the inflation and exchange rate twelve periods into the future, it can be seen that the impact of an increase in the output gap brings about a reduction in the interest rates. That is, if the economy goes through a rough patch with a decrease in production, these results state that the central bank increases its interest rates.

Finally, from Table 1, it can be seen that for some specifications, the interest rate smoothing parameter yields a value above 1, which violates the assumptions of this coefficients being between 0 and 1.

For other specifications of different leads and lags, the tables show mixed results. The relationship between the inflation rate and the interest rate is positive and mostly significant. As already stated, for nearly all specifications the results states that an increase in the expected exchange rate impacts the interest rate negatively, with some of the results being significant and others not. For all lead and lag structures, the estimates of the smoothing parameter yields significant results.

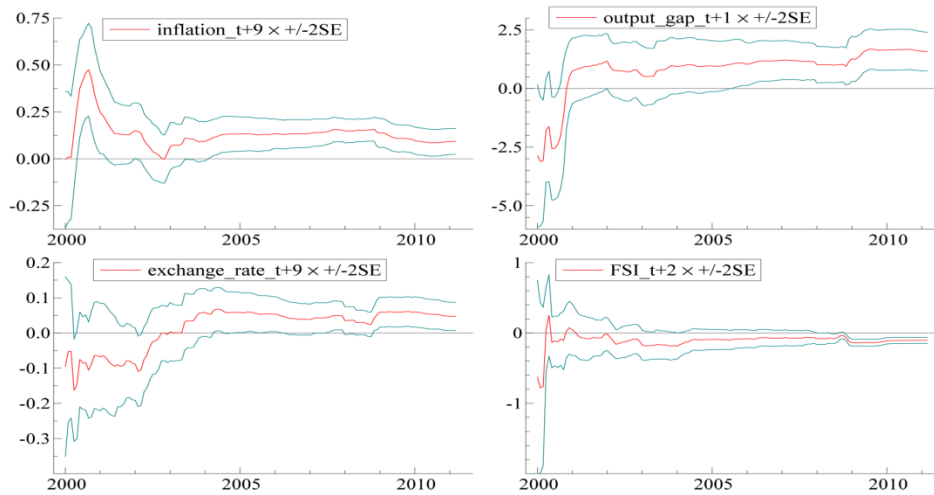
For other lead and lag structures of the monetary authority's reaction towards the financial stress index, the results are similar to the ones described above. These results is presented in Tables A1 – A4 in appendix A.1, which show the estimation results for $m=2, 0, -2, -3$.

Recursive estimation

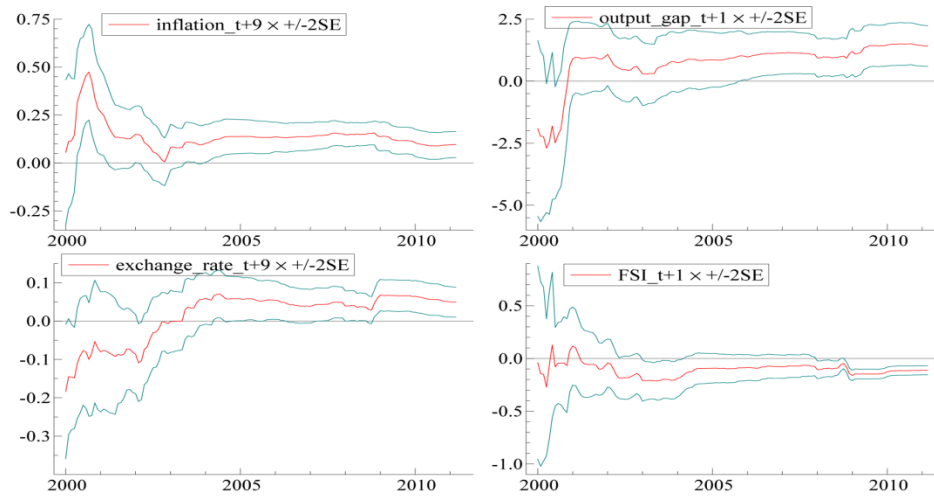
For further estimation, some of the lead specifications can thus easily be removed when estimating recursively. Immediately, an instant response to inflation rate and exchange rate may be removed from further estimation, as well as leads of -3, -1, 0, 3, 6, 9 and 12 for the output gap. For the exchange rate, leads of 6 and 12 can also be ruled out due to the insignificance of the coefficient for these lead lengths. That is, I will in the following assume that the central bank adjusts its interest rate in response to expected changes in the output gap

one period ahead and expected changes in the inflation rate and exchange rate 9 periods ahead. Specifically, as the lead structure in the estimation that follow I will use $i= k= 9, j= 1$ and $m= -3, -2, -1, 0, 1, 2$.

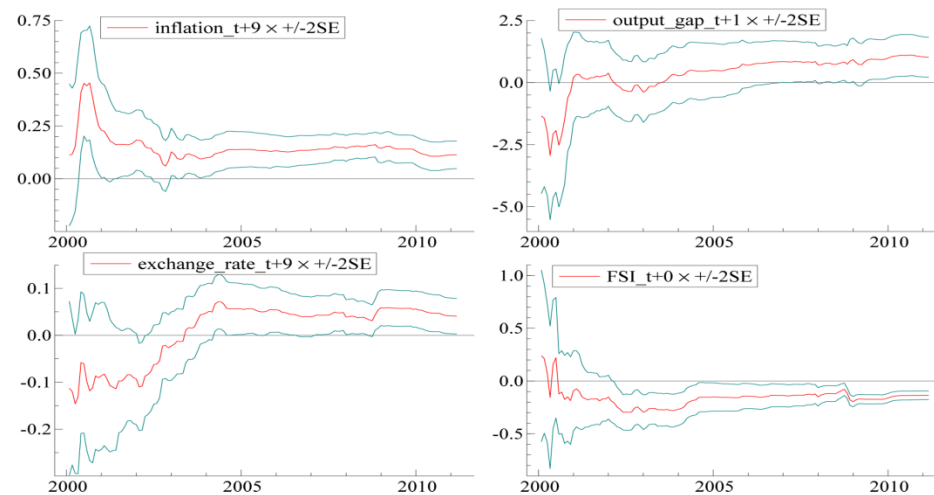
By recursively estimating the Taylor equation specified by eq. (4), I am able to find an estimated time path of the coefficients. The figures below show the recursive graphics of different lead length specifications for the financial stress index.



Panel a: Taylor rule estimated recursively with $m=2$.

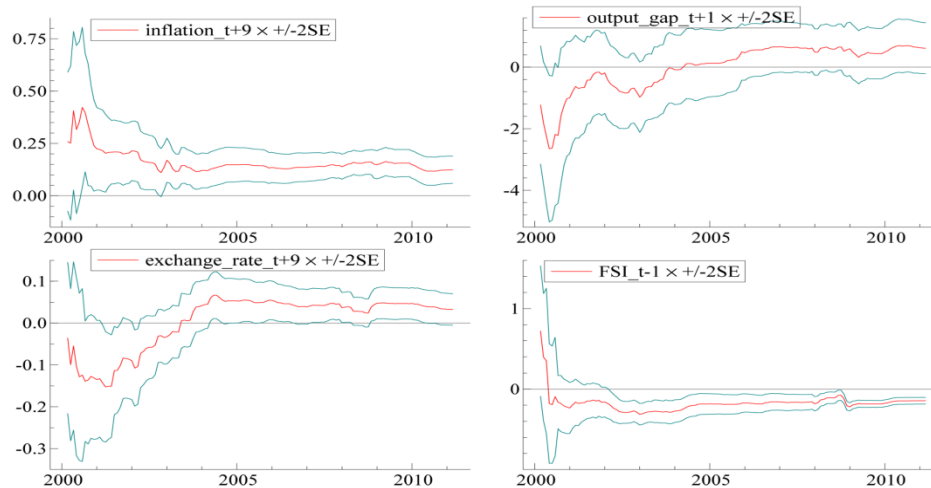


Panel b: Taylor rule estimated recursively with $m=1$.

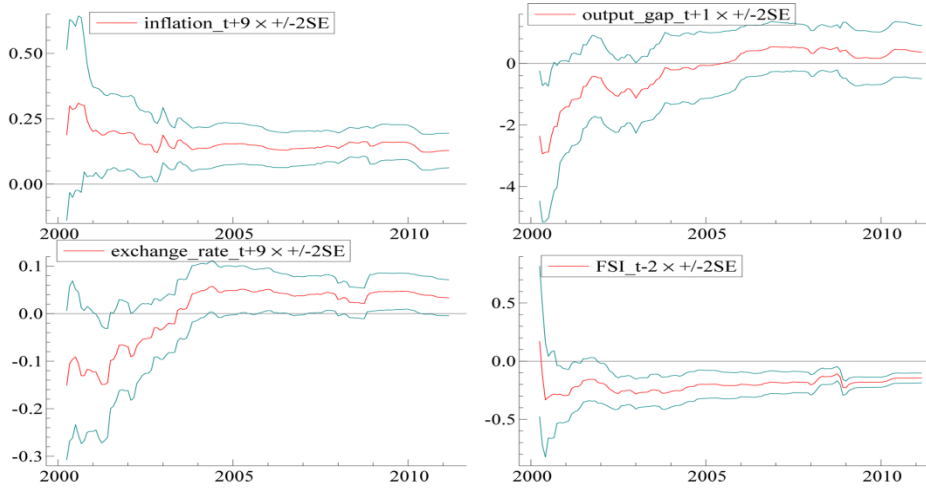


Panel c: Taylor rule estimated recursively with $m=0$.

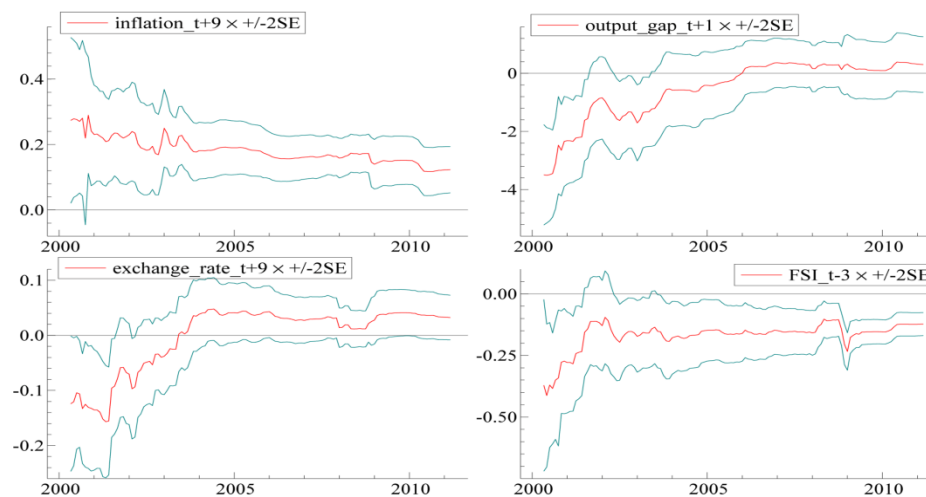
Figure 3: Recursive graphics, panels a- c. The plots show the time paths of the coefficients in the Taylor-type rule. In each panel, the top left graph is inflation, top right graph is the output gap, the bottom left graph is the exchange rate and the bottom right graph is the financial stress index.



Panel d: Taylor rule estimated recursively with $m = -1$.



Panel e: Taylor rule estimated recursively with $m = -2$.



Panel f: Taylor rule estimated recursively with $m = -3$.

Figure 4: Recursive graphics, panels d- f. The plots show the time paths of the coefficients in the Taylor-type rule. In each panel, the top left graph is inflation, top right graph is the output gap, the bottom left graph is the exchange rate and the bottom right graph is the financial stress index.

The figures show that the different coefficients all vary somewhat across time. However, the jumps in the beginning of all the plots might be attributed to the initialization. Thus, the inflation rate, output gap and exchange rate seem to demonstrate a steady convergence in all panels. For the financial stress index, the coefficient drops around 2008, seemingly giving a negative effect on the interest rate setting. This abrupt fall in the stress indicator fits well with the latest financial turmoil where it was seen that interest rates were reduced in the wake of the increased stress to the financial sector.

Time- varying coefficients estimation

In employing the varying coefficients method, I will therefore keep all the coefficients but the financial stress index parameter constant in order to isolate the time-varying effect of financial instability on the interest rate. The exchange rate coefficient could also have been included as a time-varying parameter. However, as my previous results have shown that the effect of the exchange rate on monetary policy is minimal, I will therefore treat it as time-invariant.

Thus, the time-varying model that is to be estimated is:

$$(18) r_t = (1 - \rho)[\alpha + \beta(\pi_{t+9}) + \gamma y_{t+1} + \mu e_{t+9}] + \rho r_{t-1} + \delta_t x_{t+m} + \rho_{\varphi\varepsilon}\sigma_\varepsilon\varphi_t + \rho_{\varsigma\varepsilon}\sigma_\varepsilon\varsigma_t + \rho_{\upsilon\varepsilon}\sigma_\varepsilon\upsilon_t + \rho_{\xi\varepsilon}\sigma_\varepsilon\xi_t + \zeta_t$$

$$(19) \delta_t = \delta_{t-1} + \vartheta_t$$

In the estimating the equation above, I have once more used different lags and leads for the financial stress index, with $m = -3, -2, -1, 0, 1, 2$.

The time-varying impact of changes in the financial stress index on the interest rate for the different lags and leads are showed in the figures below.

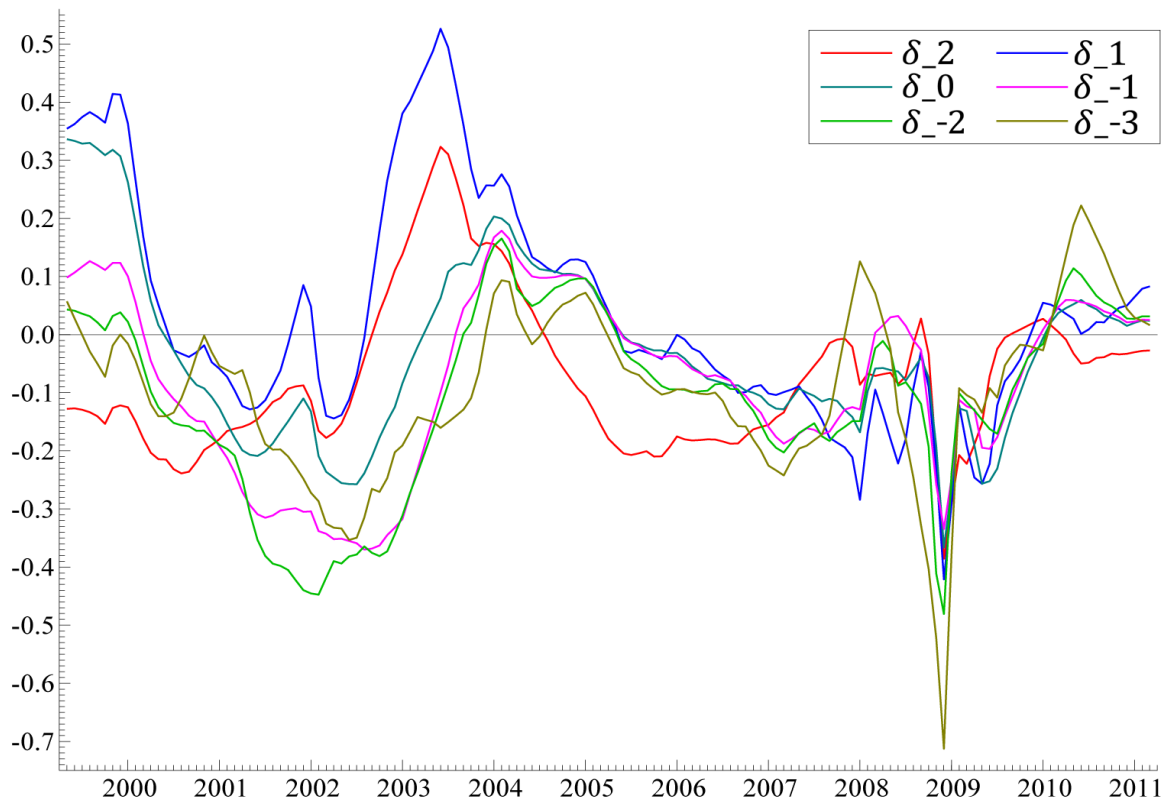


Figure 5: Time-paths for all lags and leads on the financial stress index. That is, δ_x is the time-path of the financial stress coefficient when the financial stress index is led x periods, while δ_{-x} is the time-path of the financial stress coefficient when the stress index is lagged x periods. Figures for each of the time-paths can be found in appendix A.2.

Figure 5 above show the time-varying effect of financial stress on the interest rate for $m=2, 1, 0, -1, -2, -3$, and demonstrates that there is an abrupt drop in the impact of financial stress on the interest rate in late 2008. The effect is especially evident when estimating using lagged data, i.e. the time-paths dubbed δ_{-1}, δ_{-2} and δ_{-3} . The effect also seems to become smaller when assuming that the central bank acts less sluggish to the increased stress in the financial sector. That is, the negative interest rate response is largest for δ_{-3} , and it can be seen that the effect diminishes as m increases. Moreover, the effect is smaller when the model specification assumes that the central bank acts to counteract the effects of financial stress. That is, the evidence suggests that the central bank decreases its interest rate more *ex post* than *ex ante* as a result of an increase in financial stress. In the most recent period of financial turmoil, the central bank lowered the interest rate by roughly 0.7 basis points three months after a unit increase in the financial stress index, whereas the decrease in the interest rate was

about 0.4 percentage points as a response to an expected unit increase in the stress index two periods ahead.

These results are comparable to those found by Baxa et al. (2011), who estimate the impact of financial stress on interest rates for five countries. They find that there was in fact a reduction in interest rates when financial instability increased, especially during the last period of financial distress, in 2008. Moreover, the results are supported by Borio and Lowe (2004), in that the central bank is asymmetric in its response towards financial instability.

Moreover, it can be seen that interest rate increases also exist as an effect of increased financial stress. Specifically, the plot named δ_1 in Figure 5 shows a large increase for the estimation with $m=1$, i.e. when the central bank responds to an expectation of a change one period ahead. Depending on the nature of the expected increase in financial stress, i.e. from which sector the shock is initiated, an interest rate increase may serve to amplify a situation with financial distress. That is, if there is a shock to the financial sector through an increase in the risk premium in the interbank market, this effect may be propagated if the central bank increases its interest rates. Furthermore, as financial instability may cause reduced output and inflation, increasing the interest rates might make matters worse by further amplifying a potential economic decline. The time-path of the δ_1 plot in Figure 5, that there is an increase in the interest rate as a result of increased financial stress, can also be seen as a lowering of the interest rates by the central bank as it anticipates a decrease in the financial stress index.

5.2.2 Estimating using unemployment as an output gap proxy

In what follows, I will turn to the case where the output gap is being proxied by the deviation of the unemployment rate from its natural rate. The inflation rate, the exchange rate and financial stress index are all defined as before. I have gone through the same steps of estimation as above, i.e. estimation of (4) by estimation through the use of the two-stage least squares method, recursively estimating (4) and finally estimating (18) – (19) by utilizing the varying coefficients method.

Two stage least squares estimation

In the first estimation process, I once more estimate the augmented Taylor rule using different lags and leads for the inflation rate, exchange rate, output gap proxied by unemployment rate

date and the financial stress index. The lags and leads used were the same for the inflation rate, exchange rate and the stress index, with $i=k=0, 6, 9, 12$ and $m=-3, -2, -1, 0, 1, 2$. The leads for the output gap proxy were $j=-1, 0, 1, 3, 6, 9, 12$.

The results apprehended through the two-stage least squares estimations procedure can be seen in Tables 3 and 4 below, as well as in Tables A5 – A8 in appendix A.1. In Tables 3 and 4, the estimation results using $m=1, -1$ are depicted, the estimation results using $m=2, 0, -2, -3$ are found in the tables in the appendix.

Table 3: Results from two-stage least squares estimation, with a lead of 1 period on the financial stress index.

$$r_t = (1 - \varrho) \left[\alpha + \beta \pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k} \right] + \varrho r_{t-1} + \delta x_{t+m} + \varepsilon_t$$

$i=k$	j	m		ϱ	α	β	γ	μ	δ
0	-1	1	Coefficient	0,97641	0,19061	-0,08322	-0,87576	-0,03186	-0,10732
			<i>p-value</i>	0	0	0,0738	0	0,0984	0,0004
0	0	1	Coefficient	0,97786	0,17554	-0,07392	-0,81224	-0,03108	-0,09960
			<i>p-value</i>	0	0	0,1086	0	0,1077	0,0009
0	1	1	Coefficient	0,97932	0,16376	-0,06666	-0,76429	-0,03294	-0,09333
			<i>p-value</i>	0	0	0,1463	0	0,0898	0,002
0	3	1	Coefficient	0,98254	0,15034	-0,04980	-0,72948	-0,03356	-0,09304
			<i>p-value</i>	0	0	0,2683	0	0,0877	0,0021
0	6	1	Coefficient	0,98943	0,12121	-0,02170	-0,64205	-0,03609	-0,09908
			<i>p-value</i>	0	0,0002	0,633	0	0,0756	0,0015
0	9	1	Coefficient	0,99590	0,11497	-0,01386	-0,64913	-0,04299	-0,09703
			<i>p-value</i>	0	0,0002	0,7594	0	0,0359	0,0019
0	12	1	Coefficient	1,00334	0,11127	-0,02467	-0,64150	-0,05049	-0,08678
			<i>p-value</i>	0	0,0003	0,5976	0	0,017	0,0061
6	-1	1	Coefficient	0,97350	0,10795	0,06703	-0,63305	-0,02023	-0,16318
			<i>p-value</i>	0	0,0413	0,2601	0,0035	0,3048	0
6	0	1	Coefficient	0,97399	0,09597	0,07371	-0,57915	-0,01705	-0,15628
			<i>p-value</i>	0	0,0613	0,2136	0,0055	0,373	0
6	1	1	Coefficient	0,97551	0,08343	0,08110	-0,52672	-0,01594	-0,15204
			<i>p-value</i>	0	0,0903	0,1639	0,0083	0,4045	0
6	3	1	Coefficient	0,97730	0,08585	0,08093	-0,54814	-0,01763	-0,14898
			<i>p-value</i>	0	0,0521	0,1398	0,0026	0,3521	0
9	-1	1	Coefficient	0,96877	0,09476	0,07710	-0,55377	0,03698	-0,14517
			<i>p-value</i>	0	0,0943	0,1881	0,0178	0,0696	0
9	0	1	Coefficient	0,97026	0,08374	0,08063	-0,50421	0,03683	-0,13848
			<i>p-value</i>	0	0,1319	0,1768	0,027	0,0682	0
9	1	1	Coefficient	0,97207	0,06975	0,08830	-0,44533	0,03592	-0,13450
			<i>p-value</i>	0	0,1994	0,1413	0,045	0,074	0
9	3	1	Coefficient	0,97365	0,08044	0,07776	-0,49563	0,03751	-0,12951
			<i>p-value</i>	0	0,1055	0,1742	0,0155	0,0597	0
12	-1	1	Coefficient	0,97504	0,08661	0,08048	-0,53734	-0,01823	-0,15146
			<i>p-value</i>	0	0,1625	0,164	0,0356	0,3773	0
12	0	1	Coefficient	0,97588	0,07611	0,08415	-0,48864	-0,01685	-0,14431
			<i>p-value</i>	0	0,2135	0,155	0,051	0,413	0
12	1	1	Coefficient	0,97672	0,06540	0,08967	-0,44181	-0,01691	-0,13930
			<i>p-value</i>	0	0,2657	0,1278	0,0663	0,411	0
12	3	1	Coefficient	0,97868	0,07357	0,07813	-0,47841	-0,01666	-0,13470
			<i>p-value</i>	0	0,1961	0,1887	0,041	0,416	0

Table 4: Results from two-stage least squares estimation, with a lag of 1 period on the financial stress index.

$$r_t = (1 - \varrho) \left[\alpha + \beta \pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k} \right] + \varrho r_{t-1} + \delta x_{t+m} + \varepsilon_t$$

$i=k$	j	m		ϱ	α	β	γ	μ	δ
0	-1	-1	Coefficient	0,96998	0,14033	0,03183	-0,74467	-0,02332	-0,19903
			<i>p-value</i>	0	0,0001	0,4334	0	0,1405	0
0	0	-1	Coefficient	0,97081	0,13265	0,04249	-0,72162	-0,02124	-0,19943
			<i>p-value</i>	0	0,0001	0,2842	0	0,1779	0
0	1	-1	Coefficient	0,97191	0,12715	0,04859	-0,70399	-0,02165	-0,19814
			<i>p-value</i>	0	0,0001	0,2168	0	0,1704	0
0	3	-1	Coefficient	0,97485	0,11656	0,06757	-0,68790	-0,02264	-0,20216
			<i>p-value</i>	0	0,0001	0,077	0	0,1508	0
0	6	-1	Coefficient	0,98117	0,08955	0,08920	-0,59921	-0,02550	-0,20267
			<i>p-value</i>	0	0,001	0,0221	0	0,1222	0
0	9	-1	Coefficient	0,98781	0,07760	0,09331	-0,56828	-0,03232	-0,19591
			<i>p-value</i>	0	0,0029	0,0184	0	0,0557	0
0	12	-1	Coefficient	0,99441	0,06981	0,08720	-0,54082	-0,03812	-0,19083
			<i>p-value</i>	0	0,0074	0,0333	0	0,0299	0
6	-1	-1	Coefficient	0,96507	0,04426	0,17090	-0,40202	-0,03406	-0,23928
			<i>p-value</i>	0	0,2871	0,0004	0,0179	0,0287	0
6	0	-1	Coefficient	0,96563	0,04270	0,17163	-0,39683	-0,03262	-0,23721
			<i>p-value</i>	0	0,2835	0,0003	0,0148	0,0356	0
6	1	-1	Coefficient	0,96629	0,03897	0,17503	-0,38419	-0,03204	-0,23616
			<i>p-value</i>	0	0,3014	0,0002	0,0131	0,0388	0
6	3	-1	Coefficient	0,96795	0,04822	0,16884	-0,43344	-0,03344	-0,23371
			<i>p-value</i>	0	0,1492	0,0001	0,002	0,0287	0
9	-1	-1	Coefficient	0,96307	0,06715	0,12540	-0,44813	0,02879	-0,20295
			<i>p-value</i>	0	0,1456	0,0096	0,0182	0,0818	0
9	0	-1	Coefficient	0,96422	0,06518	0,12425	-0,44044	0,02838	-0,20038
			<i>p-value</i>	0	0,152	0,011	0,0187	0,0863	0
9	1	-1	Coefficient	0,96546	0,05760	0,12893	-0,41070	0,02749	-0,19887
			<i>p-value</i>	0	0,1919	0,008	0,0242	0,0976	0
9	3	-1	Coefficient	0,96747	0,06531	0,12124	-0,45020	0,02864	-0,19575
			<i>p-value</i>	0	0,1015	0,0085	0,007	0,081	0
12	-1	-1	Coefficient	0,96871	0,10473	0,07372	-0,59726	-0,01916	-0,20162
			<i>p-value</i>	0	0,0404	0,1204	0,0044	0,2554	0
12	0	-1	Coefficient	0,96991	0,10544	0,06928	-0,59947	-0,01833	-0,19830
			<i>p-value</i>	0	0,0395	0,1536	0,0043	0,276	0
12	1	-1	Coefficient	0,97170	0,09795	0,07238	-0,57019	-0,01892	-0,19531
			<i>p-value</i>	0	0,0507	0,1373	0,0057	0,2623	0
12	3	-1	Coefficient	0,97521	0,09894	0,06595	-0,58082	-0,01881	-0,19146
			<i>p-value</i>	0	0,037	0,1725	0,0032	0,2626	0

The results in Tables 3 – 4 above show similar results as the ones obtained when using the output gap instead of the deviation of the unemployment rate from its natural rate. That is, for a structure using nine leads on the inflation and exchange rate, as well as a lag of one period on the output gap proxy, the 2SLS estimation again yields the most reasonable results. To be precise, the results show that an expected increase in the inflation rate or exchange rate nine periods ahead yields an interest rate increase. For the inflation rate, a target horizon of six months also gives results that state that the central bank increases its interest rate when the inflation increases. Unsurprisingly, an increase in the unemployment rate also leads the central bank to a lower the interest rate. Hence, if the unemployment gap is to increase through an increase in the level of unemployment, the central bank wants to counteract a possible economic downturn by reducing the interest rate. This relationship holds for all lead and lag specifications of the model, both the estimation results shown in Tables 3 and 4 above and Tables A5 – A8 in appendix A.1. The interest rate smoothing parameter is positive and significant in both tables above.

Moreover, an increase in financial stress leads to a monetary expansion, through a decrease in the interest rates. This result applies for all lead and lag structures imposed on the financial stress index. In general, the results also show that an increase in the financial stress index has a bigger impact on the interest rate setting decision when it is assumed that the monetary authority adjusts its interest rates in the same period as or after the increase in the stress index has occurred, rather than due to an expected increase. Specifically, the impact of financial stress is greater when the model is estimated using a lag structure rather than a lead structure on the financial stress index. This can, once more, be interpreted as the central bank being more aggressive towards financial stress *ex post* rather than *ex ante*.

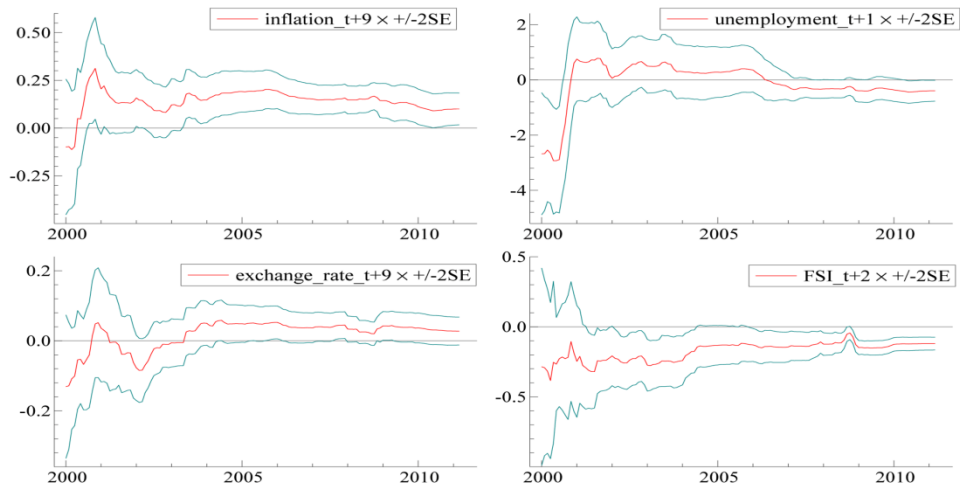
For the more counterintuitive results, it can once again be seen from Table 3 that if the monetary authority adjusts the interest rate according to an increase in inflation rate and exchange rate today, as well as an increase in the unemployment rate gap 12 periods ahead; the interest rate smoothing parameter is above 1, which, as already noted, violates the assumption that this parameter should take a value between 0 and 1. Moreover, from Table 3 it can be seen that, for a 0 lead on the inflation rate and for all lags and leads on the output gap proxy, an increase in the inflation rate yields a reduction of the interest rate. This is quite counterintuitive, as this means that the central bank fuels inflation, as cutting the interest rates in the case of an inflation rate increase in turn leads to an increase of the inflation rate. Hence,

in this model specification, the initial inflation rate increase may ultimately lead to a case where inflation ultimately spirals out of control. Both Tables 3 and 4, as well as Tables A5-A8, also show that an increase in the exchange rate, i.e. a nominal depreciation, for most model specifications tends to cause a reduction in the interest rates, which will cause a further depreciation of the exchange rate.

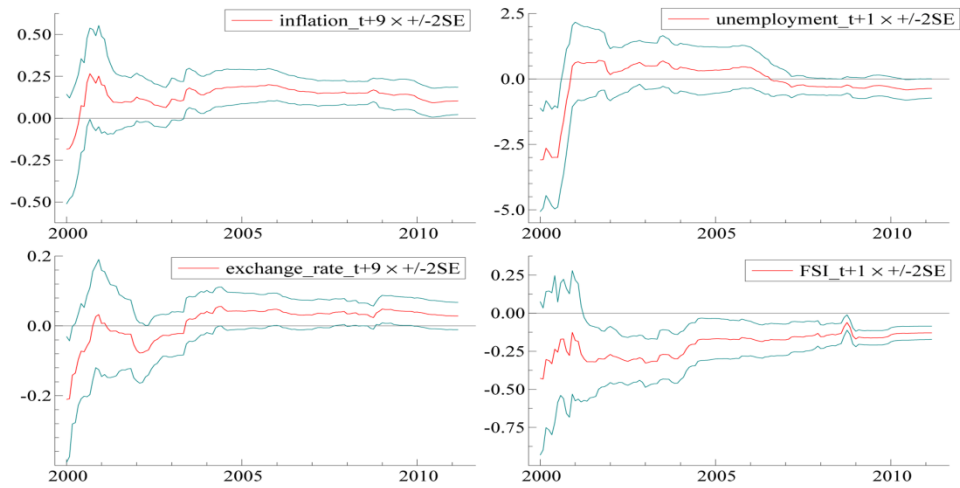
Recursive estimation

In the next step, I will estimate the augmented Taylor rule through recursive estimation. The object of this procedure is once again to identify the coefficients that seem to exhibit somewhat unstable time-paths. Moreover, I will remove some of the leads and lags used when estimating by the means of the two-stage least squares method. Specifically, I assume that the central bank's target horizon for the inflation rate and exchange rate is nine months, whereas the target horizon for the output gap is one period, giving $i = k = 9$ and $j = 1$. For the financial stress index, I will use all the different leads and lags as above, with $m = -3, -2, -1, 0, 1, 2$.

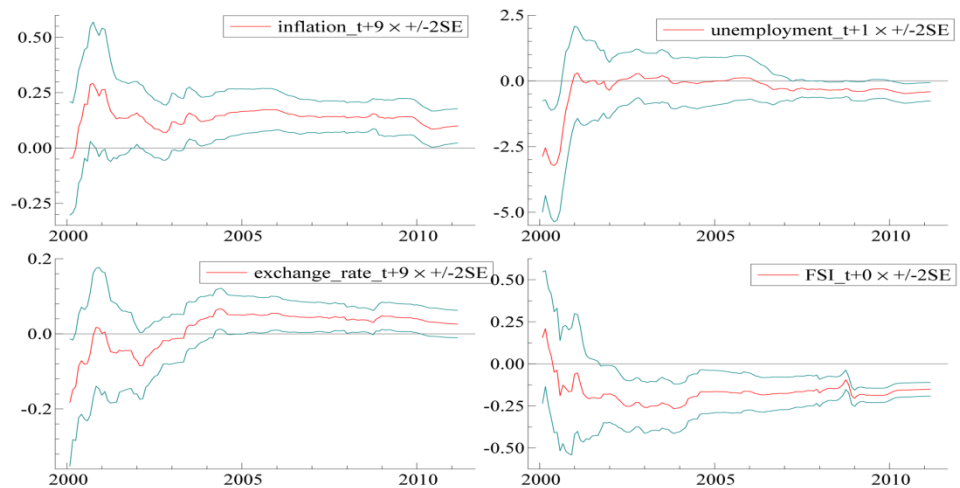
Below are the graphs showing the recursive graphics. They present estimated time-path results when running the regression with different lead lengths for the financial stress index.



Panel a: Taylor rule estimated recursively with $m=2$.

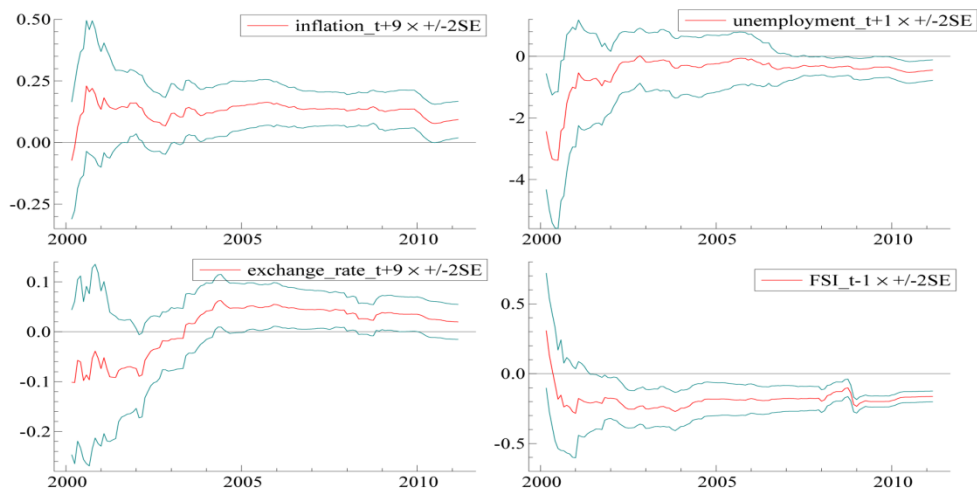


Panel b: Taylor rule estimated recursively with $m=1$.

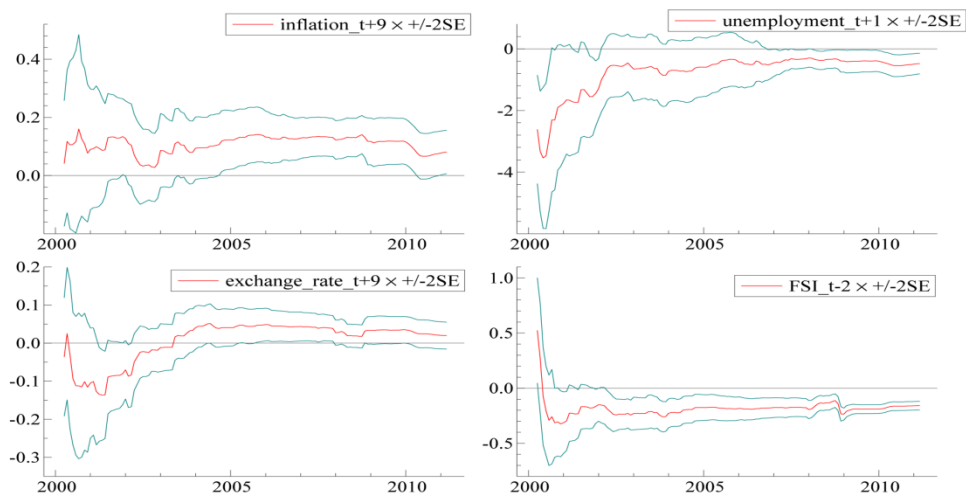


Panel c: Taylor rule estimated recursively with $m=0$.

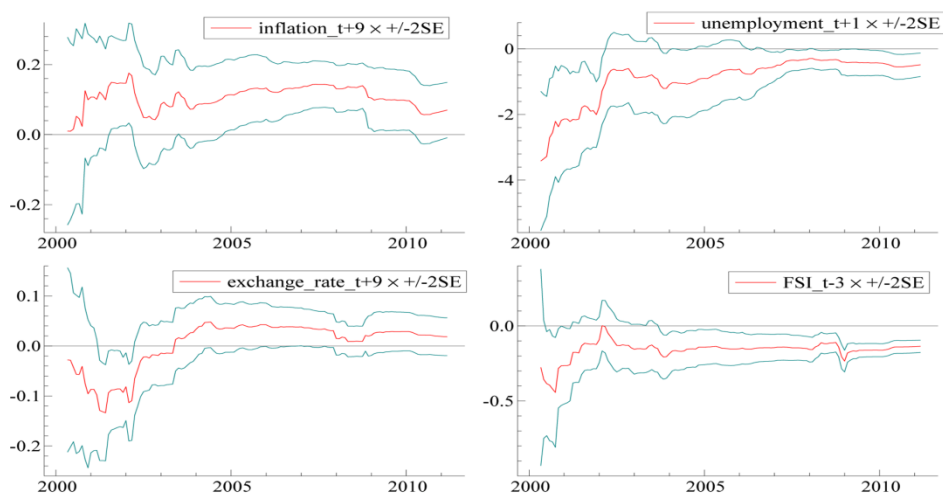
Figure 6: Recursive graphics, panels a- c. The plots show the time paths of the coefficients in the Taylor-type rule. In each panel, the top left graph is inflation, top right graph is the output gap, the bottom left graph is the exchange rate and the bottom right graph is the financial stress index.



Panel d: Taylor rule estimated recursively with $m = -1$.



Panel e: Taylor rule estimated recursively with $m = -2$.



Panel f: Taylor rule estimated recursively with $m = -3$.

Figure 7: Recursive graphics, panels d- f. The plots show the time paths of the coefficients in the Taylor-type rule. In each panel, the top left graph is inflation, top right graph is the output gap, the bottom left graph is the exchange rate and the bottom right graph is the financial stress index.

Once more, all the coefficients are somewhat unstable in the early parts of the sample, for all different leads and lags for the financial stress index. However, the plots suggest that the time-paths of the coefficients become more stable after the initial unstable phase, with the exception of a sudden drop in the coefficient measuring financial instability's impact on the interest setting decisions of the monetary authority.

Time- varying coefficients estimation

In estimating the model using the varying coefficients method, I will assume that most of the coefficients are time-invariant. As the plots above suggest convergence toward a steady-state for all parameters but the one measuring the impact of financial stress on the interest rate, I assume that all coefficients but the latter are time-invariant. Furthermore, I will utilize the specification given by eqs. (18) – (19), namely:

$$(18) \quad r_t = (1 - \rho)[\alpha + \beta(\pi_{t+9}) + \gamma y_{t+1} + \mu e_{t+9}] + \rho r_{t-1} + \delta_t x_{t+m} + \rho_{\varphi\varepsilon}\sigma_\varepsilon\varphi_t + \rho_{\varsigma\varepsilon}\sigma_\varepsilon\varsigma_t + \rho_{\upsilon\varepsilon}\sigma_\varepsilon\upsilon_t + \rho_{\xi\varepsilon}\sigma_\varepsilon\xi_t + \zeta_t$$

$$(19) \quad \delta_t = \delta_{t-1} + \vartheta_t$$

The time-varying results for the financial stress index coefficient are presented below, for different leads and lags imposed on the financial stress index.

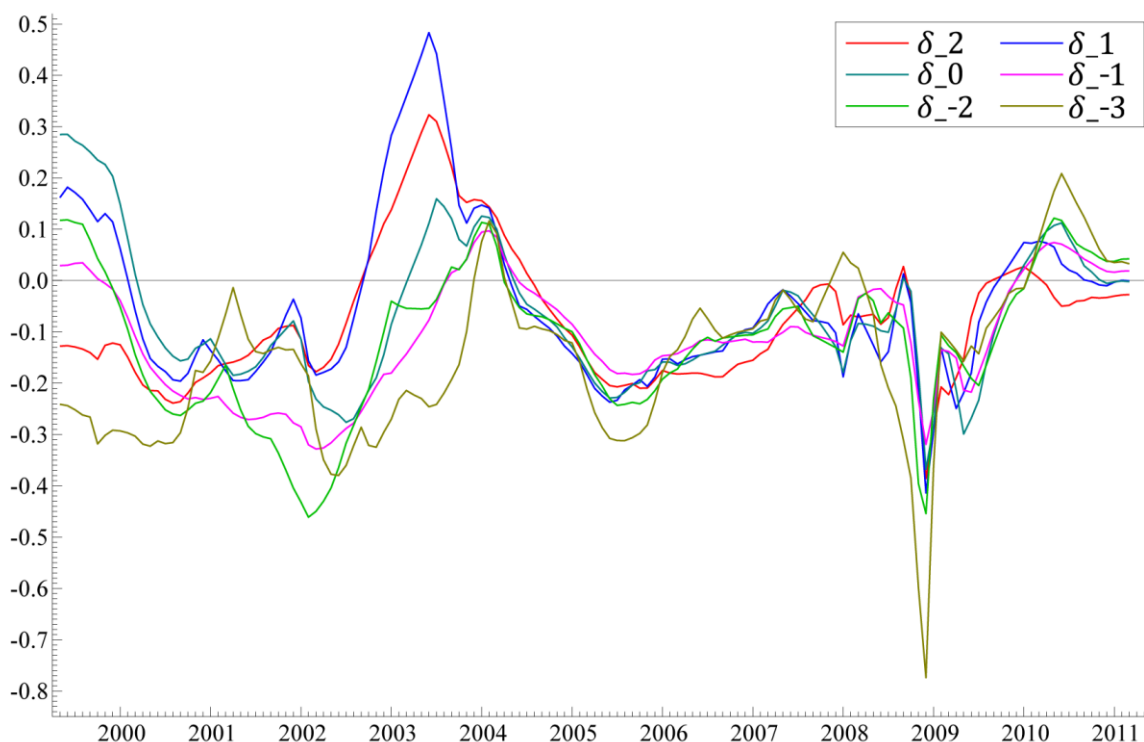


Figure 8: Time-paths for all lags and leads on the financial stress index. That is, δ_x is the time-path of the financial stress coefficient when the financial stress index is led x periods, while δ_{-x} is the time-path of the financial stress coefficient when the stress index is lagged x periods. Figures for each of the time-paths can be found in appendix A.2.

In the time-varying plots in Figure 8 above, it is evident that the occurrence of financial distress in late 2008 led the central bank to decrease the interest rate. Specifically, for all specifications of leads and lags on the financial stress index, in late 2008, the monetary authority responded by cutting its interest rate by at least 0.25 basis points per unit increase in the stress index. The largest cut is seen when the model is estimated under the assumption that the central bank was rather sluggish in its response, which can be seen looking at the plots for δ_{-1} , δ_{-2} , and δ_{-3} in Table 8 above. In particular, the plot named δ_{-3} in the figure above show that three months after the initial shock, the interest rate was reduced by more than 0.7 basis points by the monetary authority, either by lowering its policy rates, through open market operations, or both, ultimately resulting in a drop in the interbank rate. As the stress index increased by more than three units at its peak, this result means that the reduction in the interest rates were roughly 2.1 basis points three months after the increase in the stress index.

It can also be seen from the figure above that the expansionary effect on monetary policy decreases as the time elapsed since the financial stress occurred tends to zero. Additionally,

the evidence from the figures suggests that there is a double-dip in the central bank's response to the financial distress in 2008, except for in the specifications where the central bank responds three periods after the initial shock and two periods prior to an expected shock. This suggests that the initial slashing of the interest rates was not enough, and that a second cut in the interest rates was needed.

Moreover, it can also be seen, by conferring the plots dubbed δ_2 and δ_1 , that the interest rate was increased in response to an increase in financial stress in 2003. These results are especially evident when assuming that the central bank adjusts its interest rate when there is an expected increase in financial instability. That is, plot δ_2 shows that there is a monetary contraction when financial stress is expected to increase two periods ahead. The increase in the interest rate as a result of an increase in the financial stress index is, however, at its peak in the case where it is assumed that the central bank adjusts the interest rate to an expected increase in the financial stress index one period ahead. As an increase in the stress index might lead to a contraction in the real economy, through higher unemployment and lower inflation, an increase in the interest rate may act so as to propagate a possible economic downturn.

6 Conclusion

In this thesis, I have looked at the impact of increased financial stress on monetary policy in Norway. Periods of financial instability affect the real economy through their negative impact on the supply of credit. A situation with credit rationing tends to slow down the economy. Hence, shocks to the economy originated in the financial sector might spread to the real economy and thereby cause deflationary pressure and setbacks in production. For that reason, I found it interesting to investigate the Norwegian Central bank's response to such shocks. The thesis sought to find an answer to the size and timing of the central bank's response, i.e., by how much it reduced its interest rates and if it responded before or after the shock had occurred.

By estimating a Taylor-type rule in a model framework where the parameter measuring the effect of financial stress on interest rates was time-varying, the effect of an increase in the financial stress index was found. The augmented Taylor rule was also estimated using the two-stage least squares method. The interest rate estimated was the three month interbank rate, which also captures open market operations executed by the central bank, thus covering more of the set of instruments the monetary authority can utilize.

The results showed that there was a negative impact of a shock to the financial sector on the interest rates. That is, the estimation results implied that an increase in the financial stress index caused the central bank to decrease its interest rates. Moreover, by applying the time-varying coefficients method to the model, it was clear that the past financial crisis caused the central bank to be more expansionary in its policy than usual towards financial stress. The findings also suggested that the monetary authority reacted more on the increase in financial instability *ex post* than *ex ante*. That is, there seemed to be a more aggressive reaction towards financial stress after the impact rather than a reaction towards an expected increase in the stress index.

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Appendices

A.1 Tables

Table A 1: Results from two-stage least squares estimation, with a lead of 2 periods on the financial stress index, estimating using the output gap constructed from production data.

$$r_t = (1 - \rho) [\alpha + \beta\pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k}] + \rho r_{t-1} + \delta x_{t+m} + \varepsilon_t$$

$i=k$	j	m		ρ	α	β	γ	μ	δ
0	-3	2	Coefficient	0,99125	0,00611	-0,01905	1,34458	-0,04130	-0,09318
			<i>p-value</i>	0	0,7018	0,6895	0,0375	0,0689	0,0157
0	-1	2	Coefficient	0,98468	0,00794	-0,00981	1,73965	-0,03835	-0,09968
			<i>p-value</i>	0	0,5971	0,8344	0,0069	0,0849	0,0085
0	0	2	Coefficient	0,98033	0,00936	-0,00474	2,08520	-0,04569	-0,09978
			<i>p-value</i>	0	0,5198	0,918	0,0008	0,0359	0,0056
0	1	2	Coefficient	0,97646	0,01042	0,00162	2,71140	-0,05531	-0,09986
			<i>p-value</i>	0	0,4528	0,9705	0	0,0085	0,0027
0	3	2	Coefficient	0,97670	0,01410	-0,01125	3,59351	-0,06585	-0,06820
			<i>p-value</i>	0	0,2539	0,7691	0	0,0005	0,0146
0	6	2	Coefficient	0,99070	0,01146	-0,04148	2,92295	-0,05422	-0,01776
			<i>p-value</i>	0	0,4062	0,3252	0	0,0084	0,5633
0	9	2	Coefficient	1,00008	-0,00070	-0,02228	2,37361	-0,03846	-0,02435
			<i>p-value</i>	0	0,9629	0,6276	0	0,0857	0,4685
0	12	2	Coefficient	1,00272	-0,00735	-0,00885	1,12561	-0,04829	-0,05244
			<i>p-value</i>	0	0,6684	0,8616	0,0578	0,0491	0,1431
6	-3	2	Coefficient	0,98501	-0,03348	0,14185	0,81279	-0,01344	-0,16199
			<i>p-value</i>	0	0,0409	0,0055	0,2221	0,537	0
6	-1	2	Coefficient	0,97653	-0,02640	0,13659	1,62382	-0,01921	-0,17013
			<i>p-value</i>	0	0,0837	0,005	0,0116	0,3619	0
6	0	2	Coefficient	0,97211	-0,02446	0,14057	1,89228	-0,01829	-0,17073
			<i>p-value</i>	0	0,0992	0,0031	0,0022	0,3654	0
6	1	2	Coefficient	0,97042	-0,01953	0,12803	2,32896	-0,02174	-0,16464
			<i>p-value</i>	0	0,1746	0,005	0,0001	0,2662	0
9	-3	2	Coefficient	0,97827	-0,03656	0,17152	0,64080	0,04534	-0,14878
			<i>p-value</i>	0	0,0281	0,0004	0,3476	0,04	0
9	-1	2	Coefficient	0,97096	-0,02709	0,15386	1,19367	0,04767	-0,14570
			<i>p-value</i>	0	0,0772	0,001	0,0656	0,0249	0
9	0	2	Coefficient	0,96883	-0,02365	0,14651	1,40390	0,04881	-0,14304
			<i>p-value</i>	0	0,1138	0,0015	0,025	0,0187	0
9	1	2	Coefficient	0,96782	-0,01840	0,13065	1,85569	0,04491	-0,13947
			<i>p-value</i>	0	0,2037	0,0036	0,0016	0,0256	0
12	-3	2	Coefficient	0,99591	-0,05397	0,18896	-0,06490	-0,03336	-0,15124
			<i>p-value</i>	0	0,0017	0	0,9275	0,1449	0
12	-1	2	Coefficient	0,98397	-0,03845	0,16074	0,65220	-0,02047	-0,14342
			<i>p-value</i>	0	0,0228	0,0005	0,3761	0,3706	0
12	0	2	Coefficient	0,98003	-0,03256	0,14872	0,98168	-0,01880	-0,14175
			<i>p-value</i>	0	0,0472	0,0012	0,1621	0,397	0
12	1	2	Coefficient	0,97618	-0,02286	0,12385	1,67563	-0,01709	-0,14028
			<i>p-value</i>	0	0,1428	0,0054	0,0097	0,4231	0

Table A 2: Results from two-stage least squares estimation, with a lead of 0 periods on the financial stress index, estimating using the output gap constructed from production data.

$$r_t = (1 - \varrho) \left[\alpha + \beta \pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k} \right] + \varrho r_{t-1} + \delta x_{t+m} + \varepsilon_t$$

$i=k$	j	m		ϱ	α	β	γ	μ	δ
0	-3	0	Coefficient	0,97713	-0,02107	0,12140	2,50323	-0,01757	-0,24558
			<i>p-value</i>	0	0,0957	0,004	0	0,3325	0
0	-1	0	Coefficient	0,97650	-0,01875	0,11115	2,06561	-0,01803	-0,21559
			<i>p-value</i>	0	0,1424	0,0096	0,0001	0,3314	0
0	0	0	Coefficient	0,97673	-0,01606	0,09963	1,92867	-0,02726	-0,19546
			<i>p-value</i>	0	0,2153	0,0204	0,0001	0,148	0
0	1	0	Coefficient	0,97540	-0,01268	0,08989	2,21439	-0,03775	-0,17816
			<i>p-value</i>	0	0,3209	0,032	0	0,0452	0
0	3	0	Coefficient	0,97684	-0,00495	0,05784	2,98273	-0,05138	-0,13204
			<i>p-value</i>	0	0,6799	0,1372	0	0,0037	0
0	6	0	Coefficient	0,99213	-0,01720	0,05951	2,24954	-0,03529	-0,12434
			<i>p-value</i>	0	0,1931	0,1681	0	0,0627	0,0001
0	9	0	Coefficient	1,00015	-0,03600	0,10755	2,03791	-0,01539	-0,16101
			<i>p-value</i>	0	0,0077	0,0144	0	0,4325	0
0	12	0	Coefficient	1,00110	-0,04051	0,11790	1,02464	-0,02470	-0,17906
			<i>p-value</i>	0	0,0079	0,0146	0,0512	0,2467	0
6	-3	0	Coefficient	0,97260	-0,04306	0,20862	1,58994	-0,03295	-0,26236
			<i>p-value</i>	0	0,0005	0	0,0028	0,0551	0
6	-1	0	Coefficient	0,97084	-0,04242	0,20900	1,48430	-0,04093	-0,24949
			<i>p-value</i>	0	0,0005	0	0,003	0,0176	0
6	0	0	Coefficient	0,97087	-0,04392	0,21375	1,21922	-0,03858	-0,23992
			<i>p-value</i>	0	0,0004	0	0,0115	0,0225	0
6	1	0	Coefficient	0,97075	-0,04090	0,20352	1,34195	-0,03887	-0,22957
			<i>p-value</i>	0	0,001	0	0,0046	0,0204	0
9	-3	0	Coefficient	0,96904	-0,02904	0,16998	1,59892	0,04387	-0,21704
			<i>p-value</i>	0	0,0219	0	0,0062	0,0148	0
9	-1	0	Coefficient	0,96880	-0,03219	0,17885	1,08633	0,03964	-0,19933
			<i>p-value</i>	0	0,0108	0	0,0433	0,027	0
9	0	0	Coefficient	0,97018	-0,03515	0,18529	0,76231	0,03905	-0,19224
			<i>p-value</i>	0	0,0062	0	0,1448	0,0284	0
9	1	0	Coefficient	0,96980	-0,03236	0,17633	0,93899	0,03751	-0,18617
			<i>p-value</i>	0	0,0116	0	0,0664	0,0337	0
12	-3	0	Coefficient	0,98505	-0,03798	0,16144	1,09348	-0,02866	-0,21071
			<i>p-value</i>	0	0,0054	0	0,0837	0,1297	0
12	-1	0	Coefficient	0,98285	-0,03894	0,16717	0,64366	-0,02592	-0,19294
			<i>p-value</i>	0	0,0063	0	0,2986	0,1846	0
12	0	0	Coefficient	0,98364	-0,04227	0,17578	0,34402	-0,02892	-0,18852
			<i>p-value</i>	0	0,003	0	0,5585	0,1318	0
12	1	0	Coefficient	0,98163	-0,03665	0,16110	0,71778	-0,02731	-0,18448
			<i>p-value</i>	0	0,0088	0,0001	0,2024	0,1472	0

Table A 3: Results from two-stage least squares estimation, with a lag of 2 periods on the financial stress index, estimating using the output gap constructed from production data

$$r_t = (1 - \varrho) \left[\alpha + \beta \pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k} \right] + \varrho r_{t-1} + \delta x_{t+m} + \varepsilon_t$$

$i=k$	j	m		ϱ	α	β	γ	μ	δ
0	-3	-2	Coefficient	0,95849	-0,01220	0,13283	2,10263	-0,04071	-0,23079
			<i>p-value</i>	0	0,3041	0,0016	0,0001	0,0193	0
0	-1	-2	Coefficient	0,96763	-0,01517	0,11761	1,12283	-0,03794	-0,19639
			<i>p-value</i>	0	0,2313	0,0075	0,0236	0,037	0
0	0	-2	Coefficient	0,96924	-0,01439	0,11089	1,05128	-0,04151	-0,18662
			<i>p-value</i>	0	0,2671	0,0129	0,0355	0,0258	0
0	1	-2	Coefficient	0,96799	-0,01182	0,10341	1,43306	-0,04975	-0,17561
			<i>p-value</i>	0	0,3604	0,0195	0,0045	0,0078	0
0	3	-2	Coefficient	0,96778	-0,00149	0,06695	2,66060	-0,06220	-0,13136
			<i>p-value</i>	0	0,8998	0,1021	0	0,0004	0
0	6	-2	Coefficient	0,98035	-0,01771	0,09060	2,06112	-0,04546	-0,14583
			<i>p-value</i>	0	0,1439	0,0354	0	0,0111	0
0	9	-2	Coefficient	0,98562	-0,03305	0,13404	1,90115	-0,03032	-0,17648
			<i>p-value</i>	0	0,0075	0,0021	0,0001	0,1017	0
0	12	-2	Coefficient	0,98334	-0,03363	0,13895	0,67508	-0,04306	-0,19301
			<i>p-value</i>	0	0,015	0,0034	0,1885	0,0326	0
6	-3	-2	Coefficient	0,95303	-0,02763	0,20097	1,05228	-0,02379	-0,23192
			<i>p-value</i>	0	0,0213	0	0,0471	0,174	0
6	-1	-2	Coefficient	0,95738	-0,03653	0,22033	0,23768	-0,02646	-0,22261
			<i>p-value</i>	0	0,0032	0	0,6373	0,1358	0
6	0	-2	Coefficient	0,95897	-0,04045	0,23005	-0,07299	-0,02533	-0,22436
			<i>p-value</i>	0	0,0013	0	0,8853	0,1547	0
6	1	-2	Coefficient	0,95811	-0,03741	0,22160	0,15337	-0,02637	-0,22078
			<i>p-value</i>	0	0,0035	0	0,7682	0,1393	0
9	-3	-2	Coefficient	0,95274	-0,01538	0,16152	1,20508	0,04529	-0,19431
			<i>p-value</i>	0	0,2214	0	0,0384	0,0138	0
9	-1	-2	Coefficient	0,95889	-0,02933	0,19340	0,07504	0,03843	-0,18312
			<i>p-value</i>	0	0,0222	0	0,8893	0,0361	0
9	0	-2	Coefficient	0,96109	-0,03542	0,20927	-0,35020	0,03673	-0,18709
			<i>p-value</i>	0	0,0069	0	0,5204	0,0444	0
9	1	-2	Coefficient	0,95977	-0,03204	0,20071	-0,11572	0,03793	-0,18529
			<i>p-value</i>	0	0,015	0	0,8348	0,0373	0
12	-3	-2	Coefficient	0,96541	-0,02170	0,15270	0,83785	-0,00121	-0,18506
			<i>p-value</i>	0	0,1164	0,0001	0,1913	0,9496	0
12	-1	-2	Coefficient	0,97175	-0,03573	0,18412	-0,25343	-0,00981	-0,17475
			<i>p-value</i>	0	0,0134	0	0,6823	0,6191	0
12	0	-2	Coefficient	0,97445	-0,04263	0,20153	-0,69501	-0,01268	-0,17954
			<i>p-value</i>	0	0,0032	0	0,2514	0,5071	0
12	1	-2	Coefficient	0,97140	-0,03611	0,18651	-0,27687	-0,00864	-0,17832
			<i>p-value</i>	0	0,0118	0	0,647	0,6472	0

Table A 4: Results from two-stage least squares estimation, with a lag of 3 periods on the financial stress index, estimating using the output gap constructed from production data

$$r_t = (1 - \varrho) \left[\alpha + \beta \pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k} \right] + \varrho r_{t-1} + \delta x_{t+m} + \varepsilon_t$$

$i=k$	j	m		ϱ	α	β	γ	μ	δ
0	-3	-3	Coefficient	0,95950	-0,00548	0,10271	1,51936	-0,06504	-0,18668
			<i>p-value</i>	0	0,6706	0,0261	0,0056	0,0006	0
0	-1	-3	Coefficient	0,96889	-0,00982	0,09366	0,73275	-0,05998	-0,16416
			<i>p-value</i>	0	0,4707	0,0502	0,164	0,0019	0
0	0	-3	Coefficient	0,96919	-0,00908	0,08996	0,79571	-0,06266	-0,15833
			<i>p-value</i>	0	0,5159	0,0661	0,14	0,0014	0
0	1	-3	Coefficient	0,96639	-0,00301	0,07480	1,43568	-0,07022	-0,14219
			<i>p-value</i>	0	0,8265	0,1211	0,0084	0,0004	0
0	3	-3	Coefficient	0,96657	0,00884	0,03189	2,85922	-0,07872	-0,09306
			<i>p-value</i>	0	0,4778	0,473	0	0	0,0025
0	6	-3	Coefficient	0,97908	-0,01042	0,06743	2,31944	-0,06215	-0,11755
			<i>p-value</i>	0	0,3981	0,1367	0	0,0009	0,0002
0	9	-3	Coefficient	0,98340	-0,02427	0,10698	1,89660	-0,05138	-0,14509
			<i>p-value</i>	0	0,0597	0,023	0,0002	0,0098	0
0	12	-3	Coefficient	0,97998	-0,02470	0,11445	0,56125	-0,06717	-0,16527
			<i>p-value</i>	0	0,0838	0,0241	0,3092	0,0018	0
6	-3	-3	Coefficient	0,95595	-0,02958	0,19874	-0,22839	-0,02356	-0,18548
			<i>p-value</i>	0	0,033	0,0001	0,6944	0,2387	0
6	-1	-3	Coefficient	0,956275	-0,03164	0,20511	-0,37788	-0,02279	-0,18938
			<i>p-value</i>	0	0,024	0	0,523	0,2551	0
6	0	-3	Coefficient	0,954668	-0,02438	0,18376	0,15806	-0,02491	-0,17965
			<i>p-value</i>	0	0,0853	0,0004	0,796	0,2156	0
6	1	-3	Coefficient	0,957378	-0,00176	0,09793	2,01139	-0,03207	-0,12497
			<i>p-value</i>	0	0,8929	0,0487	0,001	0,0944	0,0001
9	-3	-3	Coefficient	0,95158	-0,01390	0,15717	0,51848	0,04528	-0,15060
			<i>p-value</i>	0	0,3251	0,0004	0,4143	0,0285	0
9	-1	-3	Coefficient	0,95703	-0,02607	0,18604	-0,35109	0,03973	-0,15128
			<i>p-value</i>	0	0,0666	0,0001	0,5635	0,0508	0
9	0	-3	Coefficient	0,95792	-0,03024	0,19853	-0,62921	0,03849	-0,15784
			<i>p-value</i>	0	0,0369	0	0,315	0,0575	0
9	1	-3	Coefficient	0,95542	-0,02233	0,17694	-0,09094	0,04127	-0,15001
			<i>p-value</i>	0	0,1219	0,0003	0,8868	0,0411	0
12	-3	-3	Coefficient	0,96336	-0,01981	0,14935	0,20425	0,00456	-0,14152
			<i>p-value</i>	0	0,1976	0,0005	0,769	0,8318	0
12	-1	-3	Coefficient	0,96955	-0,03204	0,17649	-0,60998	-0,00384	-0,14144
			<i>p-value</i>	0	0,0426	0,0001	0,3725	0,8594	0
12	0	-3	Coefficient	0,97056	-0,03601	0,18807	-0,86791	-0,00391	-0,14780
			<i>p-value</i>	0	0,0223	0	0,2016	0,8519	0
12	1	-3	Coefficient	0,96576	-0,02486	0,16103	-0,14558	0,00199	-0,14166
			<i>p-value</i>	0	0,1084	0,0005	0,8302	0,9235	0

Table A 5: Results from two-stage least squares estimation, with a lead of 2 periods on the financial stress index, estimating using the output gap proxied by the deviation of the unemployment rate from the natural rate of unemployment.

$$r_t = (1 - \rho) \left[\alpha + \beta \pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k} \right] + \rho r_{t-1} + \delta x_{t+m} + \varepsilon_t$$

$i=k$	j	m		ρ	α	β	γ	μ	δ
0	-1	2	Coefficient	0,97819	0,20134	-0,11431	-0,89533	-0,03528	-0,08337
			<i>p-value</i>	0	0	0,0132	0	0,0777	0,0069
0	0	2	Coefficient	0,97848	0,19040	-0,10401	-0,85266	-0,03415	-0,07822
			<i>p-value</i>	0	0	0,0205	0	0,0869	0,0096
0	1	2	Coefficient	0,97971	0,17731	-0,09734	-0,79587	-0,03677	-0,06885
			<i>p-value</i>	0	0	0,0296	0	0,0665	0,022
0	3	2	Coefficient	0,98266	0,16240	-0,08388	-0,74600	-0,03822	-0,06234
			<i>p-value</i>	0	0	0,0571	0	0,0587	0,0378
0	6	2	Coefficient	0,98941	0,13366	-0,05988	-0,65364	-0,04109	-0,06364
			<i>p-value</i>	0	0,0001	0,1801	0	0,0504	0,0394
0	9	2	Coefficient	0,99609	0,12700	-0,05078	-0,66141	-0,04816	-0,06254
			<i>p-value</i>	0	0,0001	0,2538	0	0,0227	0,0433
0	12	2	Coefficient	1,00354	0,12495	-0,06064	-0,66456	-0,05562	-0,05283
			<i>p-value</i>	0	0,0001	0,1862	0	0,0106	0,0917
6	-1	2	Coefficient	0,97652	0,12911	0,02911	-0,70396	-0,01995	-0,13905
			<i>p-value</i>	0	0,0189	0,6324	0,0019	0,3335	0
6	0	2	Coefficient	0,97433	0,12787	0,03109	-0,69325	-0,01355	-0,13063
			<i>p-value</i>	0	0,015	0,6032	0,0013	0,4952	0
6	1	2	Coefficient	0,97559	0,11411	0,03852	-0,63330	-0,01221	-0,12377
			<i>p-value</i>	0	0,0237	0,5138	0,0021	0,5384	0,0001
6	3	2	Coefficient	0,97904	0,10818	0,03971	-0,61606	-0,01401	-0,11683
			<i>p-value</i>	0	0,0186	0,48	0,0011	0,4771	0,0002
9	-1	2	Coefficient	0,97072	0,08837	0,07873	-0,52825	0,03855	-0,13035
			<i>p-value</i>	0	0,1335	0,202	0,0291	0,0694	0
9	0	2	Coefficient	0,97008	0,09467	0,06945	-0,54807	0,03970	-0,12305
			<i>p-value</i>	0	0,099	0,2623	0,0201	0,0573	0
9	1	2	Coefficient	0,97181	0,08060	0,07604	-0,48682	0,03885	-0,11731
			<i>p-value</i>	0	0,1519	0,2247	0,0339	0,0618	0,0001
9	3	2	Coefficient	0,97578	0,08622	0,06330	-0,51353	0,03801	-0,10959
			<i>p-value</i>	0	0,099	0,2961	0,016	0,0618	0,0003
12	-1	2	Coefficient	0,97849	0,06638	0,09721	-0,46495	-0,02059	-0,13928
			<i>p-value</i>	0	0,2979	0,1062	0,0767	0,3398	0
12	0	2	Coefficient	0,97640	0,07605	0,08648	-0,49605	-0,01937	-0,13216
			<i>p-value</i>	0	0,2292	0,1585	0,056	0,3669	0
12	1	2	Coefficient	0,97705	0,06443	0,09209	-0,44345	-0,01908	-0,12585
			<i>p-value</i>	0	0,2893	0,1327	0,0746	0,3737	0
12	3	2	Coefficient	0,97921	0,06328	0,08736	-0,43916	-0,01854	-0,11927
			<i>p-value</i>	0	0,2773	0,1576	0,0658	0,3826	0

Table A 6: Results from two-stage least squares estimation, with a lead of 0 periods on the financial stress index, estimating using the output gap proxied by the deviation of the unemployment rate from the natural rate of unemployment.

$$r_t = (1 - \rho) \left[\alpha + \beta \pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k} \right] + \rho r_{t-1} + \delta x_{t+m} + \varepsilon_t$$

$i=k$	j	m		ρ	α	β	γ	μ	δ
0	-1	0	Coefficient	0,97519	0,15684	-0,00374	-0,80277	-0,01528	-0,17258
			<i>p-value</i>	0	0	0,9325	0	0,3902	0
0	0	0	Coefficient	0,97665	0,14275	0,00651	-0,74621	-0,01424	-0,16803
			<i>p-value</i>	0	0,0001	0,8817	0	0,4248	0
0	1	0	Coefficient	0,97761	0,13775	0,01237	-0,73025	-0,01468	-0,16670
			<i>p-value</i>	0	0,0001	0,7754	0	0,4108	0
0	3	0	Coefficient	0,98053	0,12659	0,02915	-0,70631	-0,01466	-0,16808
			<i>p-value</i>	0	0,0001	0,4912	0	0,4152	0
0	6	0	Coefficient	0,98703	0,09865	0,05598	-0,62263	-0,01795	-0,17268
			<i>p-value</i>	0	0,0009	0,1919	0	0,3341	0
0	9	0	Coefficient	0,99322	0,09058	0,06083	-0,61327	-0,02517	-0,16737
			<i>p-value</i>	0	0,0014	0,1579	0	0,1819	0
0	12	0	Coefficient	1,00048	0,08285	0,05202	-0,58585	-0,03186	-0,15809
			<i>p-value</i>	0	0,0038	0,2468	0	0,105	0
6	-1	0	Coefficient	0,97211	0,06522	0,13548	-0,49325	-0,02627	-0,21549
			<i>p-value</i>	0	0,1598	0,0109	0,0092	0,1276	0
6	0	0	Coefficient	0,97294	0,05012	0,14601	-0,42904	-0,02393	-0,21194
			<i>p-value</i>	0	0,2659	0,0059	0,0189	0,154	0
6	1	0	Coefficient	0,97359	0,04693	0,14902	-0,41872	-0,02332	-0,21067
			<i>p-value</i>	0	0,2717	0,0039	0,0161	0,164	0
6	3	0	Coefficient	0,97527	0,05288	0,14529	-0,45355	-0,02468	-0,20790
			<i>p-value</i>	0	0,1658	0,0028	0,0041	0,1368	0
9	-1	0	Coefficient	0,96874	0,07779	0,10669	-0,50257	0,03285	-0,18574
			<i>p-value</i>	0	0,1219	0,0415	0,0153	0,0685	0
9	0	0	Coefficient	0,97042	0,06196	0,11531	-0,43482	0,03268	-0,18100
			<i>p-value</i>	0	0,2105	0,0308	0,0322	0,0681	0
9	1	0	Coefficient	0,97146	0,05611	0,11863	-0,41195	0,03185	-0,17933
			<i>p-value</i>	0	0,2435	0,0256	0,0374	0,076	0
9	3	0	Coefficient	0,97335	0,06348	0,11097	-0,44906	0,03304	-0,17561
			<i>p-value</i>	0	0,1468	0,0283	0,0136	0,0632	0
12	-1	0	Coefficient	0,97543	0,09734	0,07643	-0,59002	-0,02813	-0,18981
			<i>p-value</i>	0	0,0772	0,1362	0,0093	0,1276	0
12	0	0	Coefficient	0,97698	0,08122	0,08444	-0,51947	-0,02651	-0,18291
			<i>p-value</i>	0	0,1365	0,1086	0,0201	0,1513	0
12	1	0	Coefficient	0,97827	0,07661	0,08568	-0,50132	-0,02691	-0,18026
			<i>p-value</i>	0	0,1525	0,1049	0,0224	0,1458	0
12	3	0	Coefficient	0,98109	0,07785	0,07958	-0,51102	-0,02651	-0,17604
			<i>p-value</i>	0	0,1273	0,1317	0,0155	0,1503	0

Table A 7: Results from two-stage least squares estimation, with a lag of 2 periods on the financial stress index, estimating using the output gap proxied by the deviation of the unemployment rate from the natural rate of unemployment.

$$r_t = (1 - \rho) \left[\alpha + \beta \pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k} \right] + \rho r_{t-1} + \delta x_{t+m} + \varepsilon_t$$

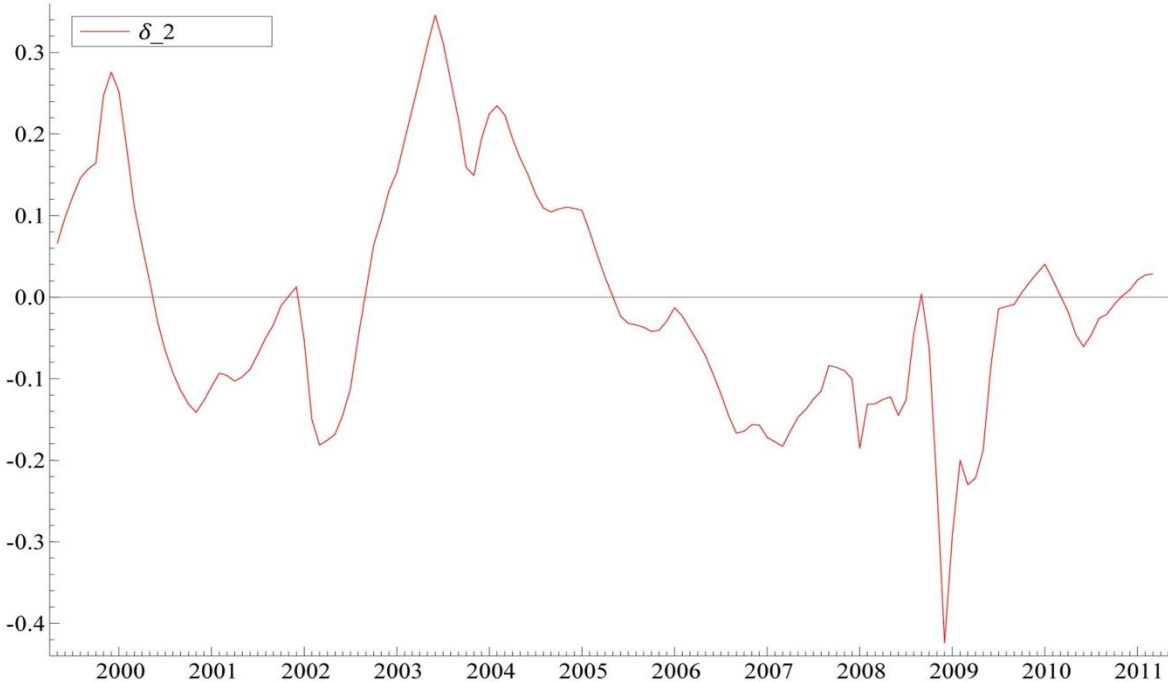
$i=k$	j	m		ρ	α	β	γ	μ	δ
0	-1	-2	Coefficient	0,95969	0,14308	0,04191	-0,73865	-0,04090	-0,19750
			<i>p-value</i>	0	0	0,3138	0	0,009	0
0	0	-2	Coefficient	0,96069	0,13442	0,05280	-0,71113	-0,03886	-0,19769
			<i>p-value</i>	0	0,0001	0,1946	0	0,0129	0
0	1	-2	Coefficient	0,96195	0,12943	0,05943	-0,69710	-0,03880	-0,19777
			<i>p-value</i>	0	0	0,1383	0	0,0129	0
0	3	-2	Coefficient	0,96460	0,11817	0,08012	-0,67967	-0,04042	-0,20297
			<i>p-value</i>	0	0	0,0393	0	0,0093	0
0	6	-2	Coefficient	0,97120	0,08942	0,10143	-0,58141	-0,04306	-0,20275
			<i>p-value</i>	0	0,001	0,0109	0	0,0085	0
0	9	-2	Coefficient	0,97793	0,07594	0,10584	-0,54116	-0,04879	-0,19692
			<i>p-value</i>	0	0,0036	0,0092	0	0,0037	0
0	12	-2	Coefficient	0,98441	0,06780	0,09884	-0,51040	-0,05434	-0,19089
			<i>p-value</i>	0	0,01	0,0193	0	0,0019	0
6	-1	-2	Coefficient	0,95288	0,07329	0,14467	-0,47644	-0,02999	-0,22381
			<i>p-value</i>	0	0,0862	0,0032	0,0068	0,0665	0
6	0	-2	Coefficient	0,95365	0,07098	0,14594	-0,46884	-0,02829	-0,22148
			<i>p-value</i>	0	0,0819	0,0025	0,0054	0,0824	0
6	1	-2	Coefficient	0,95477	0,06591	0,15005	-0,45147	-0,02794	-0,22040
			<i>p-value</i>	0	0,0875	0,0014	0,0048	0,0858	0
6	3	-2	Coefficient	0,95669	0,07046	0,14802	-0,48216	-0,02928	-0,21818
			<i>p-value</i>	0	0,0401	0,0008	0,0009	0,0683	0
9	-1	-2	Coefficient	0,95150	0,10668	0,09099	-0,56920	0,03806	-0,19301
			<i>p-value</i>	0	0,0263	0,062	0,004	0,024	0
9	0	-2	Coefficient	0,95319	0,10313	0,09035	-0,55573	0,03739	-0,18980
			<i>p-value</i>	0	0,0285	0,0657	0,0042	0,0267	0
9	1	-2	Coefficient	0,95515	0,09204	0,09742	-0,51284	0,03597	-0,18803
			<i>p-value</i>	0	0,0416	0,045	0,0062	0,0336	0
9	3	-2	Coefficient	0,95766	0,09575	0,09279	-0,53707	0,03750	-0,18451
			<i>p-value</i>	0	0,0192	0,044	0,0018	0,0251	0
12	-1	-2	Coefficient	0,95621	0,13024	0,05700	-0,66417	-0,00240	-0,19282
			<i>p-value</i>	0	0,0155	0,2444	0,0025	0,8897	0
12	0	-2	Coefficient	0,95766	0,13216	0,05118	-0,67204	-0,00180	-0,18944
			<i>p-value</i>	0	0,014	0,3057	0,0022	0,9172	0
12	1	-2	Coefficient	0,96025	0,12215	0,05562	-0,63373	-0,00313	-0,18621
			<i>p-value</i>	0	0,0191	0,2652	0,003	0,8565	0
12	3	-2	Coefficient	0,96423	0,12069	0,05054	-0,63500	-0,00305	-0,18157
			<i>p-value</i>	0	0,0145	0,3084	0,0019	0,8598	0

Table A 8: Results from two-stage least squares estimation, with a lead of 2 periods on the financial stress index, estimating using the output gap proxied by the deviation of the unemployment rate from the natural rate of unemployment.

$$r_t = (1 - \rho) \left[\alpha + \beta \pi_{t+i} + \gamma y_{t+j} + \mu e_{t+k} \right] + \rho r_{t-1} + \delta x_{t+m} + \varepsilon_t$$

$i=k$	j	m		ρ	α	β	γ	μ	δ
0	-1	-3	Coefficient	0,95529	0,14940	0,02086	-0,72618	-0,05920	-0,16692
			<i>p-value</i>	0	0,0001	0,6585	0	0,0006	0
0	0	-3	Coefficient	0,95644	0,14161	0,03141	-0,70329	-0,05730	-0,16751
			<i>p-value</i>	0	0,0001	0,4947	0	0,0009	0
0	1	-3	Coefficient	0,95739	0,13558	0,04088	-0,68795	-0,05751	-0,16874
			<i>p-value</i>	0	0,0001	0,3719	0	0,0009	0
0	3	-3	Coefficient	0,96001	0,12529	0,05739	-0,66809	-0,05851	-0,17043
			<i>p-value</i>	0	0,0001	0,1991	0	0,0008	0
0	6	-3	Coefficient	0,96737	0,09374	0,07794	-0,55600	-0,06165	-0,16877
			<i>p-value</i>	0	0,0021	0,0891	0	0,0008	0
0	9	-3	Coefficient	0,97416	0,08368	0,08131	-0,53386	-0,06630	-0,16321
			<i>p-value</i>	0	0,004	0,0801	0,0001	0,0004	0
0	12	-3	Coefficient	0,98108	0,07756	0,07172	-0,51134	-0,07122	-0,15605
			<i>p-value</i>	0	0,0082	0,1373	0,0002	0,0002	0
6	-1	-3	Coefficient	0,94756	0,10595	0,09081	-0,55434	-0,02364	-0,17812
			<i>p-value</i>	0	0,0323	0,1039	0,0066	0,2129	0
6	0	-3	Coefficient	0,94874	0,10707	0,08885	-0,56234	-0,02199	-0,17534
			<i>p-value</i>	0	0,0228	0,1035	0,0039	0,2438	0
6	1	-3	Coefficient	0,94976	0,10220	0,09358	-0,54693	-0,02140	-0,17437
			<i>p-value</i>	0	0,0213	0,0775	0,0031	0,2557	0
6	3	-3	Coefficient	0,95238	0,10024	0,09609	-0,55117	-0,02288	-0,17145
			<i>p-value</i>	0	0,0118	0,0559	0,0011	0,2204	0
9	-1	-3	Coefficient	0,94637	0,12603	0,05766	-0,60614	0,03847	-0,15536
			<i>p-value</i>	0	0,0242	0,2978	0,0083	0,046	0
9	0	-3	Coefficient	0,94824	0,12839	0,05224	-0,61874	0,03771	-0,15236
			<i>p-value</i>	0	0,0175	0,3432	0,0055	0,0496	0
9	1	-3	Coefficient	0,95017	0,12085	0,05647	-0,59131	0,03603	-0,15067
			<i>p-value</i>	0	0,02	0,2992	0,006	0,061	0
9	3	-3	Coefficient	0,95334	0,11984	0,05496	-0,59676	0,03807	-0,14575
			<i>p-value</i>	0	0,0106	0,2879	0,0024	0,046	0
12	-1	-3	Coefficient	0,94906	0,14736	0,03180	-0,69349	0,00187	-0,16002
			<i>p-value</i>	0	0,02	0,5717	0,007	0,9242	0
12	0	-3	Coefficient	0,95047	0,15587	0,02091	-0,72981	0,00220	-0,15758
			<i>p-value</i>	0	0,0124	0,7124	0,004	0,9103	0
12	1	-3	Coefficient	0,95286	0,15039	0,02182	-0,71077	0,00079	-0,15467
			<i>p-value</i>	0	0,0129	0,6993	0,004	0,9677	0
12	3	-3	Coefficient	0,95770	0,14584	0,01834	-0,70086	0,00072	-0,14845
			<i>p-value</i>	0	0,01	0,7426	0,0027	0,9705	0

A.2 Time-varying plots of the financial stress effect



Panel a: Taylor rule estimated with time-varying coefficient for the FSI, and $m=2$.

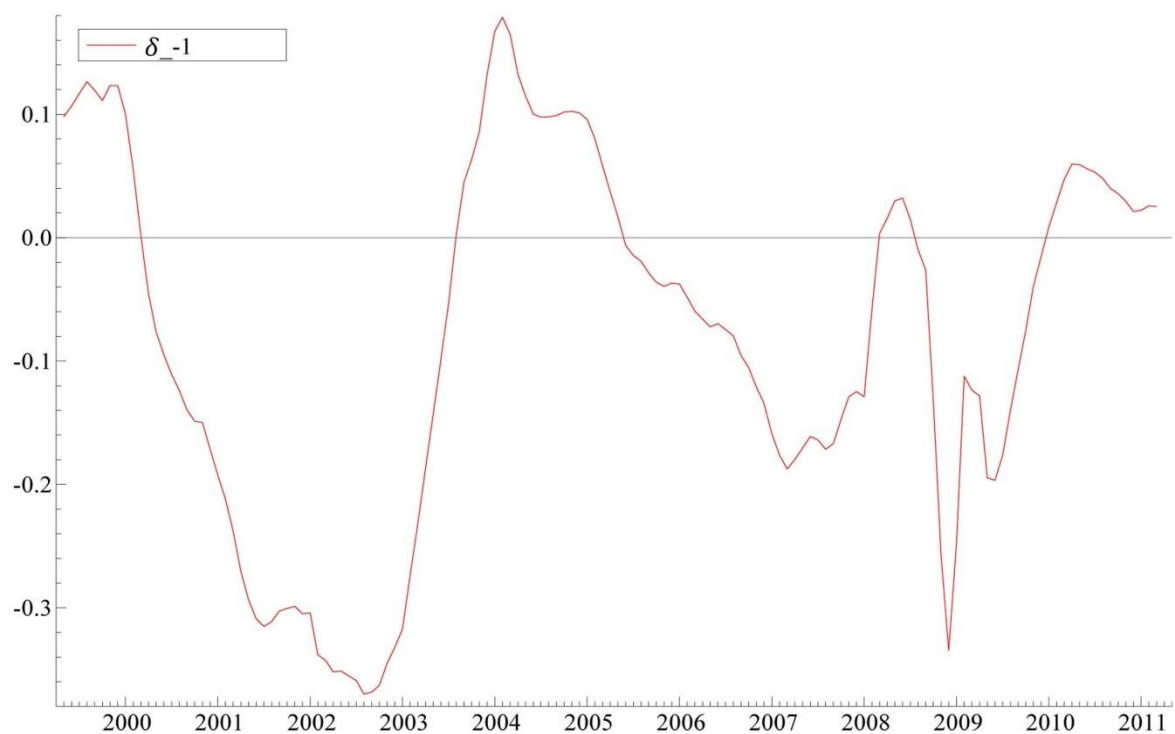


Panel b: Taylor rule estimated with time-varying coefficient for the FSI, and $m=1$.

Figure A 1: Time-paths for all lags and leads on the financial stress index, where δ_x is the time-path of the financial stress coefficient when the financial stress index is led x periods, and δ_{-x} when the stress index is lagged x periods. The effect is estimated using the output gap constructed from production data.



Panel c: Taylor rule estimated with time-varying coefficient for the FSI, and $m=0$.

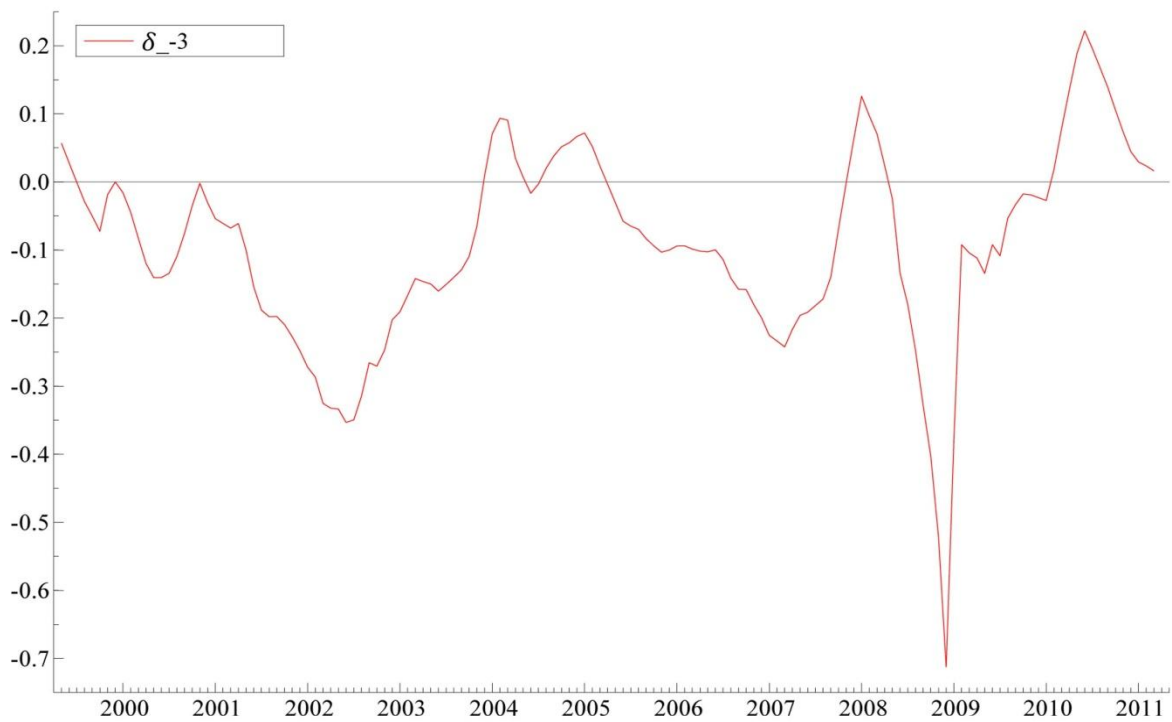


Panel d: Taylor rule estimated with time-varying coefficient for the FSI, and $m=-1$.

Figure A 2: Time-paths for all lags and leads on the financial stress index, where δ_x is the time-path of the financial stress coefficient when the financial stress index is led x periods, and δ_{-x} when the stress index is lagged x periods. The effect is estimated using the output gap constructed from production data.

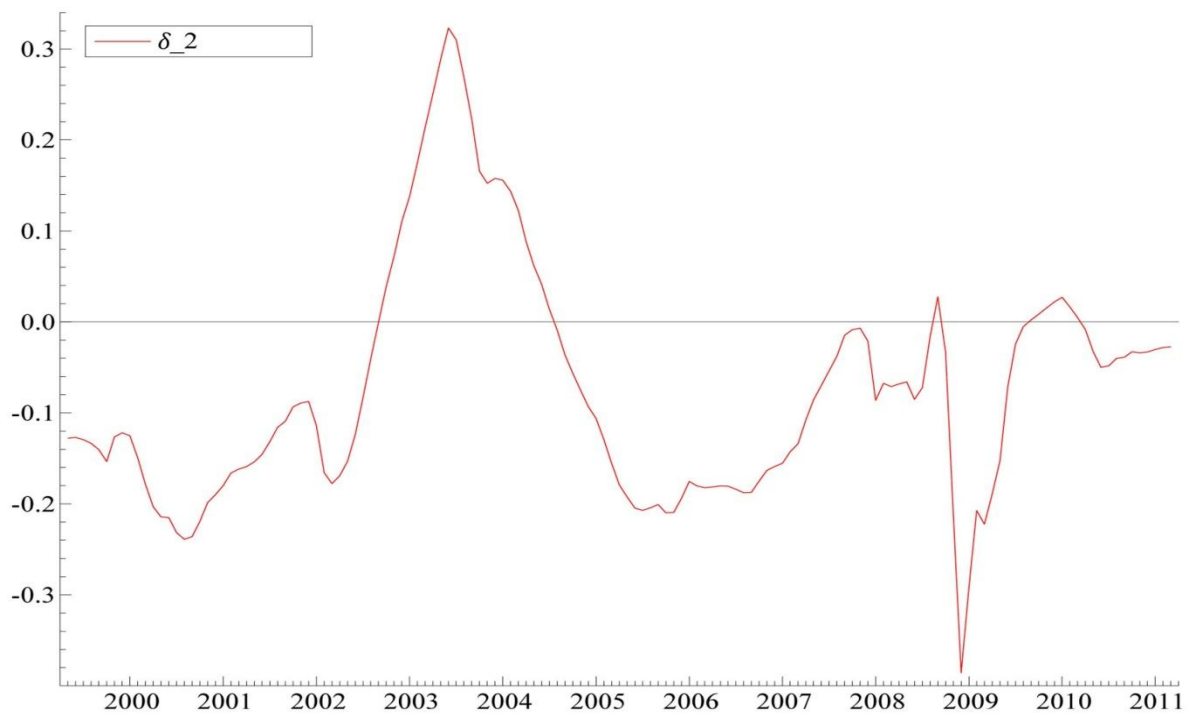


Panel e: Taylor rule estimated with time-varying coefficient for the FSI, and $m = -2$.

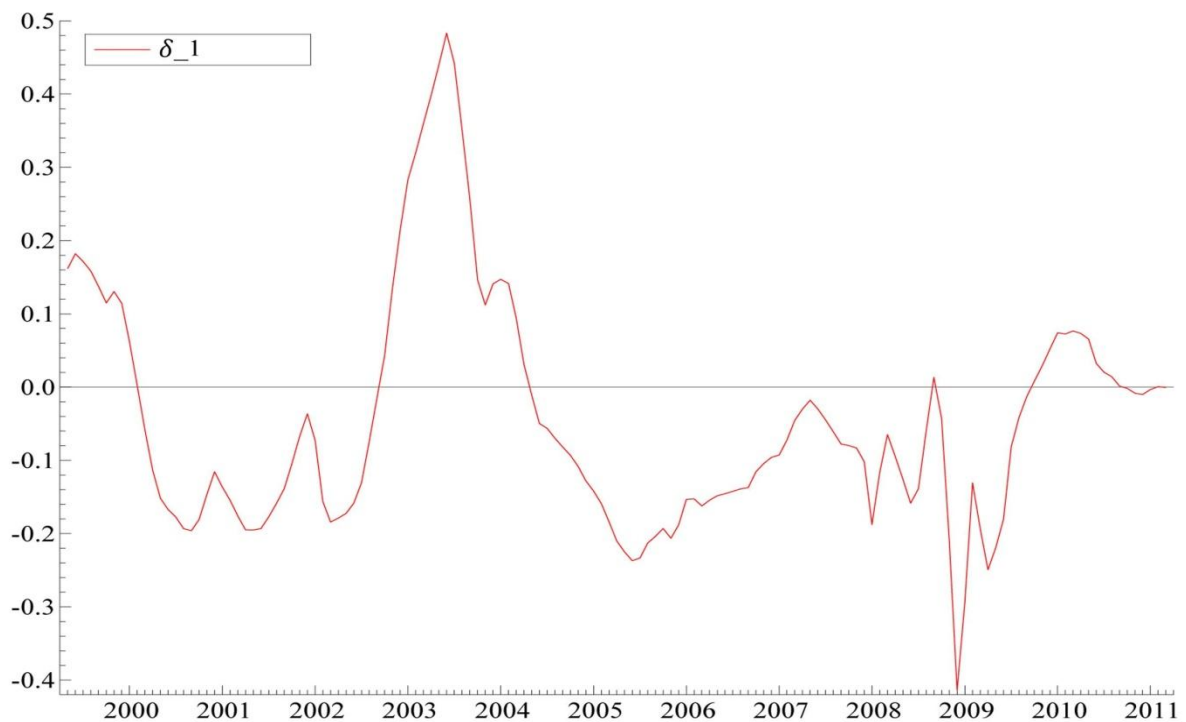


Panel f: Taylor rule estimated with time-varying coefficient for the FSI, and $m = -3$.

Figure A 3: Time-paths for all lags and leads on the financial stress index, where δ_x is the time-path of the financial stress coefficient when the financial stress index is led x periods, and δ_{-x} when the stress index is lagged x periods. The effect is estimated using the output gap constructed from production data.

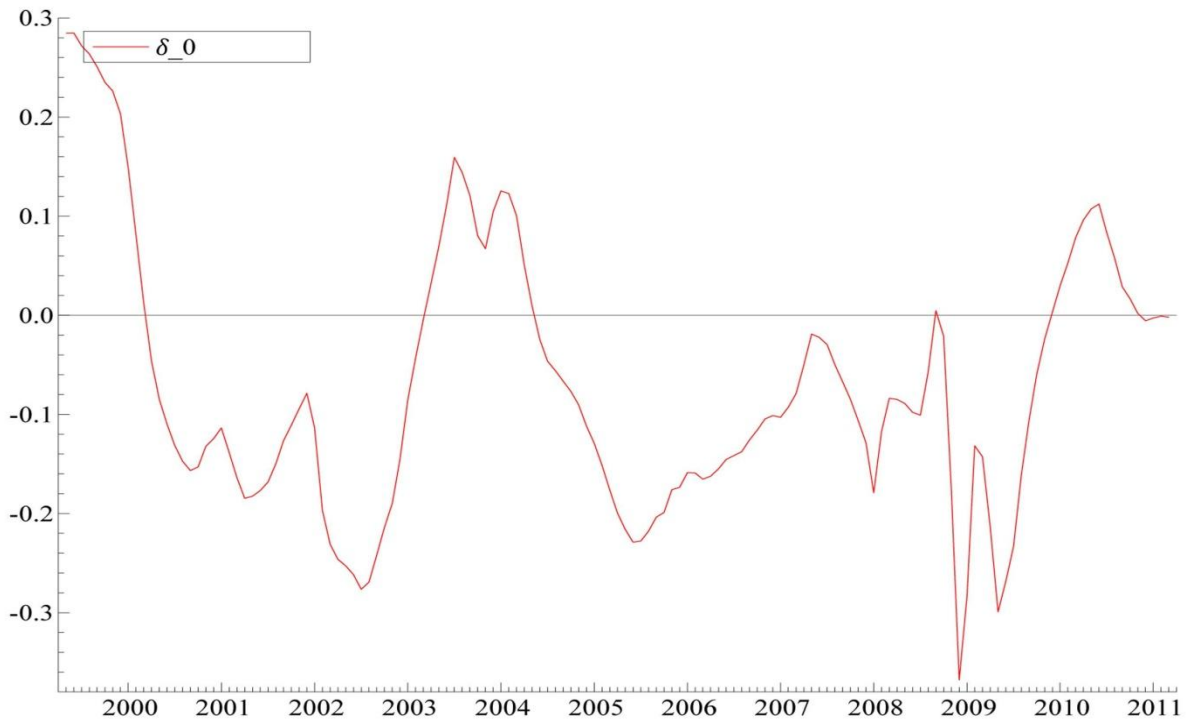


Panel a: Taylor rule estimated with time-varying coefficient for the FSI, and $m=2$.



Panel b: Taylor rule estimated with time-varying coefficient for the FSI, and $m=1$.

Figure A 4: Time-paths for all lags and leads on the financial stress index, where δ_x is the time-path of the financial stress coefficient when the financial stress index is led x periods, and δ_{-x} when the stress index is lagged x periods. The effect is estimated using the output gap proxied by the deviation of the unemployment rate from the natural rate of unemployment.

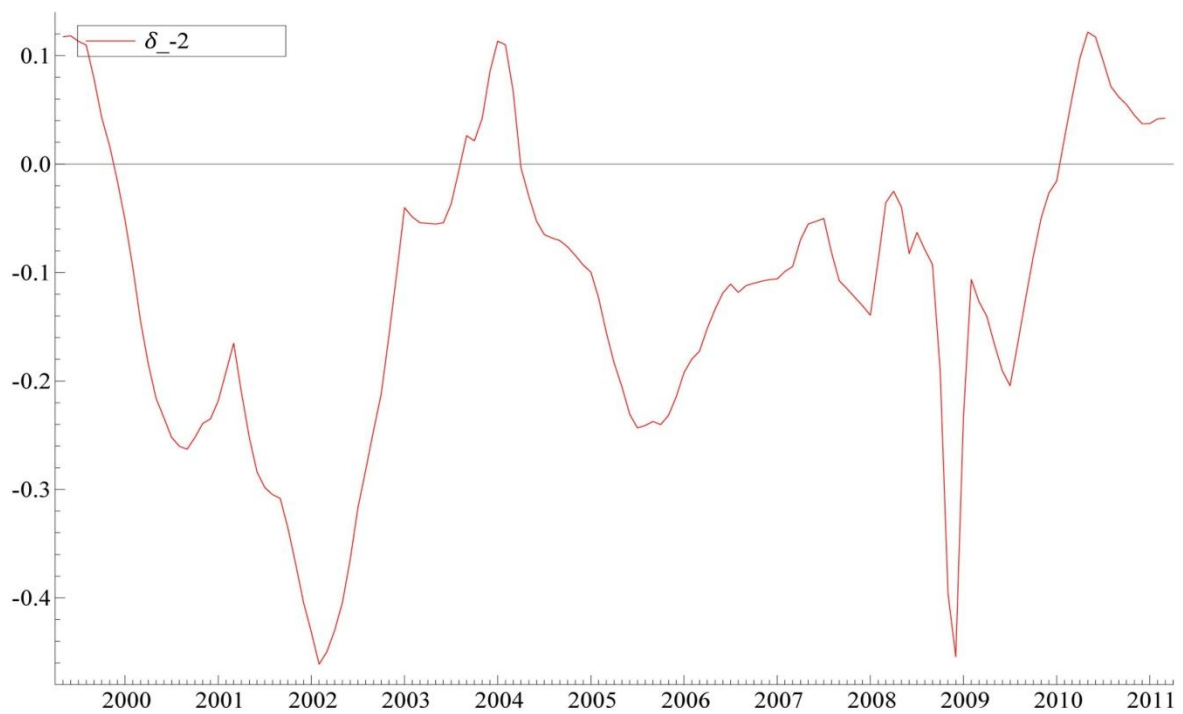


Panel c: Taylor rule estimated with time-varying coefficient for the FSI, and $m=0$.

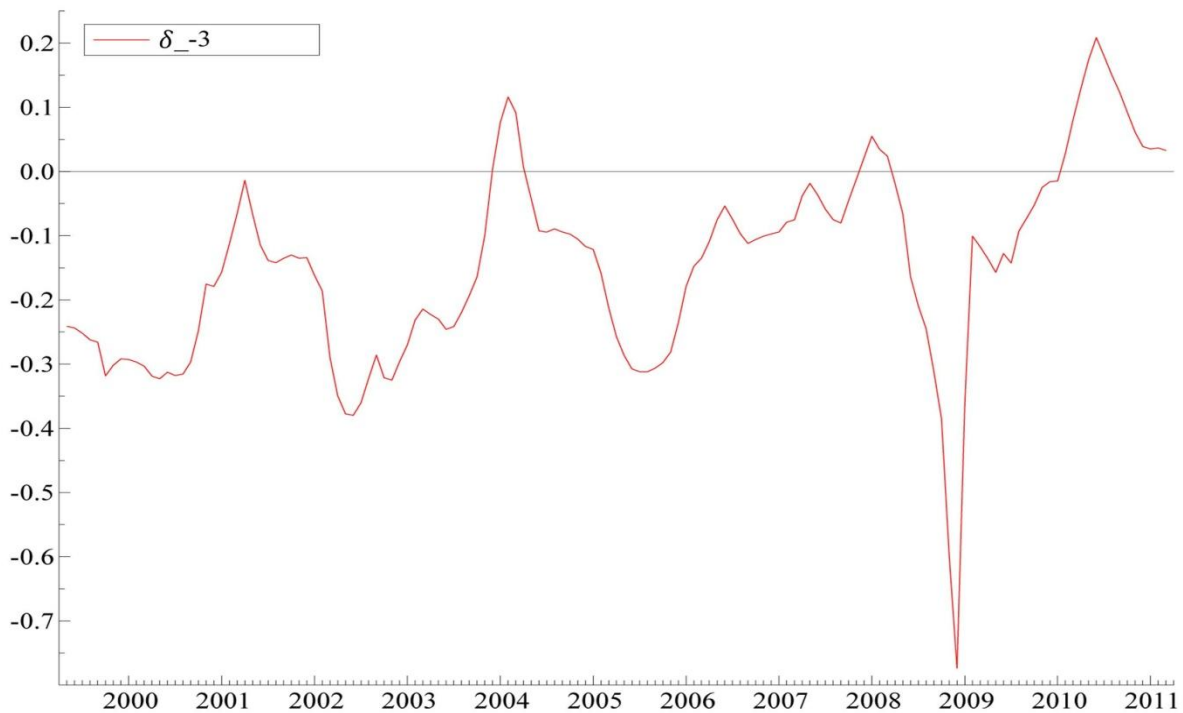


Panel d: Taylor rule estimated with time-varying coefficient for the FSI, and $m=-1$.

Figure A 5: Time-paths for all lags and leads on the financial stress index, where δ_x is the time-path of the financial stress coefficient when the financial stress index is led x periods, and δ_{-x} when the stress index is lagged x periods. The effect is estimated using the output gap proxied by the deviation of the unemployment rate from the natural rate of unemployment.



Panel e: Taylor rule estimated with time-varying coefficient for the FSI, and $m = -2$.



Panel f: Taylor rule estimated with time-varying coefficient for the FSI, and $m = -3$.

Figure A 6: Time-paths for all lags and leads on the financial stress index, where δ_x is the time-path of the financial stress coefficient when the financial stress index is led x periods, and δ_{-x} when the stress index is lagged x periods. The effect is estimated using the output gap proxied by the deviation of the unemployment rate from the natural rate of unemployment.