



**University of Lund**

Department of Economics

Master thesis

**Measuring Monetary Policy -  
A Theoretical Foundation and an Application of the Factor  
Augmented Vector Autoregressive Approach**

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### **Abstract**

This essay uses the Factor Augmented Vector Autoregressive (FAVAR) approach to quantify the effects of monetary policy. Traditional methods to estimate the effects of monetary policy, such as Vector Autoregressive (VAR) models, have yielded unsatisfactory results, mainly due to sparse information sets included in the models. Augmenting the VAR model with factors summarizing the information of a vast dataset addresses this issue. Hence, the FAVAR framework is supposed to estimate the effects of monetary policy much more accurately. The estimates of the FAVAR model show that the price puzzle is minimized, if not eliminated. Additionally, the FAVAR approach allows calculation of impulse response functions for all variables of the initial dataset. This results in a much more comprehensive picture of the economy. The FAVAR analysis is based on 95 data series from the United States, reaching from February 1960 till February 2008.

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# 1 Introduction

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This chapter contains an introduction to the topic of empirical monetary policy analysis. The purpose of the essay is given and an outline for the thesis is provided.

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## 1.1 Purpose of the thesis

The role of money has been widely discussed in economic history and its influence on the economy is ambiguous in different economic theories. Classical economists postulate the neutrality of money meaning that money has no real effect on the economy. In their paradigm the price level is the only source of influence. In contrast, Keynesian Theory assumes that monetary policy is indeed able to affect real economy through falling interest rates and raising investments (Keynes Effect). Actual economic theory postulates the neutrality of money in the long-run, however monetary policy is able to absorb economic fluctuations in the short-run.<sup>1</sup>

Accurate measurement of the effects of monetary policy is essential, both for good policy-making and for choosing among alternative macroeconomic theories.

During the evolution of empirical monetary policy analysis, several methods to quantify the effects of monetary policy have been developed. The Vector Autoregressive (VAR) approach has attracted most attention has become the workhorse of the last two decades. The outcome of the VAR approach was insufficient mostly due to incorporating too little data.

The recent literature suggests a new procedure, the Factor Augmented VAR (FAVAR) approach.<sup>2</sup>

This essay gives a brief theoretical description of the evolution of empirical monetary policy analysis, including the narrative approach and the VAR framework. The downsides of the VAR model lead to a new method - the FAVAR approach. The fundamentals of this method are explained in greater detail. Additionally, this approach is applied to a dataset consisting of 95 data series which represent the stance of the US economy. The data span the period from January 1959 through August 2001. The generated results of the VAR and FAVAR method are compared and analyzed. Finally, the results are interpreted by the use of economic theory.

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<sup>1</sup>For further information about Classical economics and Keynesian theory see Mankiw (1997).

<sup>2</sup>Pioneering work in this area was done by Belviso and Milani (2006), Bernanke and Boivin (2003), Bernanke and Mihov (1998) and Bernanke, Boivin and Elias (2005).

## 1.2 Outline

The outline of this essay is as follows:

### *Section 2: Theory and Method*

This section outlines the various approaches to estimate the effects of monetary policy. Special attention is paid to the VAR and FAVAR approaches. Additionally, the determination of an appropriate policy instrument is explained.

### *Section 3: Empirical Implementation*

The empirical implementation of the FAVAR model is explained. The implementation of the model is done in two steps: First, the factors are estimated. In a second step the FAVAR model is estimated. The data is also briefly explained.

### *Section 4: Results*

The results of the VAR model and the FAVAR approach are compared. The estimates of the FAVAR model are illustrated by means of impulse response functions. Additionally, it is argued that the FAVAR model augmented with one factor seems to yield the most appropriate results.

### *Section 5: Summary and Conclusion*

A final summary of the thesis is given in this section. Furthermore, it is explained why the FAVAR approach is superior to the VAR framework.

## 2 Theory and Method

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This section gives a review of the various approaches to measure the effects of monetary policy. Special attention is paid to the VAR approach since the FAVAR approach is generally a generalization of the former. The advantages and disadvantages of the FAVAR model are also discussed.

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### 2.1 Traditional Methods to Measure the Effects of Monetary Policy

During the last decades, the empirical analysis of monetary policy has been dominated by the VAR approach. Another mentionable method is the narrative approach developed by Romer and Romer (1989). The following section explains both approaches although the focus lies on the VAR approach, as this approach constitutes the foundation of the FAVAR model.

The narrative approach identifies monetary policy shocks by interpreting the actions of the central bank. For example, Romer and Romer examined the US Federal Open Market Committee (FOMC) meetings. They analyzed the meetings over a period of almost 30 years and investigated on the basis of the collected data the impact of monetary policy on macroeconomic data. An advantage of this approach is that the use of additional information such as policy-makers' statements of their own intentions distinguishes between monetary supply and monetary demand shocks. Unfortunately, the endogenous and exogenous components of the shocks cannot be separated, which according to today's common knowledge of monetary policy, is necessary for the identification of the effects of monetary policy on the economy.

VAR models address this issue. The VAR approach has revealed much interest in the analysis of empirical policy and gained attention in the literature. The following section explains why VAR models are widely accepted in monetary research when quantifying the effects of monetary policy.

#### 2.1.1 The VAR model

The VAR model has been widely used in the empirical analysis of monetary policy. Pioneering work in this area was done by Bernanke and Blinder (1992). The VAR framework assumes that the economy is represented by the following structural model:

$$X_t = B_1 X_{t-1} + C_0 Y_t + C_1 Y_{t-1} + u_t \quad (1)$$

$$Y_t = D_0 X_t + D_1 X_{t-1} + G_1 Y_{t-1} + v_t \quad (2)$$

where  $X_t$  is a vector of non-policy variables and  $Y_t$  is a vector of policy variables. The disturbances  $u_t$  and  $v_t$  are supposed to be orthogonal. The structural system (1)-(2) cannot be estimated without imposing restrictions.<sup>3</sup>

The vector of non-policy variables  $X_t$  usually consists of macroeconomic key variables such as Gross Domestic Product (GDP), consumer price index, producer price index, etc. whereas the vector of policy variables  $Y_t$  contains a measure of the stance of monetary policy such as the federal funds rate, monetary aggregates, the amount of non-borrowed reserves etc. Equation (2) represents the central bank's monetary policy rule. It states that the policy instrument depends on current and lagged macroeconomic variables and lagged of the policy instrument itself.

The VAR methodology has the merit not to require a complete specification of the structure of the economy. Identification of monetary shocks is sufficient for the analysis of the dynamics of the VAR model since the VAR methodology focuses on monetary policy innovations rather than on its systematic or endogenous component. The exogenous part of (2) is the disturbance term  $v_t$ . The disturbance term  $v_t$  is supposed to be orthogonal to the elements of  $X_t$ . The orthogonality assumption is referred to as the recursiveness assumption which implies that monetary policy shocks do not have any contemporaneous effects on the economy, represented by  $X_t$  in the above equation. By considering monetary policy shocks, the VAR approach fully recognizes the Lucas Critique.

### The Lucas Critique

According to Favero (2001) the purpose of VAR models is to answer questions like 'How should a central bank respond to shocks in macroeconomic variables?'. The duty of monetary authorities is not to formulate a monetary policy which aims to achieve desired levels of key macroeconomic variables such as GDP. Central banks are rather assigned to react on unanticipated economic fluctuations. Thus, VAR models are estimated to provide empirical evidence on the response of macroeconomic variables to monetary policy innovations rather than to provide a decision-support to monetary authorities during the process of monetary policy formulation.

By focusing on structural monetary policy shocks, the VAR approach fully recognizes the Lucas Critique. Lucas (1976) states that policy changes which are known in advance are adapted by rational acting citizens and accordingly, the policy action will loose its impact. Hence, economic agents are aware

<sup>3</sup>See section 3.3 for a discussion of the identifying assumptions.

of central banks intention if they plan to influence the economy. As an example, if central banks intend to stimulate the economy by expansionary policy, the individual's behaviour is influenced by the costs of expected rising inflation. Thus, the expansionary policy loses its impact and is not able to stimulate the economic activity. According to the Lucas Critique, only unanticipated monetary policy shocks can have real effects. This explanation is supported by the inconsistent effects of monetary policy. Monetary policy sometimes seems to have large output effects but at other times the effects are rather small. The varying effects of monetary policy over the years confirms the Lucas Critique that only unanticipated monetary policy shocks have real effect. Additionally, the implication that systematic monetary policy has no effects confirms the difficulties that central banks are facing in fine tuning inflation and GDP fluctuations by trying to systematically offset real shocks.

Due to the Lucas Critique, policy actions, which are endogenous response to changes in the economy, need to be separated from exogenous policy shocks. Only when the latter are identified the dynamic analysis of VAR systems yield reliable information about monetary policy. Hence, it is crucial that monetary policy shocks are appropriately identified. Otherwise the impulse response functions deduced from the VAR model are biased.

The VAR approach recognizes the fact that central banks systematically influence the economy by monetary policy rules, such as the Taylor rule, in order to provide price stability. The part of monetary policy formulation that cannot be explained by the monetary policy rule is the unanticipated or exogenous part and signifies the monetary policy shock. Formally, the error term in the monetary policy rule, the so called reaction function stated below, signifies a monetary shock:

$$Y_t = f(\Omega_t) + \epsilon_t \tag{3}$$

where  $Y_t$  is the policy instrument and  $f_t$  is a linear function that relates the policy instrument to the information set  $\Omega_t$ , which is available to the monetary authorities when the  $R_t$  is set. As discussed, the fitted values from this regression are the endogenous monetary policy actions; the residuals are the exogenous policy actions.

However, within the VAR framework the reaction function does not need to be estimated explicitly since it is included in the VAR equation. The information set in the VAR framework consists of all variables included in the VAR models except for the policy instrument. According to the equation system (1)-(2) the information set consist of  $X_t$  and lagged values of  $X_t$  and lagged values of  $Y_t$ . In a VAR model  $X_t$  is of low dimension suggesting the sparse information set. It typically includes variables representing industrial production and the price level.

Christiano, Eichenbaum and Evans (1996) explain that monetary policy shocks arise from shifts in the relative weight given to unemployment and inflation in central bank's feedback rule. These shifts could also reflect shocks to the preferences of the board members of central banks, or to weights by which their views are aggregated. Another source of exogenous shocks is of technical nature. The data available to central banks may suffer from measurement errors when deciding about monetary policy interventions or it is even not available at the date of central bank meetings.<sup>4</sup> The latter argument seems important since this issue is addressed with the FAVAR approach (see section 2.2.1).

### Identification Restrictions

The VAR methodology is also supported by Sims (1980) who illustrates that an incredible amount of identifying assumptions needs to be imposed on large scale models to connect the models with reality and to be able to estimate the models. Due to the unknown structure of the economy, imposing correct a priori restrictions seems virtually impossible. Inaccurate restrictions lead to contaminated estimates.

The VAR approach requires only a minimum of identifying assumptions. The restrictions are needed to distinguish between endogenous monetary policy actions and exogenous policy formulations. Endogenous or reactive policy responds to developments in the economy whereas exogenous policy consists of all other actions. The researcher remains agnostic about the structure of the remainder macroeconomic model. Thus, less restrictions have to be imposed and the risk of imposing inaccurate restrictions is reduced.

According to these two arguments the VAR methodology proceeds in two steps. Firstly, the monetary shocks are identified. Secondly, the response of the relevant economic variables to these monetary shocks is calculated. The identification of monetary policy shocks is done using a VAR model and the dynamic effects of these monetary policy shocks are quantified using impulse response functions.

#### 2.1.2 Achievements and Downsides of VAR Models

During the past few years the VAR literature produced consistent but somewhat controversial results not always in line economic theory.<sup>5</sup> Sims (1998) summarizes the achievements of monetary policy as follows. Firstly, most variations in the policy instruments is accounted for by responses of policy to the state of the economy, not by random disturbances to policy behavior. Secondly, responses of real variables to monetary policy shifts are modest or nil. Thirdly, monetary policy has historically increased interest

<sup>4</sup>To investigate the impact of measurement errors in the data available to central banks when deciding about monetary policy actions Bernanke and Mihov (2003) conduct monetary policy analysis with three different types of datasets: a real-time dataset and two different types of revised datasets.

<sup>5</sup>The price puzzle is an example of a controversial result. See section 2.2.1 for further information.

rates in response to nonpolicy shocks that create inflationary pressure by more than it would have under a policy of fixing the monetary stock. Finally, a reasonable picture of the effects of monetary policy shifts emerges only under the identifying assumption of delay in the reaction of certain 'sluggish' private sector variables to monetary policy shifts.

Although the VAR approach is successful in monetary policy analysis, recent research criticized the sparse information content of VAR models. The traditional monetary policy models were fairly small and did often not include more than 5 to 8 variables. Since central banks are known to be keen on interpreting the state of the economy by a vast amount of data, there is much information not reflected in the VAR model and thus a new methodology was developed that considers this shortcoming.

## 2.2 The FAVAR Methodology

The FAVAR methodology intends to eliminate the drawback of a sparse information set. The FAVAR procedure consist of two equations. To identify the monetary policy shocks a factor augmented VAR model is first uset up. This is the FAVAR, or transition, equation . The second equation relates the dataset  $X_t$  to the policy instrument  $Y_t$  and factors  $F_t$ .

### 2.2.1 The FAVAR Model

The idea behind the FAVAR approach is that the information inherent in a large dataset can be summarized by a smal set of factors which can be estimated using principal component analysis. Forecasts based on this small set of factors outperform other forecasts based in conventional methods, such as the VAR model.

As discussed, the FAVAR model consist of two equations: The first equation is a VAR model consisting of factors  $F_t$  that summarize the information contained in the dataset  $X_t$  and a vector of observed variables,  $Y_t$ . The second equation relates  $X_t$  to  $F_t$  and  $Y_t$ , and is required to determine the factors.

Let  $Y_t$  be a  $M \times 1$  vector. As mentioned earlier,  $Y_t$  contains the policy instrument and possibly other policy variables not contained in  $X_t$ , which are assumed to be known when formulating new monetary policies.

Additional economic information not captured by  $Y_t$  may be relevant. The additional information is denoted with  $X_t$  in the equation system (1)-(2). Central Banks are known to monitor a vast amount of data. This leads to a large  $X_t$ , which cannot be included in a model. Thus, the additional information is summarized by including a  $K \times 1$  vector of factors,  $F_t$ . The factors are assumed to represent economic concepts such as economic activity or financial markets, which cannot be readily captured by a few

variables. Thus, the factors summarize a wide range of economic variables.

The FAVAR equation can be written in the following way:

$$A_0 \begin{bmatrix} F_t \\ Y_t \end{bmatrix} = A(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + u_t \quad (4)$$

where  $A(L)$  is a lag polynomial of finite order  $d$ , which can contain some structural a priori restrictions.  $A_0$  is supposed to be an invertible matrix that captures the contemporaneous relations between  $Y_t$  and  $F_t$ . The error vector  $u_t$  is assumed to be mean zero with covariance matrix  $D$ .

The difference between standard VAR models and the FAVAR approach is the presence of the unobservable factors. A VAR model contains the policy variable and only a few key variables<sup>6</sup> which are assumed to influence the dynamics of the policy instrument. In contrast, the FAVAR model contains factors representing a much larger data set<sup>7</sup>. Hence, the FAVAR equation is a more realistic depiction of the economy and should therefore outperform the results from standard VAR model. The incorporation of the factors eliminates the downside of a sparse information set on which VAR models were based. Thus, all the information considered by central banks when formulating new monetary policies is reflected in the model.

The FAVAR model in (4) cannot be estimated since  $F_t$  is not observed. However, since  $F_t$  is assumed to represent the information contained in  $X_t$  it should be possible to infer something about  $F_t$  from these data. The following relationship between  $X_t$  and  $F_t$  is assumed:

$$X_t = \Lambda^f F_t' + \Lambda^y Y_t' + e_t \quad (5)$$

where  $\Lambda^f$  and  $\Lambda^y$  are factor loadings of dimension  $N \times K$  and  $N \times M$ , respectively. The errors are mean zero and largely idiosyncratic. Stock and Watson (2002) refer to equation (5) as a factor model.<sup>8</sup>

The policy instrument  $Y_t$  is assumed to be completely exogenous and controlled by the policy maker. To identify the effects of exogenous policy shocks on the various macroeconomic variables without needing to identify the entire model structure, it is sufficient to assume that policy shocks do not affect macroeconomic variables within the current period, here a month.<sup>9</sup>

<sup>6</sup>Sims (1992) includes variables for the consumer price index, the industrial production index, the index of foreign exchange value of domestic currency and a commodity index.

<sup>7</sup>The dataset could contain a couple of hundred variables. Belviso and Milani (2006) use a dataset with 205 variables.

<sup>8</sup>The implication of equation (5) that  $X_t$  depends only on the current and not on lagged values of the factors is not restrictive, since  $F_t$  can also include arbitrary lags.

<sup>9</sup>See section 3.3 for further explanation of the restrictions imposed on the model.

### 2.2.2 Why using FAVAR Models?

The small information set of the VAR model leads to two potential problems. First, to the extent that central banks respond to information not reflected in the VAR model, the measurement of policy innovations is contaminated. The classical example of this phenomena is the price puzzle discovered by Sims (1992). In the VAR framework, the price level usually does not react as predicted by theory. A contractionary monetary policy shock tends to rise inflation instead of decrease the inflation, as expected. Sims suggests that monetary authorities have information about inflation pressures that is not covered by the variables included in the VAR model. Hence, central banks recognize inflationary pressures at an earlier stage than the VAR model. If central banks know that inflationary pressure is raising they dampen the effects with a restrictive policy. Since the VAR model recognizes the inflationary pressures with a time lag, the price level in the VAR model raises after the monetary contraction although by far less than without intervention of the monetary authorities. The use of the FAVAR approach minimizes (if not eliminates) the price puzzle since much more information is incorporated.

A further downside with the VAR model is that the response of economic variables to monetary policy shocks can be calculated only for the few variables. The FAVAR approach instead allows calculation of the reaction of all macroeconomic variables contained in  $X_t$ . The reason is that all variables in the data set can be represented as linear combinations of the estimated factors. Since we can calculate the dynamic responses of the factors to policy shocks, we can also calculate impulse responses for any observed variable. Additionally, this approach enables quantification of the effects of monetary policy innovations on multiple indicators, signifying that responses can be calculated for economic concepts such as foreign factors or economic activity.

By conditioning monetary policy on a large dataset, the FAVAR approach depicts a much more realistic model and thus, more accurate and precise estimates and impulse response functions. In general, the FAVAR methodology intends to incorporate as much information as possible while keeping the advantage of parsimonious models.

An additional and probably the most crucial reason for the use of FAVAR models is that monetary authorities are faced with information constraints. Macroeconomic data is subject to multiple rounds of revisions and are never free of measurement errors. Additionally, theoretical concepts do not necessarily align well with specific data. For example, inflation hardly reflects true price fluctuations since price indexes do not reflect quality improvements, substitutions effect, etc. Hence, there is a reason to think that the central banks treats some variables as unobserved when deciding about monetary policy interventions. This implies that central banks never have distinct information about the stance of the economy when

they formulate new monetary policy actions. Under this information structure, the monetary authorities need to exploit the information in the dataset, a process that is naturally done by the FAVAR structure.

The information constraint turns out to be crucial for the monetary authorities when it comes to the empirical implementation of the model. According to Bernanke, Boivin and Elias (2005) the only variable assumed to be observed is the policy instrument. By the date of central bank meetings the only variable supposed to be truly observed is the federal funds rate, thus  $Y_t$  contains only this policy instrument. All other variables and economic indicators are supposed to be known with a time lag and their information content is exploited with the FAVAR model.  $F_t$  is assumed to summarize the information of the unknown data  $X_t$ .

### 2.2.3 Criticism of the FAVAR approach

The downside of the FAVAR approach should not be concealed. The fact that the FAVAR model and all methods based on VAR models consider only the effects of unanticipated monetary policy shocks and not the possibly more important effects of the systematic component of the monetary authorities' feedback rule, is subject to criticism among the researchers. Cochrane (1998) decomposes the impact of monetary policy in effects caused by anticipated monetary policy interventions and unexpected monetary policy shocks. He concludes that anticipated monetary policy interventions reach the maximum of influence with a shorter time lag than unanticipated shocks. Additionally, the extent of the effects of expected monetary policy formulations are smaller than with unexpected monetary policy shocks. However, the emphasis of the VAR based approach on policy innovations arises not because monetary policy shocks are essential. This is due to the fact that the dynamic response of the economy to monetary policy innovations could be traced out by a minimal set of identifying assumptions. Thus, the risk of imposing inaccurate restrictions, which would lead to biased estimates, is reduced.<sup>10</sup>

The main drawback of the FAVAR approach seems to be the fact that the factors can be difficult to interpret economically. This issue is addressed by Belviso and Milani (2006). To resolve this problem they summarize similar kinds of variables to so-called structural factors e.g. real activity factor, inflation factor, financial market factor etc. However, the advantage of an economic interpretation of the factors comes at cost of additional restrictions on the structure of the VAR. In fact, each group of structural variables in the VAR model such as the group of real activity is allowed to influence the system only through the corresponding factor.

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<sup>10</sup>See section 3.3 for a discussion about the identifying assumptions.

### 2.2.4 Choice of the Policy Instrument

Before implementing the model, a policy instrument needs to be defined in order to measure the policy shocks. There is a long tradition in monetary economics of searching for a single policy variable - perhaps a monetary aggregate perhaps an interest rate - that is controlled by central banks. Conditions for the existence of such a variable are stringent.<sup>11</sup> Unfortunately, attempts to quantify the links between central bank actions and the economy quickly run into a major roadblock: there is no consensus on how to measure the size and direction of changes in monetary policy.

However, during the evolution of monetary policy, different methods to provide price stability were applied. The two dominating strategies were monetary supply policy and inflation targeting and hence, there are two monetary policy instruments which could be considered: it could be either a monetary aggregate or an interest rate.

After the collapse of the Bretton Woods system monetary authorities intended to guarantee price stability by the method of monetary targeting. This strategy aimed at providing a robust price level by changing the growth rate of monetary aggregates. The most important instrument for influencing the supply of money was open market operations where government bonds or other securities are sold and bought. The growth rate of monetary aggregates is supposed to equalize the growth rate of the economy. The equality of these two variables led to long-run price stability if the elasticity of money demand is equal to one, that is the velocity of money does not depend on the income. This strategy, which was developed by Milton Friedman, has met with criticism. Especially the assumption of equalizing the elasticity of money to one is equivocal. It is also uncertain what type of monetary aggregate should be controlled. Is it M1, M2, M3 or the monetary base? Due to the above drawbacks, a new strategy has prevailed in the last two decades.

Currently, central banks use inflation targeting meaning that the target is to keep inflation within a desired range, e.g. not more than 2%. The instrument used for this purpose is the rate of interest. The interest rate used by the Federal Reserve System is the federal funds rate. The federal funds rate is the interest rate at which commercial banks lend balances at the Federal Reserve System to maintain their reserve requirements and it is an overnight interest rate.

Inflation targeting is conducted in three steps. First, a desired range of inflation is determined. The second step consist of an inflation forecast. According to the forecast monetary policy interventions are defined. If the forecast is above the defined range, restrictive policy actions are followed up. In case that

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<sup>11</sup>For a discussion of the conditions of a policy variable and identifying assumptions see Leeper, Sims, Zha, Hall and Bernanke (1996).

the forecast is below the range, an expansionary policy is realized.

As the previous paragraphs showed, finding an appropriate policy instrument that reflects the monetary policy over the observed period is equivocal due to the different strategies of the central banks. However, it is crucial to determine an appropriate policy instrument that allows us to unambiguously identify monetary shocks. If the shocks are not clearly identified they suffer from idiosyncratic errors. Thus, the impulse response functions which are calculated to determine the dynamic response of economic variables to shocks in monetary policy will be biased.

Bernanke and Blinder (1992) argue that the federal funds rate is an appropriate policy instrument. In their paper it is shown that the federal funds rate is superior to monetary aggregates and other interest rates, mainly due to two reasons: Firstly, the federal funds rate outperforms monetary aggregates and other interest rates when predicting macroeconomic key variables. Secondly, the federal funds rate seems to respond to Federal Reserve's perception of the state of the economy. This argument is verified by regressing the federal funds rate on lagged economic variables as in equation (2). Thus, the information content of the federal funds rate seems to be superior to monetary aggregates or other interest rates.

Bernanke and Mihov (1998) confirm that the federal funds rate is appropriate when determining an policy instrument. They have argued that monetary aggregates do not reflect monetary policy since growth rates of monetary aggregates depend on a variety of nonpolicy influences leading to an idiosyncratic component in the policy instrument. Due to the fact that monetary growth is caused by changes in money demand and money supply, it is questionable to measure the stance of monetary policy by the growth rate of these monetary aggregates. Additionally, it is explained that changes in velocity brought about by financial innovation, deregulation, and other factors are a further barrier to using money growth rates alone as a measure of the direction of policy.

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## 3 Empirical Framework

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This section addresses questions concerning the empirical implementation of the model. The estimation of the factors is discussed, the method to uncover the common space spanned by the dataset is defined and the estimation of the transition equation is also illustrated. Additionally, the data is briefly described.

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As discussed, the FAVAR model consists of the policy variable,  $Y_t$ , and factors,  $F_t$ , that summarize the data  $X_t$ . In this essay  $Y_t$  comprises a single variable, the federal funds rate. The problem is how to recover the unknown factors. There are two different methods, a two-step principal component approach and single-step Bayesian likelihood approach.

The two-step approach, which is used in this essay, provides a method to uncover the common space spanned by the factors of  $X_t$ , denoted by  $\hat{F}_t$ . These are the factor estimates. In the second step, the FAVAR equation is estimated with  $F_t$  replaced by the  $\hat{F}_t$ .

The second approach is a single-step Bayesian likelihood approach. This approach is not considered in this essay and readers are therefore referred to Bernanke, Boivin and Elias (2005) for further information.

The two approaches differ in various ways and it is not clear a priori that one should be favored to the other. The two-step approach is semi-parametric, indicating that neither distributional restriction is imposed on the observation equation (5) nor that the structure of the transition equation (4) is exploited. In contrast, the Bayesian likelihood approach is fully parametric indicating that the model needs to be fully specified. Thus, the hazard of imposing incorrect restrictions leading to contaminated estimates is avoided with the two step approach.

### 3.1 The two Step Principal Components Approach

#### 3.1.1 Estimation of the Factors

As described above, the two-step approach proceeds as follows. First, the factors are estimated, and secondly the transition equation is set up.

For the estimation of the factors, the guideline of Bai and Ng (2002) has been followed.<sup>12</sup> Their proposed procedure applies asymptotic principal components to estimate the common factors.

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<sup>12</sup>Note that the factors are obtained entirely from the observation equation.

The true number of factors is unknown albeit fixed, thus one begins with an arbitrary number  $k$  of factors ( $k < \min N, T$ ). The factors can be obtained by solving the following optimization problem:

$$V(k) = \min_{\Lambda} \frac{1}{NT} \sum_{i=1}^N \sum_{t=1}^T (X_{it} - \lambda_i^{k'} \hat{F}_t^k)^2$$

subject to the normalization of  $\lambda^{k'} \lambda^k / N = I_k$ .<sup>13</sup> Let  $F_t^k$  indicate the true common factors,  $\lambda_i^{k'}$  are the factor loadings and  $k$  is the true number of factors. It is assumed that  $r$  does not depend on the number of series,  $N$ . The normalization of the factor loadings is a usual restriction enabling unique identification of the factors.

A solution<sup>14</sup> to this minimizing problem results in the subsequent estimates of the common factors  $\bar{F}^k$

$$\bar{F}^k = \frac{(X\bar{\Lambda}^k)}{N}$$

where  $\bar{\Lambda}^k$  is given by  $\sqrt{N}$  times the eigenvectors corresponding to the  $k$  largest eigenvalues of the  $N \times N$  matrix  $X'X$ .

Finally, the factors  $\bar{F}^k$  have to be rescaled in the following way in order to obtain the final estimator of the factors

$$\hat{F}^k = \bar{F}^k \left( \frac{\bar{F}^{k'} \bar{F}^k}{T} \right)^{1/2}$$

This procedure allows calculation of the factors  $\hat{F}^k$  which are inserted in the transition.

### 3.1.2 Estimating the Number of the Common Factors

A question which arises with the empirical implementation, is how many factors should be included in the FAVAR model to properly model effects of monetary policy. Including a large number of factors improves the fit of the model, however efficiency is lost by incorporating too many factors. The usual trade-off between fit and efficiency appears. Since traditional information criteria do not account for the cross-section dimension and the time dimension, a new criterion is needed.

Bai and Ng (2002) provide several criteria to determine the number of factors present in the data.<sup>15</sup>

<sup>13</sup>The superscript of  $\lambda^k$  and  $F^k$  indicates the allowance of  $k$  factors in the estimation.

<sup>14</sup>There exists another way of solving the problem which is not discussed in this essay. For further information see Bai and Ng (2002).

<sup>15</sup>The groundbreaking paper of Bernanke, Boivin and Elias (2005) explore the sensitivity of the number of factors included in the FAVAR equation by incorporating different numbers of factors.

Their information criteria contain penalty functions accounting for both  $N$  and  $T$ . The following two criteria were proposed:

$$AIC(k) = V(k, \hat{F}^k) + k\hat{\sigma}^2 \left( 2 \frac{(N + T + k)}{NT} \right) \quad (6)$$

$$BIC(k) = V(k, \hat{F}^k) + k\hat{\sigma}^2 \left( \frac{(N + T + k)\ln(NT)}{NT} \right) \quad (7)$$

where  $V(k, \hat{F}^k)$  denotes the sum of squared residuals<sup>16</sup> and thus the fit of the model. The second part of the formulas is a penalty function which depends on both  $N$  and  $T$ . The number of factors is denoted by  $k$ .

The table below shows the AIC and BIC estimated as in (6) and (7). It advises how many factors should be included in the FAVAR equation.

No. of Factors	AIC	BIC
1	<b>427.00</b>	<b>472.47</b>
2	436.64	527.33
3	466.36	608.54
4	479.46	669.24
5	490.67	727.86
6	502.13	786.84
7	513.22	845.24
8	528.86	911.44

Table 1: Determination of the number of factors

Both information criteria show that one factor captures the information of the dataset sufficiently since both AIC and BIC are minimized when one factor is included. This is in accordance with the principal component analysis which signifies that the first factor accounts for approximately 85% of the variance of the initial dataset. Thus, one factor is supposed to summarize enough information of the initial dataset. The fact that one factor summarizes the data accurately is not surprising, since the construction of the series of the initial dataset inhere some degree of multicollinearity. However, an additional FAVAR model

<sup>16</sup>The sum of squared residuals is given by  
 $V(k, \hat{F}^k) = \min_{\Lambda} \frac{1}{NT} \sum_{i=1}^N \sum_{t=1}^T (X_{it} - \lambda_i^{k'} \hat{F}_t^k)^2$ .

consisting of three factors is set up, in order to ascertain that the information of the initial dataset is appropriately summarized and in order to illustrate the sensitivity of adding additional factors.

### 3.2 Orthogonalization of the Common Components

The first step of the principal components approach intends to uncover the common space spanned by the factors of  $X_t$ , which we denote by  $C(F_t, Y_t)$ . Since  $Y_t$  is not assumed to be observed in the first step, the first  $k$  principal components are assumed to uncover the space spanned by the estimated factors,  $\hat{C}(F_t, Y_t)$ , of the dataset  $X_t$ . When estimating the factors by use of the observation equation (5) the policy instrument  $Y_t$  is excluded and the factors are obtained from  $X_t = \Lambda^f F_t'$ . Since the fact that  $Y_t$  is observed is not exhausted when determining the factors, any of the factors  $F_t$  underlying the common space  $C(F_t, Y_t)$  could involve the policy instrument. Stated otherwise, since  $Y_t$  was disregarded when estimating the factors, any of the factors could involve the monetary policy instrument,  $Y_t$ . Thus it would not be valid to estimate a VAR model with the factors  $\hat{F}_t$  and  $Y_t$ . Instead the direct dependence of  $\hat{C}(F_t, Y_t)$  on  $Y_t$  has to be removed, this is that space not spanned by  $Y_t$  has to be determined.

To correct for the dependence of  $\hat{C}(F_t, Y_t)$  on the policy instrument, the initial data set is divided in slow- and fast-moving variables. The slow-moving variables, such as industrial production or employment, are assumed not to respond contemporaneously on monetary policy innovations within one period i.e. a month. In contrast, fast-moving variables, such as asset prices or exchange rates, are allowed to respond contemporaneously to unanticipated changes in monetary policy.

The strategy to avoid dependence of  $\hat{C}(F_t, Y_t)$  on the policy instrument  $Y_t$  is to run a multiple regression

$$\hat{C}(F_t, Y_t) = b_{C^*} \hat{C}^*(F_t) + b_Y Y_t + e_t$$

where  $\hat{C}^*(F_t)$  is an estimate of all the common components other than  $R_t$ . To obtain  $\hat{C}^*(F_t)$ , the principal components from the subset of slow-moving variables are extracted since they are not contemporaneously affected by  $Y_t$ . The factors  $F_t$  are constructed as  $\hat{C}(F_t, Y_t) - \hat{b}_R R_t$ . This method allows revelation of the common space  $\hat{C}(F_t, Y_t)$  which is not spanned by the policy variable  $Y_t$ . Hence, correlation between the factors and the policy instrument is removed.

### 3.3 Estimation of the FAVAR Equation

Unfortunately, the structural model specified in the transition equation (4) cannot be estimated although the factors are known. Suppose that the  $A'_i$ s, the  $u'_i$ s and the covariance matrix  $D$  were known, it

would not be possible to compute the dynamic response function of  $F_t$  to the fundamental shocks in the economy. The main reason is that  $u_t$  is the one-step ahead forecast error in  $F_t$  and  $Y_t$ , respectively. In general, each element of  $u_t$  reflects the effects of all the fundamental economic shocks. There is no reason to presume that any element of  $u_t$  corresponds to a particular economic shock, say for example, a shock to monetary policy.

There are two possibilities to estimate the transition equation (4). First, imposing a set of restrictions on the transition equation enables estimation of the structural VAR model, as it is indicated in equation (4). The aim of the structural VAR model is to use economic theory (rather than the Cholesky decomposition) to recover the structural innovations from the residuals of the reduced form of the VAR model. Though, this method requires imposing strong a priori restrictions in order to be able to estimate the model. Imposing inaccurate restrictions therefore leads to biased estimates. Additionally, inference drawn from a structural model are sensitive to identifying restrictions.

The second method restricts the contemporaneous relation between the factors,  $F_t$ , and the policy instrument  $Y_t$ . It intends to isolate a direct measure of the stance of the policy. This implies that a monetary policy instrument such as the federal funds rate has to be determined. Its innovations are interpreted as monetary policy shocks. The restrictions with this approach are by far less restrictive than with the structural model. Assumptions have to be made about the interaction between the monetary policy shock and the factors and the economic dataset  $X_t$ , respectively. One assumption is that the policy shock is orthogonal to these variables. Throughout, this is referred to as the recursiveness assumption and it implies that the factors respond with a time lag to monetary policy innovations. Along with linearity of the central bank's feedback rule (3), this assumption allows estimation of the policy shocks by the fitted residuals of the ordinary least squares regression of the Fed's policy instrument on the Fed's information set.<sup>17</sup>

The reduced form of the model is obtained by solving the transition equation (4) for the policy instrument  $Y_t$  and the factors  $F_t$ , this by premultiplying the transition equation with  $A_0^{-1}$ . The estimation is as below:

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = B(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + \epsilon_t \quad (8)$$

where  $B(L)$  is a lag polynomial of finite order  $d$ . The variance of  $\epsilon_t$  is given by the symmetric, positive definite matrix  $\Omega$ . The lag polynomial is consistently estimated with ordinary least squares equation

<sup>17</sup>The information set is denoted with  $\Omega$  in the Fed's feedback rule (3). The economic content of the recursiveness assumption is that the time  $t$  variables in the Fed's information set do not respond to time  $t$  realizations of the monetary policy shock.

by equation. The covariance matrix  $\Omega$  is calculated with the estimated residuals  $\epsilon_t$ . In contrast to the structural disturbances, the residuals of the reduced form of the model,  $\epsilon_t$ , are supposed to be correlated.

A comparison between the structural and the reduced form equation show that the two relations stated below are valid:

- $B_i = A_0^{-1}A_i$
- $\epsilon_t = A_0^{-1}u_t$

The left-hand-side of these two relations indicates the parameters of the reduced model which are possible to estimate. Thus, a linear relationship between the structural and reduced model is assumed.

### The Cholesky Decomposition<sup>18</sup>

A problem which arises with the reduced model is the correlation of the elements of the disturbance vector  $\epsilon_t$ . Due to the correlation the isolated impact of the elements of  $\epsilon_t$  on a variable of the model cannot be analyzed. Impulse response functions deduced from  $\epsilon_t$  are biased and lead to inappropriate conclusions. The problem is to take the observed values of  $\epsilon_t$  and to restrict the system so that  $u_t$  is recovered. It is assumed that there is a linear relation between the observed, correlated disturbances  $\epsilon_t$  and the unobserved, uncorrelated shocks  $u_t$ . As discussed, the relation is as follows:

$$u_t = A_0\epsilon_t \tag{9}$$

The issue is to restrict the system to recover the various  $u_t$  and to preserve the assumed error structure concerning the independence of the  $u_t$ .

By considering the covariance matrix of the reduced form errors and the structural disturbances, respectively, one recognizes an identification problem. It is not possible to calculate the covariance matrix  $D$  from the structural model by the use of the covariance matrix  $\Omega$  without making some assumptions. Let us have a look at the covariance matrices of both models, they are as follows:

$$\Omega = \begin{bmatrix} \epsilon_1^2 & \epsilon_1\epsilon_2 & \dots & \epsilon_1\epsilon_n \\ \epsilon_2\epsilon_1 & \epsilon_2^2 & \dots & \epsilon_2\epsilon_n \\ \vdots & \vdots & \ddots & \vdots \\ \epsilon_n\epsilon_1 & \epsilon_n\epsilon_2 & \dots & \epsilon_n^2 \end{bmatrix} \quad D = \begin{bmatrix} var(u_1) & 0 & \dots & 0 \\ 0 & var(u_2) & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & var(u_n) \end{bmatrix}$$

<sup>18</sup>The Cholesky Decomposition implies short-run restrictions on the error terms of the VAR model. This is a standard assumption in monetary policy analysis which enables transformation of the errors of the reduced form of the VAR model into structural innovations. This procedure is well explained in Bagliano and Favero (1998), Eichenbaum, Christiano and Evans (1998) and Gerke and Werner (2001)

The elements on the main diagonal of  $D$  represent the variance of the structural innovations whereas the zeros denote that the structural shocks are uncorrelated. In order to be able to estimate the impact of historical monetary policy shocks it is required that they are uncorrelated as they are in  $D$ . The matrix  $\Omega$  is symmetric and thus, the errors are correlated.  $\Omega$  therefore has to be transformed into an uncorrelated covariance matrix.

For the transformation the following relation is used:

$$\begin{aligned} D &= E[u_t u_t'] \\ &= E[A_0 \epsilon_t \epsilon_t' A_0'] \\ &= A_0 E[\epsilon_t \epsilon_t'] A_0' \\ &= A_0 \Omega A_0' \end{aligned}$$

The only matrix which can be calculated from the above relation, is the covariance matrix  $\Omega$  from the reduced VAR model. Rewriting the above relation yields:

$$\Omega = A_0^{-1} D A_0^{-1'} \tag{10}$$

where  $D$  is the covariance matrix of the structural innovations. Given that the diagonal elements of  $A_0$  are all unity,  $A_0$  contains  $n^2 - n$  unknown values.<sup>19</sup> Additionally, the covariance matrix  $D$  contains  $n$  unknown values, this are the variances of the structural errors. Thus, the structural model contains  $n^2 - n + n = n^2$  unknown elements. In contrast, the covariance matrix  $\Omega$  of the reduced model contains due to its symmetric nature only  $(n^2 + n)/2$  elements. The equation (10) is under-identified and cannot be solved. To identify the structural model from an estimated (reduced) VAR model, it is necessary to impose  $(n^2 - n)/2$  restriction on the structural model.

A method to impose restrictions is the Cholesky decomposition. The Cholesky decomposition restricts the contemporaneous effects of the innovations of the variables included in the model. In this essay this implies that the factors do not respond to monetary shocks within a month. This Cholesky decomposition implies that the  $A_0$  is a lower triangular. Since the matrix is lower triangular  $(n^2 - n)/2$  elements of  $A_0$  are set to zero and (10) is exactly identified.

Since both sides of the equation (10) are equivalent, they must be the same element by element. The structural innovations show the following pattern:<sup>20</sup>

<sup>19</sup>Note that the inverse of a lower triangular matrix is also a lower triangular.

<sup>20</sup>For a numerical example of the Cholesky decomposition it is referred to Enders (2004).

$$\begin{aligned}
u_{1,t} &= \epsilon_{1,t} \\
u_{2,t} &= a_{21}\epsilon_{1,t} + \epsilon_{2,t} \\
u_{3,t} &= a_{31}\epsilon_{1,t} + a_{22}\epsilon_{2,t} + \epsilon_{3,t} \\
&\vdots \\
u_{n,t} &= a_{n,1}\epsilon_{1,t} + a_{n-1,2}\epsilon_{2,t} + \dots + \epsilon_{n,t}
\end{aligned}$$

The previous equation system denotes that the correlated disturbances  $\epsilon$  are orthogonalized by the use of a recursive (Cholesky) structure. The Cholesky decomposition implies a causal impact of the shocks:  $u_1$  affects  $u_2$ ,  $u_2$  affects  $u_3$ , and so on. However, the converse is not true, this is that  $u_3$  has no contemporaneous effect on the previous structural disturbances. Although the recursiveness indicates that the monetary policy innovation has no direct effect of the factors, there is an indirect effect in the lagged values of the policy instrument which affect the contemporaneous value of the factors. Important is that the decomposition forces an asymmetry since not all innovations effect the variables contemporaneously. Hence, the ordering of the variables in the VAR model is crucial. The variables which are causally prior are supposed to be ordered first in the VAR model.

It may seem that the Cholesky decomposition with the causal impact of the shock as a consequence is a too restrictive assumption. However, it cannot be avoided as the model would otherwise not be possible to estimate.

### 3.4 Impulse Response Function

A VAR model consists of a large amount of parameters and thus it is difficult to identify the dynamic interaction between the variables. It is of advantage to estimate impulse response functions (IRF) where the dynamic effects are illustrated graphically. The IRF shows the dynamic effect of a structural shock on macroeconomic variables.

All stationary VAR(p) models can be illustrated as an Moving Average process of infinite order (MA( $\infty$ )), where the current value of the factors and variables is a weighted average of all historical innovations. The MA( $\infty$ ) representation is used to calculate the dynamic effects and it is as follows:

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Psi_0 \begin{bmatrix} \epsilon_{F,t} \\ \epsilon_{Y,t} \end{bmatrix} + \Psi_1 \begin{bmatrix} \epsilon_{F,t-1} \\ \epsilon_{F,t-1} \end{bmatrix} + \Psi_2 \begin{bmatrix} \epsilon_{Y,t-2} \\ \epsilon_{F,t-2} \end{bmatrix} + \dots$$

where  $\Psi_0$  is the identity matrix and the vector  $\Psi_j$  indicates the effect of an innovation at time  $t - j$  on the current value of  $F_t$  and  $Y_t$ .

The previous MA( $\infty$ ) process consist of the estimated disturbances of the reduced form of the model. As discussed, the error vector,  $\epsilon_t$ , is correlated and an isolated analysis of the effects of the disturbances is not possible. Thus, the disturbance has to be replaced with the orthogonal shocks  $u$  by the use of the relationship in (9):

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = A_0^{-1} \begin{bmatrix} u_{F,t} \\ u_{Y,t} \end{bmatrix} + A_0^{-1} \Psi_1 \begin{bmatrix} u_{F,t-1} \\ u_{F,t-1} \end{bmatrix} + A_0^{-1} \Psi_2 \begin{bmatrix} u_{Y,t-2} \\ u_{F,t-2} \end{bmatrix} + \dots$$

However, the interest lies not in the response of the unobserved factors  $F_t$ , but in the variables of the initial dataset  $X_t$  or economic concepts such as inflation or real activity. As discussed, a benefit of the FAVAR approach is that the effects of a monetary policy shock can be calculated for all variables of the initial dataset. The response of a variable of  $X_t$  to a monetary policy shock is calculated as below:

$$\frac{\partial X_{it+j}}{\partial FFR_t} = \lambda_{i,1} \frac{\partial F_{1,t+j}}{\partial FFR_t} + \dots + \lambda_{i,k} \frac{\partial F_{1,t+j}}{\partial FFR_t} \quad (11)$$

where  $\frac{\partial F_{1,t+j}}{\partial FFR_t}$  is the j-period ahead response of factor one to a shock in the federal funds rate, calculated from the MA( $\infty$ ) process consisting of the structural errors. Equation (11) enables calculation of impulse response functions for all variables of the dataset  $X_t$ .

### 3.5 The Data

The data driven FAVAR approach is based on an information rich dataset. The dataset employed in this essay consists of 95 variables and reflects all branches of the economy. The data are monthly measures and all series are transformed to induce stationarity. The dataset is described and explained in greater detail in the Appendix.

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## 4 Results

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This section provides an overview of the effects of monetary policy estimated with the VAR model and the FAVAR approach. The impact of monetary policy is quantified with a VAR model and two types of FAVAR models, either augmented with one or three factors. The results indicate that the FAVAR approach is superior to the VAR model mainly because the FAVAR model manages to minimize the price puzzle.

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The VAR part of the FAVAR approach consists of either one or three factors and includes 20 lags to capture the dynamics of the factors and the federal funds rate. The diagnostic tests of the VAR model denote that this lag length is the most appropriate. However, impulse response function from models with 10 or 15 lags yield similar results.

### Inflation

The first figure of the below three graphs illustrates the dynamic effects on inflation, which is the first difference of the Consumer Price Index (CPI). The impact of monetary policy is estimated with a standard VAR model.<sup>21</sup> The other two figures describe the dynamic response of the price level on a monetary shock, either estimated with a VAR model augmented with one factor or with three factors.<sup>22</sup>

As discussed in section 2.2.1, the most controversial result of the VAR models is that the price level raises after a contractive monetary policy, i.e. an increase in the federal funds rate. As it can be seen in the estimated graphs, contractive monetary policy innovations seem to affect the CPI with a much larger time lag in the VAR framework than it does with FAVAR models.<sup>23</sup> In the VAR model, the price level begins to decrease after approximately ten months whereas in the FAVAR augmented with one factor, the price level declines already after four months. The large time lag in the VAR model denotes the above mentioned price puzzle.

A comparison between the impulse response function of the VAR model and the FAVAR models shows that the strong price puzzle present in the VAR model is reduced in the augmented VAR model. As mentioned, the FAVAR model augmented with one factor shows that the price level begins to decrease already after around four months, a significant reduction of the price puzzle. This shows that the

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<sup>21</sup>The model consist of three variables: Consumer Price Index, Industrial Production and the federal funds rate.

<sup>22</sup>The impulse response function shows the dynamics of the economy after a one standard deviation shock to the variable of interest.

<sup>23</sup>Please note that the x-axis indicates the time measured in months.

additional information of  $X_t$ , summarized in  $F_t$ , is relevant when modeling the effects of monetary policy on the price level. The FAVAR model augmented with three factors shows an immediate negative effect (this is after the assumed time lag of one month) on the CPI after a contractive policy shock. However, this seems rather unrealistic, since the economy cannot be expected to react within a month on a policy change. Some economic branches, such as financial markets can be expected to react immediately on monetary policy news but the for the economy as a whole, a longer time lag could be assumed.<sup>24</sup>

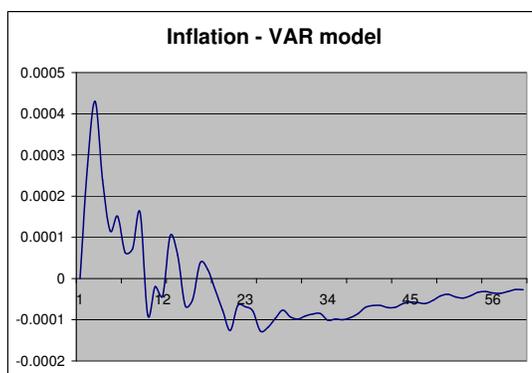


Figure 1: Dynamic Response of Inflation estimated with a VAR model

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<sup>24</sup>For further analysis of monetary policy, the model augmented with one factor will be used. This is due to the fact that the model augmented with one factor seems to be more realistic. The criterion developed by Bai and Ng (2002) also illustrates that one factor is sufficient.

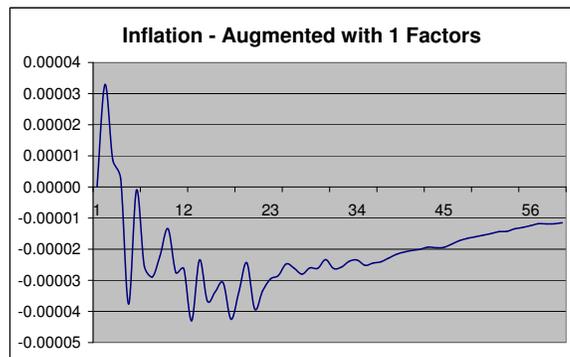


Figure 2: Dynamic Response of Inflation estimated with a FAVAR model augmented with 1 factor

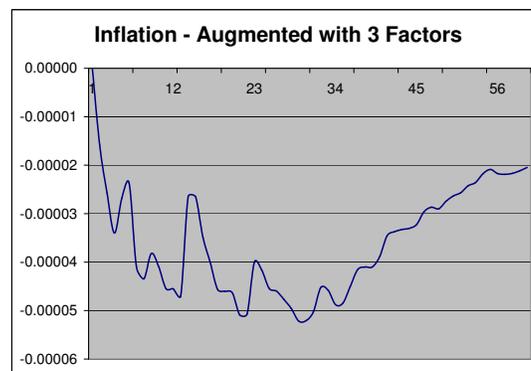


Figure 3: Dynamic Response of Inflation estimated with a FAVAR model augmented with 3 factors

A further advantage of the FAVAR framework is the possibility to quantify the effects of all variables of the dataset  $X_t$ . The following section presents an overview of the impact of a monetary policy on some

macroeconomic key variables.

### **Industrial Production**

The Federal Reserve System formulates its monetary policy mainly with respect to the anticipated inflation, but also with the economic situation in mind. The reduction of economic fluctuation is a secondary goal of the Federal Reserve System. Usually, the Industrial Production Index is used to represent the real activity of the economy. The figure shows that the economy responds with a time lag of one month to monetary policy interventions. This is due to the recursiveness assumption which was needed in order to be able to estimate the model. The first period's increase in the growth rate of industrial production is caused by the assumed time lag of one period. This indicates the lagged impact of monetary policy. After four to five months monetary policy seems to reduce economy activity since the growth rate of industrial production becomes negative. Monetary policy seems to reach its maximum impact after a period of 13 to 16 months, where the negative growth is at its lowest level. Thereafter, the growth rate begins to increase again, although it is still negative. The effect of monetary policy vanishes with the time as the growth rate of industrial production tends towards zero. This confirms economic theory stating that monetary policy is able to affect economic activity in the short run whereas its impact is not significant in the long run.<sup>25</sup>

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<sup>25</sup>Note that the graph indicates the first difference of the index, thus the growth rate of industrial production is indicated. Please note that all graphs show the first difference of the series, except the PMI series used to represent expectation on the near-term economic development.

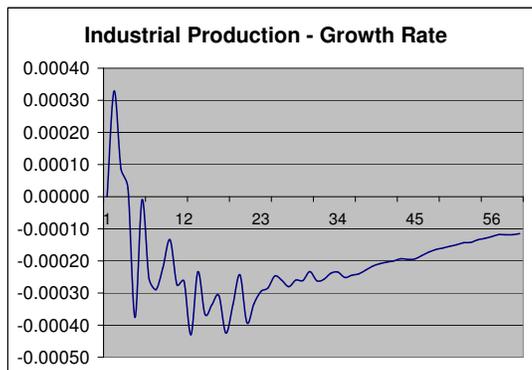


Figure 4: Dynamic Response of Industrial Production Index

The GDP could be determined by means of production or by accumulating the demand from a whole economy. The industrial production index represents the economic activity based on production. However, the GDP is often determined as  $GDP = C + I + G + NX$ . This formula calculates the GDP by accumulating the demand of private consumers  $C$ , industry  $I$  (investment), government  $G$  and the net demand from foreigners  $NX$  (net export). The two most important variables are private consumption and investment. These two concepts are represented by the following two series of the dataset: Personal Consumption Expenditure and Investment.

Let us start with personal consumption since it accounts, although it may vary among countries, for about 70% of the GDP.

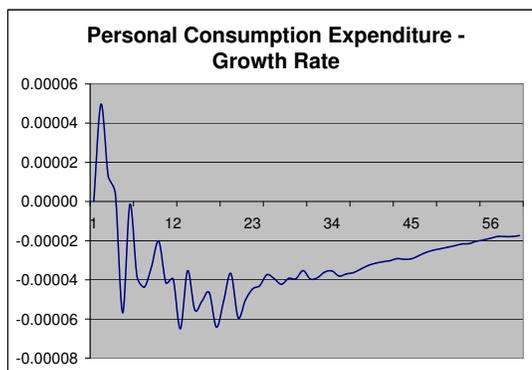


Figure 5: Dynamic Response of Personal Consumption Expenditure

The above figure shows the expected effect: The growth rate of personal consumption expenditure declines for about one to one and a half years, afterwards the effect of the shock declines and the growth rate tends towards zero. However, monetary policy does not seem to have a strong impact on personal consumption expenditure as one can see on the value of the y-axis.

According to economic theory, investment declines after a contractive intervention of the FOMC. Due to the higher interest rate money becomes more expensive and investment projects become less profitable. Hence, the investment volume decreases. The below picture shows that the growth rate of investment is negative during the first five months after an increase in the federal funds rate. Thereafter the growth rate of investment is positive, indicating that investments increase.

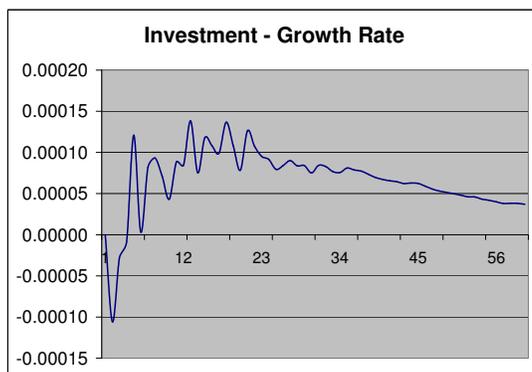


Figure 6: Dynamic Response of Investment Index

This result is somewhat surprising since the growth rate of investment begins to increase already after two months (although it remains negative for the first five months). This would imply that investors react positively to an increase in the federal funds rate. One could save this argumentation by assuming that with increased interest rates, investors expect a positive development of the economy. Therefore investments are assumed to be worthwhile even though they are more costly. This effect is coincident with the theory of expectation of John M. Keynes<sup>26</sup> where he claims that investors not only consider present factors but also expectation about the forthcoming development of the economy. This shows that investors are willing to proceed with their investment plans even though the federal funds rate raises, since increasing interest rates indicate that the economy is in a good state.

### Monetary Aggregates

Measurements of the impact of monetary policy were often biased when monetary aggregates were used as a policy instrument since they were not truly exogenous, meaning that they were also affected by a variety of nonpolicy influences, such as money demand of commercial banks. The below graph shows the dynamic response on the monetary base of a federal funds rate shock. The monetary base comprises currency (notes and coins) and commercial bank's reserves with the central bank and can also be defined as money supply. As one can see in the below figure, the monetary base' growth rate begins to decline

<sup>26</sup>For further information about the theory of expectation see Mankiw (2006).

after two to three months although it remains positive until around five months after the monetary policy intervention. Then the monetary base decreases since the growth rate is negative. After around 20 months, the growth rate of the monetary base begins to increase again and tends towards zero. It can be assumed that the policy intervention has now started to loose its impact.

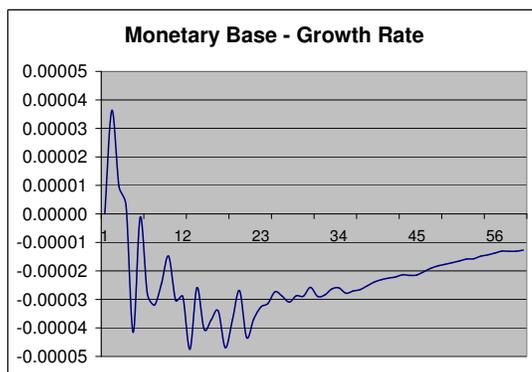


Figure 7: Dynamic Response of Monetary Base

### Financial Market

The response of financial markets on a monetary policy intervention is an open question among the researchers.<sup>27</sup> The below picture shows a decrease in the stock returns after a contractionary intervention during the first five months. Afterwards the returns increase relatively quickly and reach maximum after 18 months.

<sup>27</sup>For the interested reader, it is referred to Willem Thorbecke (1997). Thorbecke argues that expansionary monetary policy increases stock returns. However, he also presents evidence that monetary policy has no influence on stock returns.

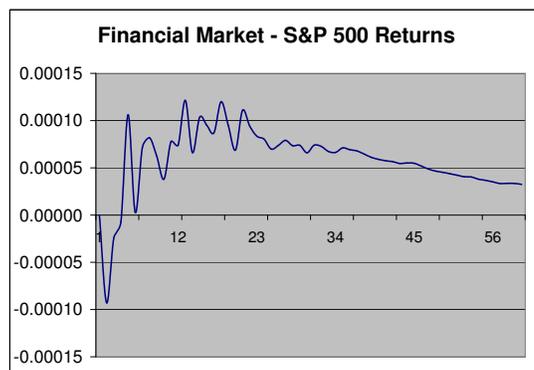


Figure 8: Dynamic Response of the Returns of the SP 500 Market Portfolio

The results are ambiguous though, as monetary policy is assumed to affect the economy not until after one month (see section 3.3). This seems rather unrealistic for financial markets since it can be expected that they respond immediately to monetary policy news. Additionally, the impact of policy interventions on financial markets seems to be of less extent compared to other variables, for example industrial production and monetary aggregates. This, in contrast to the above results picturing a decrease in the stock returns, would confirm the hypothesis that monetary policy has no impact on the financial markets.

### Expectation

The Institute for Supply Management (ISM) publishes monthly manufacturing reports on business, a long-established purchasing survey and indicator of economic trends. This is the most widely used barometers concerning the short-term economic development. The indexes are constructed so that the index figure is between 0 and 100 and a value over 50 represents a positive outlook, whereas a value below 50 indicates a slow down of the economy.

The Purchasing Manager Index (PMI) is an index of business activity and a proxy for the general business cycle. It is a weighted index of five "sub-indicators", which are extracted through surveys to more than 400 purchasing managers from all over the US. The weights of the PMI are as below:<sup>28</sup>

<sup>28</sup>The weights of the PMI are obtained from: <http://www.investopedia.com/university/releases/napm.asp>.

- Production level: 25%
- New orders (from customers): 30%
- Supplier deliveries (are they coming faster or slower?): 15%
- Inventories: 10%
- Employment level: 20%

The dynamic effects for the "sub-indicators" look similar as the response of the PMI, thus the analysis of the dynamic effect on monetary policy is only illustrated for the PMI. The following figure shows the dynamic effect on the PMI of a monetary policy shock.

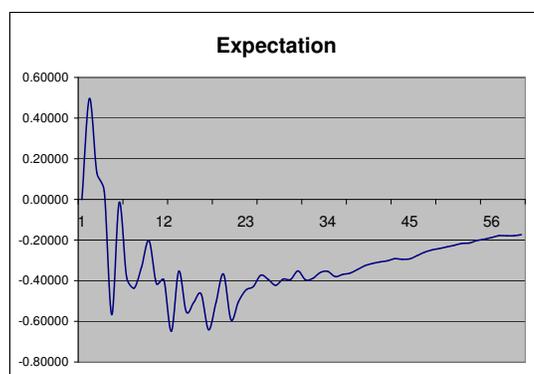


Figure 9: Dynamic Response of Purchasing Manager Index

The economic agents react positively to an increase in the federal funds rate as the contractive policy intervention signalizes that the economy could be in a good state. Thus, the consumers expect a further positive development of the economy. The positive effect of a contractionary policy on expectations is rather short since the consumers expect new information from FOMC, which meets eight times a year.

### Credit Factor

Adjustments of the federal funds rate are supposed to have a strong impact on the credit volume. Through a tightened monetary policy many investment projects become unprofitable and the demand

for commercial credits decreases. The figure shows the desired result. After the assumed time lag, the demand for credits decreases until the maximum impact is reached after 18 months. Thereafter the demand raises again and the contracting monetary policy shock loses its effect.

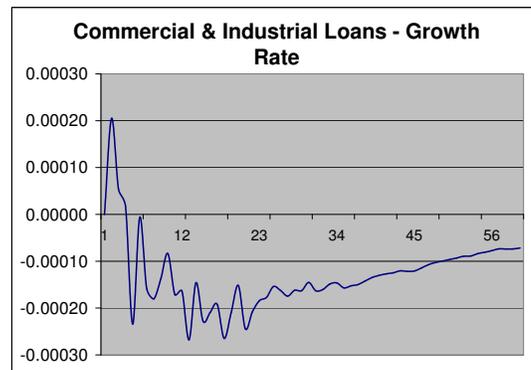


Figure 10: Dynamic Response of Commercial and Industrial Loans

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## 5 Summary and Conclusion

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This section gives a short summary about the method used in the essay and the results obtained with this method. Finally, it is explained why the FAVAR approach is preferred to the traditional VAR model.

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This essay intended to replicate the FAVAR approach, which is used to measure the effects of monetary policy. The novel contribution of this approach is that traditional VAR model are augmented with factors, which are assumed to summarize the information content of a large dataset. The factors and their number are estimated according to the procedure proposed by Bai and Ng (2002).

Traditional VAR models were not able to accurately answer the question what happens after a monetary policy shock. In the VAR framework a contractionary monetary policy is always followed by an increase in the price level. This phenomena is called the price puzzle. The price puzzle arises since the monetary authorities recognize inflation pressure much earlier than a VAR model. This is due to the fact that central banks are supposed to monitor inflation by means of a vast amount of data series, most of them not included in the VAR model. Thus, a new approach which considers the prior mentioned drawback was developed. The new model augments the standard VAR model with factors which are supposed to summarize information of a large dataset, thus the factors contain information about future inflation not captured in the VAR model.

Comparing the impulse response function on inflation of a monetary policy shock between a VAR model and a FAVAR model either augmented with one factor or with three factors shows that the FAVAR approach successfully reduces the price puzzle. The negative impact of contractionary monetary policy occurs on the price level in the VAR model after nine months, whereas in the FAVAR model augmented with one factor the price level decreases already after four months. In the FAVAR model with three factors the price level decreases immediately after a tightening monetary policy intervention. Although an immediate decrease in the price level was not expected, it seems that the factors comprehend information about forthcoming inflationary pressures. This indicates that the factors summarize information which is relevant for the monetary authorities when deciding about policy intervention.

An additional advantage is that the effects of a monetary policy shock can be calculated for all variables of the initial dataset. The impulse response functions presented in section 4 show only a little subset of all possible impulse response functions.

The results could for the most part be explained by economic theory. It seems that monetary policy is able to affect economic variables and their growth rates, respectively, in the short run. However, the

impact tends towards zero with the time. This confirms economic theory, saying that monetary policy is able to minimize short-term macroeconomic fluctuations whereas in the long-run, economic output is determined by the supply of production factors.

In general, the FAVAR gives a much more comprehensive picture of the effects of monetary policy and it therefore provides a better guideline for monetary authorities when deciding about monetary policy interventions. When it comes to determination of the effects of monetary policy, the FAVAR approach seems to be superior to the VAR model.

## References

- Bai, Jushan, and Serena Ng (2002), 'Determining the Number of Factors in Approximate Factor Models,' *Econometrica*, Vol.70, pp. 191-221
- Bagliano, Fabio C., and Carlo A. Favero (1998), 'Measuring monetary policy with VAR models: An evaluation,' *European Economic Review*, Vol. 42, pp. 1069-1112
- Belviso, Francesco, and Fabio Milani (2006), 'Structural Factor-Augmented VARs (SFAVARs) and the Effects of Monetary Policy,' *Topics in Macroeconomics*, Vol. 6, article 2
- Bernanke, Ben S., and Alan S. Blinder (1992), 'The Federal Funds Rate and the Channels of Monetary Transmission,' *American Economic Review*, Vol. 82, pp. 901-921
- Bernanke, Ben S., and Jean Boivin (2003), 'Monetary Policy in a Data-Rich Environment,' *Journal of Monetary Economics*, Vol. 50, pp. 525-546
- Bernanke, Ben S., and Ilian Mihov (1998), 'Measuring Monetary Policy,' *Quarterly Journal of Economics*, Vol. 113, pp. 896-902
- Bernanke, Ben S., Jean Boivin and Piotr Elias (2005), 'Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach,' *Quarterly Journal of Economics*, Vol. 120, pp. 382-442
- Cochrane, John H. (1998), 'What do VARs mean? Measuring the Output Effects of Monetary Policy,' *Journal of Monetary Economics*, Vol. 41, pp. 277-300
- Christiano, Lawrence J., Martin Eichenbaum and Charles Evans (1998), 'Monetary Policy Shocks: What Have We Learned and to What End?,' *NBER Working Paper No. 6400*
- Christiano, Lawrence J., Martin Eichenbaum and Charles Evans (1996), 'The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds,' *Review of Economics and Statistics*, Vol. 78, pp. 16-34
- Enders, Walter, 'Applied Econometric Time Series 2nd edition,' New York: Wiley, 2004
- Favero, Carlos A., 'Applied Macroeconometrics,' New York: Oxford University Press Inc., 2001
- Gerke, Rafael, and Thomas Werner (2001), 'Monetäre Schocks in VAR Modellen,' *Darmstadt Discussion Papers in Economics No. 106*
- Leeper, Eric M., Christopher Sims, Thao Zha, Robert E. Hall and Ben S. Bernanke (1996), 'What does Monetary Policy do?,' *Brookings Paper on Economic Activity*, Vol.1996, pp. 1-78
- Mankiw, Gregory N., 'Macroeconomics 3rd edition,' New York: Worth Publishers, 1997

- Romer, Christina D., and David H. Romer (1989), 'Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz,' *NBER Macroeconomics Annual*, Vol. 4, pp. 121-170
- Sims, Christopher A. (1998), 'Comment on Glenn Rudebuschs "Do Measures of Monetary Policy in a VAR Make Sense?"', *International Economic Review*, Vol. 39, pp. 933-941
- Sims, Christopher A. (1992), 'Interpreting the macroeconomic time series facts: The Effects of Monetary Policy,' *European Economic Review*, Vol.36, pp. 975-1000
- Sims, Christopher A. (1980), 'Macroeconomics and Reality,' *Econometrica*, Vol. 48, pp. 1-48
- Stock, James H., and Mark W. Watson (2002), 'Macroeconomic Forecasting using Diffusion Indexes,' *Journal of Business and Economic Statistics*, Vol.20, pp. 147-162
- Lucas, Robert E. Jr. (1976), 'Econometric Policy Evaluation: A Critique,' *Carnegie-Rochester Conference Series on Public Policy*, Vol.1, pp. 19-46

## A The Data

The dataset of this essay consist of 95 series. Except the hereafter mentioned exceptions all the series were taken from the Federal Reserve Economic Database (FRED). The series of the Foreign Factor and Financial Market Factor are downloaded from the Datastream database and those from the Expectation Factor are obtained from the ISM. The ISM constructs several indexes intended to reflect the near-term future of the US economy. The link to access the data is as follows:

The FRED database:

<https://research.stlouisfed.org/fred2/>

Institute for Supply Management:

<http://www.ism.ws/ISMReport/MfgROB.cfm?navItemNumber=12942>

The Datastream database:

<http://www.datastream.com/><sup>29</sup>

All series are transformed to induce stationarity. The transformation code is specified in the column denominated Trans. and it is read as follow:

1. no transformation
2. first difference
3. logarithm
4. first difference of logarithm

The results of the Unit Root test are listed in the column labeled URT. A single asterisk, ‘\*’, denotes that the hypothesis that the series contains a unit root is rejected at a 1% significance level. A double asterisk, ‘\*\*’, show that the unit root hypothesis is rejected at a 5% significance level. Finally, a triple asterisk, ‘\*\*\*’, indicates the rejection of this hypothesis on a 10% level. Depending on the transformation different deterministic components are included in the Unit Root test.

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<sup>29</sup>The access to the Datastream is restricted, thus the link to Thomson’s Datastream start page is denoted.

## Real Activity Factor

No.	Series ID	Trans.	URT	Series Description
1.	USTRAD	4	**	All Employees: Retail Trade
2.	AWHMAN	1	**	Average Weekly Hours: Manufacturing
3.	AWOTMAN	1	*	Average Weekly Hours: Overtime: Manufacturing
4.	EMRATIO	4	*	Civilian Employment-Population Ratio
5.	CIVPART	4	*	Civilian Participation Rate
6.	HOUSTMW	3	**	Housing Starts in Midwest Census Region
7.	HOUSTNE	2	*	Housing Starts in Northeast Census Region
8.	HOUSTS	3	*	Housing Starts in South Census Region
9.	HOUSTW	3	*	Housing Starts in West Census Region
10.	HOUST	3	*	Housing Starts: Total: New Privately Owned Housing Units Started
11.	IPBUSEQ	4	*	Industrial Production: Business Equipment
12.	IPCONGD	4	**	Industrial Production: Consumer Goods
13.	IPDCONGD	4	*	Industrial Production: Durable Consumer Goods
14.	INDPRO	4	*	Industrial Production Index
15.	IPMAT	4	*	Industrial Production: Materials
16.	IPNCONGD	4	*	Industrial Production: Nondurable Consumer Goods
17.	PCE	4	*	Personal Consumption Expenditures
18.	PCEPILFE	2	**	Personal Consumption Expenditures: Chain-Type Price Index Less Food and Energy
19.	PCEDG	4	*	Personal Consumption Expenditures: Durable Goods
20.	PCEND	4	*	Personal Consumption Expenditures: Nondurable Goods
21.	PCES	4	*	Personal Consumption Expenditures: Services
22.	DSPIC96	4	*	Real Disposable Personal Income
23.	PAYEMS	4	*	Total Nonfarm Payrolls: All Employees

## Credit Factor

No.	Series ID	Trans.	URT	Series Description
24.	BUSLOANS	4	*	Commercial and Industrial Loans at All Commercial Banks
25.	CONSUMER	4	*	Consumer (Individual) Loans at All Commercial Banks
26.	OTHSEC	4	*	Other Securities at All Commercial Banks
27.	REALLN	4	*	Real Estate Loans at All Commercial Banks
28.	TOTALSL	4	*	Total Consumer Credit Outstanding
29.	INVEST	4	*	Total Investments at All Commercial Banks
30.	LOANINV	4	*	Total Loans and Investments at All Commercial Banks
31.	LOANS	4	*	Total Loans and Leases at Commercial Banks
32.	NONREVSL	4	*	Total Nonrevolving Credit Outstanding

## Money Factor

No.	Series ID	Trans.	URT	Series Description
33.	BOGAMBSL	4	*	Board of Governors Monetary Base
34.	CURRSL	4	*	Currency Component of M1
35.	CURRDD	4	*	Currency Component of M1 Plus Demand Deposits
36.	DEMDEPSL	4	**	Demand Deposits at Commercial Banks
37.	EXCRESNS	2	*	Excess Reserves of Depository Institutions
38.	M1SL	4	**	M1 Money Stock
39.	M2SL	4	*	M2 Money Stock
40.	M3SL	4	*	M3 Money Stock
41.	REQRESNS	4	*	Required Reserves
42.	RESBALNS	4	*	Reserve Balances with Federal Reserve Banks
43.	SVSTCBSL	4	*	Savings and Small Time Deposits at Commercial Banks
44.	SVSTSL	4	**	Savings and Small Time Deposits - Total
45.	SVGCBSL	4	*	Savings Deposits at Commercial Banks
46.	SAVINGSL	4	*	Savings Deposits - Total
47.	STDCBSL	4	*	Small Time Deposits at Commercial Banks
48.	STDSDL	4	**	Small Time Deposits - Total
49.	TCDSL	4	**	Total Checkable Deposits

**Inflation Factor**

No.	Series ID	Trans.	URT	Series Description
50.	CPIAUCSL	4	**	Consumer Price Index For All Urban Consumers: All Items
51.	CPILEGSL	4	*	Consumer Price Index for All Urban Consumers: All Items Less Energy
52.	CPIULFSL	4	**	Consumer Price Index for All Urban Consumers: All Items Less Food
53.	PCE	4	*	Personal Consumption Expenditures
54.	PCEDG	4	*	Personal Consumption Expenditures: Durable Goods
55.	PCEND	4	*	Personal Consumption Expenditures: Nondurable Goods
56.	PCES	4	*	Personal Consumption Expenditures: Services
57.	PPICRM	4	*	Producer Price Index: Crude Materials for Further Processing
58.	PPIFCF	4	*	Producer Price Index: Finished Consumer Foods
59.	PPIFCG	4	*	Producer Price Index: Finished Consumer Goods
60.	PFCGEF	4	*	Producer Price Index: Finished Consumer Goods Excluding Foods
61.	PPIFGS	4	*	Producer Price Index: Finished Goods
62.	PPICPE	4	*	Producer Price Index Finished Goods: Capital Equipment
63.	PPIITM	4	**	Producer Price Index: Intermediate Materials: Supplies & Components
64.	OILPRICE	4	*	Spot Oil Price: West Texas Intermediate

**Interest Rate Factor**

No.	Series ID	Trans.	URT	Series Description
65.	TB3MS	2	**	3-Month Treasury Bill: Secondary Market Rate
66.	TB6MS	2	**	6-Month Treasury Bill: Secondary Market Rate
67.	GS1	2	*	1-Year Treasury Constant Maturity Rate
68.	GS3	2	*	3-Year Treasury Constant Maturity Rate
69.	GS5	2	*	5-Year Treasury Constant Maturity Rate
70.	GS10	2	*	10-Year Treasury Constant Maturity Rate
71.	AAA	2	*	Moody's Seasoned Aaa Corporate Bond Yield
72.	BAA	2	*	Moody's Seasoned Baa Corporate Bond Yield

**Foreign Factor**

No.	Series ID	Trans.	URT	Series Description
73.	USEXPRTSA	4	*	US Exports f.a.s. Currency
74.	USIMPORTA	4	*	US Imports f.a.s. Currency
75.	CNI61...	1	*	Canada Government Bond Yield - longterm
76.	CNB14007	1	*	Canada Interest Rates: 3 Month treasury Billtender
77.	CNI62...F	4	*	Canada Share Price Index
78.	UKI61...	1	*	UK Government Bond Yield - longterm
79.	JPSHRPRCF	4	*	Japan Tokyo Stock Exchange - TOPIX (EP)
80.	JPUN%TOTQ	4	*	Japan Unemployment Rate
81.	JPCONPRCF	4	*	Japan Consumer Price Index: National Measure
82.	BDGBOND.	1	*	BD Long Term Government Bond Yield (9-10 Years Maturity)
83.	BDUN%TOTR.	1	*	BD Unemployment: % Civilian Labour
84.	BDCONPRCF.	4	***	BD Consumer Price Index (PAN BD from 1991)
85.	BDPROPRCF	4	*	BD Producer Price Index Incl. Products

**Expectation Factor**

No.	Series ID	Trans.	URT	Series Description
86.	PMI	1	*	Purchasing Manager's Index
87.	NAPM_PROD	1	*	NAPM Production Index
88.	NAPM_EMPL	1	*	NAPM Employment Index
89.	NAPM_NEWORD	1	*	NAPM New Orders Index
90.	NAPM_SUPDEL	1	*	NAPM Supply Deliveries Index
91.	NAPM_INVENT	1	*	NAPM Inventories Index

**Financial Market Factor**

No.	Series ID	Trans.	URT	Series Description
92.	USOSP001F	4	*	US Share Price Index - NYSE Common Stocks
93.	USSHRPCF	4	*	US Dow Jones Industrials Share Price Index
94.	SP_INDEX	4	*	S&P Common Stock Price Index: Composite

**Federal Funds Rate**

No.	Series ID	Trans.	URT	Series Description
95.	FEDFUNDS	1	**	Effective Federal Funds Rate