

# **Optimal Monetary Policy for Postwar Iraq**

**Bedri Kamil Onur Tas and Selahattin Togay**

**Department of Economics  
TOBB University of Economics and Technology**



**Working Paper No: 08-13**  
TOBB University of Economics and Technology  
Department of Economics

**September 2008**

TOBB University of Economics and Technology Department of Economics Working Papers are published without a formal refereeing process, with the sole purpose of generating discussion and feedback.

# Optimal Monetary Policy for Postwar Iraq

Bedri Kamil Onur Taş<sup>\*†</sup> and Selahattin Togay<sup>‡</sup>

September 25, 2008

## Abstract

This paper theoretically investigates optimal monetary policy regime for post-war Iraq. We analyze macroeconomic dynamics (inflation, output and exchange rate) and credibility and reputation of the CBI under alternative monetary policy regimes. We construct a detailed and realistic model that can be used to analyze macroeconomic structure and expectation dynamics of an oil producing open economy. The simulation results indicate that an independent central bank with inflation targeting achieves credibility and reputation. The model constructed in this paper can be used to investigate oil producing open countries.

Keywords: Credibility, partial information, Kalman filter, monetary policy

JEL Classification: E42, E31, E37, E47, E52

(Preliminary Results. Please Do Not Quote.)

## 1 Introduction

Determining optimal monetary policy for postwar Iraq is non-trivial since many economic institutions and markets are not operational in Iraq and postwar conditions should be taken into account. This paper theoretically investigates the following question: What is the optimal monetary policy regime for postwar Iraq? We analyze and compare the theoretical implications of three alternative monetary policy regimes on inflation, growth, expectations, credibility and macroeconomic stability. As mentioned in Hanke and Sekerke (2003), the analyzed monetary policy alternatives are: An independent central bank, a currency board and Dollarization. While theoretically investigating these alternatives, we take into account the following conditions of postwar Iraq: 1) Incomplete financial markets 2) lack of credibility 3) oil producing country 4) expectation dynamics.

---

<sup>\*</sup>Corresponding Author, TOBB ETU Department of Economics, Email: onur-tas@etu.edu.tr

<sup>†</sup>The matlab codes for the Kalman filtering algorithm and simulations are available from the corresponding authors website, onurtas.etu.edu.tr.

<sup>‡</sup>Gazi University Department of Economics, Email:stogay@gazi.edu.tr

We extend the control-theoretic model of Svensson and Woodford (2004) and Faust and Svensson (2000) with oil price and exchange dynamics. Also, we incorporate asymmetric information and hierarchical information structure as in Townsend (1983) into the model to investigate expectation dynamics of the Central Bank of Iraq (CBI) and the private-sector. Then we solve and implement this model to investigate optimal monetary policy regime for postwar Iraq. We analyze macroeconomic dynamics (inflation, output and exchange rate) and credibility and reputation of the CBI under alternative monetary policy regimes. We construct a detailed and realistic model that can be used to analyze macroeconomic structure and and expectation dynamics of an oil producing open economy.

There are several studies like Hanke and Sekerke (2003) and Roubini and Setser (2003) that analyze and propose monetary policy for postwar Iraq. All of these studies are descriptive and do not conduct any theoretical investigations. Thus, this study is making several important contributions to the literature. First of all, this will be the first study which theoretically investigates optimal monetary policy for postwar Iraq. Second, this study contributes to the discussion of pegging the currency to export price. We construct a model of signaling and learning as in Tas (2007,2008) to investigate the changes in the expectations of the public under currency board (peg the currency to oil price). This forward-looking model allows us to analyze changes in expected inflation and output under currency board regime. Frankel and Saiki (2002), Frankel (2005) and Setser (2007) indicate that pegging to export price might be a better option and is robust to terms of trade shocks. Frankel (2003) analyze the case of Iraq and propose that Iraq should include oil to the basket of currencies to which the dinar is to be pegged. All of these studies are descriptive. This study models the arguments in these studies and theoretically investigates the implications. Finally, this study takes into account the credibility issue and the effect of different policies on expectations of the public.

## 2 Economic and Structural Conditions of Postwar Iraq

While constructing the model about economic dynamics of the postwar Iraq, we took into account the following special conditions of the country. The modeling specifics are explained in detail in section 4.

1. Incomplete financial markets: By November 2006, there are 6 state and 23 private banks in Iraq. Two state-owned banks ( Rafidain bank and Rashid bank) have a share of 80% in the banking sector. As mentioned by Looney (2005), the interbank money market is not developed in Iraq. The banking sector is about 5% of the GDP.
2. Lack of credibility: Since there is not a central bank of Iraq. CBI starts with very low credibility.

3. Oil producing country: Oil production and constructs almost 60% of GDP of Iraq. The economy of Iraq is vulnerable to resource curse and oil price shocks.
4. Expectation dynamics: Expectations of the private-sector is crucial to maintain stability and credibility of the CBI.

### 3 Monetary Policy Alternatives for Postwar Iraq

As mentioned in Hanke and Sekerke (2003), we investigated and compared three monetary policy alternatives for postwar Iraq.

An independent central bank with and without inflation targeting, a currency board and Dollarization.

## 4 The Model of Learning and Expectations Dynamics

### 4.1 Macroeconomic Dynamics of an Oil Producing Open Economy:

The generic economic dynamics of this paper is an extended and modified version of the model used in Svensson and Woodford (2004)<sup>1</sup> and Aoki (2003)<sup>2</sup>.

As in Svensson and Woodford (2004), inflation and output are determined by the following VAR(1) process<sup>3</sup> Iraq is a country where output is dominated by production of oil. As mentioned in Bayoumi and Eichengreen (1994)

In those countries, a change in relative prices is likely to show up as both an aggregate supply disturbance and an aggregate demand

---

<sup>1</sup>There are four main differences of the model in this paper and the model in Svensson and Woodford (2004) (SW). First, the the Central Bank of Iraq possesses private information in this study not the private sector. Second, asymmetric information is investigated in the context of reputation, credibility and optimal monetary policy regime for post-war Iraq. Third, the source of information asymmetry is modeled in detail. (This is required to investigate the hierarchical information structure and the learning dynamics as shown in Townsend (1983).) Fourth, the effects of asymmetric information and learning on the expectations of the public are derived and described in detail. ( SW assume a functional form for the expectations.)

<sup>2</sup>Faust and Svensson (2001) and Tas (2008a,b) also implement similar modelling specifications and solutions.

<sup>3</sup>This forward-looking structure has been used extensively in the literature and captures both contemporaneous and dynamic effects.

<sup>4</sup>The model can easily be updated to include private-sector expectation of inflation at time  $t + 1$ ,  $E(\pi_{t+1} | \Omega_t^{PRI})$  instead of current inflation expectation,  $E(\pi_t | \Omega_t^{PRI})$  in the current model. This will not change the results since private-sector expectations affect current inflation in both cases. This timing is chosen to avoid the "curse of dimensionality". The usage of  $t + 1$  expectations requires addition of higher dimensions of some variables to the state vector which exponentially increases the size of the Kalman updating equation and other vectors. Thus, Townsend (1983) uses time  $t$  expectations also. As mentioned above, this specification does not change the results but makes the analysis tractable and simpler.

disturbance. A rise in oil prices is likely to effect Indonesia, for example, both by raising the underlying level of output through the increased incentive to produce oil and by boosting aggregate demand through the favorable impact of the terms of trade on real incomes.

Thus, to take into account the changes of oil prices on the economy of Iraq and determine optimal monetary policy regime for an oil producing economy we define an AR(1) equation for the oil prices and model the responses of inflation and output to the changes in oil prices.

Rautava (2004) indicates that “over the long run, a 10% permanent increase (decrease) in international oil prices is associated with a 2.2% growth (decline) in the level of Russian GDP. In addition, a 10% real appreciation (depreciation) of the ruble is associated with a 2.7% decrease (increase) in the level of GDP in the long run.”

Exchange rate pass through: As explained in Gagnon and Ihrig (2004) exchange rate effects both inflation (exchange rate pass-through) and output.

The generic economic dynamics of the economy are as the following:

$$\pi_{t+1} = \beta_{11}\pi_t + \beta_{12}x_t + \beta_{13}E(\pi_t | \Omega_t^{PRI}) + \beta_{14}E(x_t | \Omega_t^{PRI}) + \beta_{15}OilP_t + \beta_{17}ex_t + \varepsilon_{t+1}^\pi$$

$$x_{t+1} = \beta_{21}\pi_t + \beta_{22}x_t + \beta_{23}E(\pi_t | \Omega_t^{PRI}) + \beta_{24}E(x_t | \Omega_t^{PRI}) + \beta_{25}OilP_t + \beta_{26}r_t + \beta_{27}ex_t + \varepsilon_{t+1}^x$$

$$OilP_{t+1} = \beta_{35}OilP_t + \varepsilon_{t+1}^{OilP}$$

$$ex_{t+1} = \beta_{46}r_t + \beta_{47}ex_t + \varepsilon_{t+1}^{ex}$$

The inflation, output and oil price equations can be displayed in a convenient statespace representation as the following:

$$\begin{bmatrix} \pi_{t+1} \\ x_{t+1} \\ OilP_{t+1} \\ ex_{t+1} \end{bmatrix} = \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{15} & \beta_{17} \\ \beta_{21} & \beta_{22} & \beta_{25} & \beta_{27} \\ 0 & 0 & \beta_{35} & 0 \\ 0 & 0 & 0 & \beta_{47} \end{bmatrix} \begin{bmatrix} \pi_t \\ x_t \\ OilP_t \\ ex_t \end{bmatrix} + \begin{bmatrix} \beta_{13} & \beta_{14} & 0 \\ \beta_{23} & \beta_{24} & \beta_{26} \\ 0 & 0 & 0 \\ 0 & 0 & \beta_{46} \end{bmatrix} \begin{bmatrix} E(\pi_t | \Omega_t^{PRI}) \\ E(x_t | \Omega_t^{PRI}) \\ r_t \end{bmatrix} + \begin{bmatrix} \varepsilon_{t+1}^\pi \\ \varepsilon_{t+1}^x \\ OilP \\ \varepsilon_{t+1}^{ex} \end{bmatrix} \quad (1)$$

or

$$\zeta_{t+1} = A\zeta_t + B\Upsilon_t + v_{t+1}$$

$\pi_{t+1}$  is inflation at time  $t+1$  and  $x_{t+1}$  is output at  $t+1$ .  $E(\pi_t | \Omega_t^{PRI})$  and  $E(x_t | \Omega_t^{PRI})$  are inflation and output expectations of the private sector. The

equation for inflation is a Phillips curve equation that relates inflation positively to lagged output, lagged inflation, private sector expectations of inflation and output and world oil price. The equation for output relates output to lagged inflation, output, inflation and output expectations of the private sector, the interest rate and the world oil price.  $\beta_{26}$  is assumed to be negative.  $\varepsilon_{t+1}^\pi$  is a shock to t+1 inflation at time t+1, and  $\varepsilon_{t+1}^x$  is a shock to t+1 output at time t+1. World oil price is assumed to follow an AR(1).  $\varepsilon_{t+1}^\pi$  and  $\varepsilon_{t+1}^x$  are assumed to be the sum of an autoregressive component  $\theta_{t+1}$  and a completely transitory component  $z_{t+1}$  such that,<sup>5</sup>

$$\varepsilon_{t+1}^\pi = \theta_{t+1}^\pi + z_{t+1}^\pi$$

$$\varepsilon_{t+1}^x = \theta_{t+1}^x + z_{t+1}^x$$

$\theta_{t+1}^\pi$  and  $\theta_{t+1}^x$  follow an AR(1) process as:

$$\theta_{t+1}^\pi = \rho^\pi \theta_t^\pi + e_{t+1}^\pi \quad (2)$$

$$\theta_{t+1}^x = \rho^x \theta_t^x + e_{t+1}^x \quad (3)$$

where  $\varepsilon_{t+1}^{OilP}$ ,  $e_{t+1}^\pi$ ,  $e_{t+1}^x$ ,  $z_{t+1}^\pi$ ,  $z_{t+1}^x$  are jointly normally distributed, independent among themselves and over time, with mean zero and variances  $\sigma_{OilP}^2$ ,  $\pi\sigma_e^2$ ,  $x\sigma_e^2$ ,  $\pi\sigma_z^2$  and  $x\sigma_z^2$  respectively.

## 4.2 Agents and Information Structure

The model features two agents, the Central Bank of Iraq (CBI) and a representative private-sector agent. The information structure is hierarchical since the CBI is assumed to possess private information that the private-sector agent tries to deduce by observing the CBI's actions. Hierarchical information structure and the source of asymmetric information (private signals) are modeled as in Townsend (1983).

The information structure consists of two steps:

- The CBI receives private signals about inflation and output and uses a forward-looking Taylor rule to determine the interest rate and a forward-looking rule for the inflation target (This target is announced to the public in the inflation targeting case).
- The representative private-sector agent observes the interest rate and the inflation target (in the inflation targeting case) and revises her inflation and output expectations.

---

<sup>5</sup>This specification is required to investigate the learning dynamics of the private sector. Faust and Svensson (2001) and Townsend (1983) use the same methodology to model the error terms. This error specification introduces uncertainty and learning into the system since the private sector agent does not have information about the transitory component  $z_{t+1}$ .

The CBI receives the following private signals about autoregressive components of shocks to inflation and output at time  $t$ .<sup>6</sup>

$$\pi_t \theta_t^* = \theta_{t+1}^\pi + u_t^\pi \quad (4)$$

$$x_t \theta_t^* = \theta_{t+1}^x + u_t^x \quad (5)$$

where  $u_t^\pi$  and  $u_t^x$  are jointly normally distributed, independent among themselves and over time, with mean zero and variances  $\pi \sigma_u^2$ , and  $x \sigma_u^2$ , respectively.

The private-sector agent observes the interest rate and the inflation target (in the inflation targeting case) set by the CBI. The private-sector agent is assumed to receive no signal about inflation and output.<sup>7</sup> She then forms her own expectations about future inflation and output. The expectations of the representative investor are derived in section 2.2.

### 4.3 Monetary Policy Implementation of the the Central Bank of Iraq (CBI)

After receiving the private signals mentioned above the CBI uses a forward-looking Taylor rule to determine the interest rate and the CB also determines the inflation target using its private information and announces it to the public.<sup>9</sup>

The rule for the interest rate is specified as:

$$r_t = \lambda_1^r \{E(\pi_t | \Omega_t^{CBI}) - \tilde{\pi}_t\} + \lambda_2^r E(x_t | \Omega_t^{CBI}) + \lambda_3^r r_{t-1} + \varepsilon_t^r \quad (6)$$

where  $r_t$  is the current period interest rate and  $\tilde{\pi}_t$  is the current period inflation target of the CBI.<sup>10</sup> CBI is announced to the public in the inflation targeting case.  $\Omega_t^{CBI}$  is the information set of the CBI at time  $t$ . The information set of the CB will be explained in detail in section 3.  $E(\cdot | \Omega_t^{CBI})$  denotes

<sup>6</sup>This modelling specification is used in Townsend (1983). It is needed to introduce asymmetric information and Hierarchical information structure which leads to learning and expectation formation of the private-sector agent.

<sup>7</sup>The model can be modified such that investor also receives a private signal that is different from the signal received by the Fed. In that case, we still have asymmetric information since the signals of the Fed and the representative investor are not the same. Assuming that the investor receives a signal does not change the results as the original model has asymmetric information but makes the analysis more complicated. Here I assume that the investor has no private information for the purpose of simplicity.

<sup>8</sup>Romer and Romer (2000) state that “Our estimates suggest that if they had access to the Federal Reserve’s forecast of inflation, commercial forecasters would find it nearly optimal to discard their forecasts and adopt the Federal Reserve’s.”

<sup>9</sup>Clarida, Gali, and Gertler (1999) show that approximate and in some cases exact forms of this rule are optimal for a central bank that has a quadratic loss function in deviations of inflation and output from their respective targets, given a generic macroeconomic model with nominal price inertia. The forward-looking specification allows the central bank to consider a broad array of information (beyond lagged inflation and output) to form beliefs about the future condition of the economy.

<sup>10</sup>Svensson and Woodford (2004) show that optimal policy under discretion can be characterized by a linear equation that relates the interest rate to expectations.

the CBI's expectation at time  $t$  about the next period.<sup>11</sup>  $\lambda_1^r$  and  $\lambda_2^r$  determine the response of the interest rate to the inflation and output expectations of the CBI.  $\lambda_3^r$  is the interest rate smoothing coefficient<sup>12</sup>.  $\varepsilon_t^r$  is the shock to the interest rate, which is normally distributed with mean zero and variance  $r\sigma_\varepsilon^2$  and is independent over time.

As in Gurkaynak, Sack, and Swanson (2003), the rule for the inflation target is specified as:

$$\tilde{\pi}_t = \lambda_1^{\tilde{\pi}} \{E(\pi_t | \Omega_t^{CBI})\} + \lambda_2^{\tilde{\pi}} E(x_t | \Omega_t^{CBI}) + \lambda_3^{\tilde{\pi}} \tilde{\pi}_{t-1} + \varepsilon_t^{\tilde{\pi}} \quad (7)$$

$\lambda_1^{\tilde{\pi}}$  and  $\lambda_2^{\tilde{\pi}}$  determine the response of the inflation target to the inflation and output expectations of the CBI.  $\varepsilon_t^{\tilde{\pi}}$  is the shock to the inflation target, which is normally distributed with mean zero and variance  $\tilde{\pi}\sigma_\varepsilon^2$  and is independent over time.

## 5 Expectation Dynamics

This section focuses on a highly stylized structure to illustrate the hierarchical information structure and the interplay of expectations across agents. We construct a learning model using a Kalman filter algorithm to model the information dynamics between the CBI and the private-sector agent as suggested by Townsend (1983). The modelling structure and solution of the model is inline with Svensson and Woodford (2004) and Townsend (1983). The computation of the equilibrium involves three steps: the definition of an appropriate state space, the solution of the filtering problem for each agent, and the derivation of the expectations of the CBI and the private-sector agent. The expectation dynamics of the CBI and the private-sector should be determined to be able to investigate the credibility and reputation properties of the CBI.

### 5.1 Expectations of the Central Bank of Iraq

As shown in Faust and Svensson (2000) and Townsend (1983) the Kalman filter provides the optimal solution to the public learning problem. Thus, the equations for the expectations of the CBI is found using a Kalman filtering algorithm. The CBI determines its expectations based on the information in its information set,  $\Omega_t^{CBI}$ .  $\Omega_t^{CBI} = \{\pi_{t-1}, \dots, x_{t-1}, \dots, \pi_t \theta_t^*, \pi_t \theta_{t-1}^*, \dots, x_t \theta_t^*, x_t \theta_{t-1}^*, \dots\}$ . The VAR(1) system of generic economic dynamics (Eq.1) and the private signals of the CBI (Eq. 4 and Eq.5) form a state-space representation that can be fed into the Kalman filter to obtain the CBI's expectations.

<sup>11</sup>Central banks usually forecast current inflation and output. For example, The Greenbooks of the Federal Reserve Bank contain forecasts of current inflation (gdp deflator) and current output (gdp) as well as forecasts up to six quarters ahead.

<sup>12</sup>Rudebusch (1995) provides empirical evidence on the serial correlation of interest rate changes. Goodfriend (1991) names fear of disruption of financial markets as an explanation for interest rate smoothing, and Sack (1997) mentions uncertainty about the effects of interest rate changes.

The state vector is  $\begin{bmatrix} \zeta_{t+1} \\ \theta_{t+1}^\pi \\ \theta_{t+1}^x \end{bmatrix}$ , with corresponding state equation

$$\begin{bmatrix} \zeta_{t+1} \\ \theta_{t+1}^\pi \\ \theta_{t+1}^x \end{bmatrix} = C \begin{bmatrix} \zeta_t \\ \theta_t^\pi \\ \theta_t^x \end{bmatrix} + D \begin{bmatrix} \Upsilon_t \\ 0 \\ 0 \end{bmatrix} + \nu_{t+1} \quad (8)$$

or

$$\Psi_{t+1} = C\Psi_t + D\Gamma_t + \nu_{t+1} \quad (9)$$

The CBI then observes private signals about autoregressive components of shocks to time t inflation and output at time t. So, the observation equation is

$$\begin{bmatrix} \pi_t \theta_t^* \\ x_t \theta_t^* \end{bmatrix} = \begin{bmatrix} 0_{2 \times 4} & 1 & 0 \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \zeta_t \\ \theta_t^\pi \\ \theta_t^x \end{bmatrix} + \begin{bmatrix} u_t^\pi \\ u_t^x \end{bmatrix} \quad (10)$$

or

$$z_t = H\Psi_t + \omega_t \quad (11)$$

The Kalman filtering algorithm indicates that when a system can be represented in a state-space representation form as above, the forecast equation is

$$E(\Psi_{t+1} | \Omega_{t+1}^{CBI}) = CE(\Psi_t | \Omega_t^{CBI}) + D\Gamma_t + K_t(z_t - H(CE(\Psi_t | \Omega_t^{CBI}) + D\Gamma_t))$$

Where  $K_t$  is the Kalman gain and can be expressed in  $H$ ,  $C$ ,  $D$  and  $K_t$  are presented in detail in the Appendix.

Equations (9) and (11) form a state-space representation. After application of the Kalman filter algorithm and appropriate substitutions and manipulations, the Fed's expectations about one-period ahead inflation and output can be written as:

$$E(\Psi_{t+1} | \Omega_{t+1}^{CBI}) = (C - K_t HC)E(\Psi_t | \Omega_t^{CBI}) + (D - K_t HD)\Gamma_t + K_t(H\Psi_t + \omega_t) \quad (12)$$

(Detailed description of Eq (12) is provided in the Appendix)  $(C - K_t HC)$  provides the relationship between the current and previous expectations of the CBI.  $K_t H$  delivers the connection of the current expectations of the CBI with current inflation, output, oil price, exchange rate and current shocks to inflation, and output.  $C$ , are defined in equations (7), (9), and (12) respectively. Derivations of equation (12) and  $(C - K_t HC)$  are displayed in the Appendix. By proposition 13.1 in Hamilton (1994) it can be shown that  $K_t$  converges to some constant  $K$ .<sup>13</sup> Equation (12) indicates that the CBI's inflation, output, oil price, exchange rate, autoregressive components of shocks to inflation, and output expectations are linear combinations of expectations made at the previous period, current macroeconomic variables and components of shocks to inflation and output.

<sup>13</sup> Proposition 13.1 in Hamilton (1994) is as follows: Let  $F$  be (rxr) matrix whose eigenvalues are all inside the unit circle, let  $H'$  denote an arbitrary (nxr) matrix, and let  $Q$  and  $R$

## 5.2 Expectations of the Private Sector

The results in section 5.1 provides the linear equations for CBI's expectations<sup>14</sup>. Using the result above, we now derive the expectations of the private-sector agent. The private-sector agent observes the Federal Funds rate and inflation target of the CBI (for the inflation targeting case) which is determined by the CBI's private information about future inflation and output. Thus, the private-sector agent sees a filtered version of the CBI's private information. The private-sector agent establishes her expectations based on her information set  $\Omega_t^{CBI} = \{\pi_{t-1}, \dots, x_{t-1}, \dots, \pi_t \theta_t^*, \pi_t \theta_{t-1}^*, \dots, x_t \theta_t^*, x_t \theta_{t-1}^*, \dots\}$ . Similarly, we can use a Kalman filter to obtain the private-sector agent's expectation equations.

### 5.2.1 Expectation Dynamics With Inflation Targeting

The state-space representation of the system faced by the private-sector agent under inflation targeting is as follows:

State equation:

$$G \begin{bmatrix} \Psi_{t+1} \\ E(\Psi_{t+1} | \Omega_{t+1}^{CBI}) \\ r_t \\ \tilde{\pi}_t \end{bmatrix} = C^{PRI} \begin{bmatrix} \Psi_t \\ E(\Psi_t | \Omega_t^{CBI}) \\ r_{t-1} \\ \tilde{\pi}_{t-1} \end{bmatrix} + D^{PRI} \begin{bmatrix} E(\pi_t | \Omega_t^{PRI}) \\ E(x_t | \Omega_t^{PRI}) \end{bmatrix} + \begin{bmatrix} \nu_{t+1} \\ K\omega_t \\ \varepsilon_t^r \\ \varepsilon_t^{\tilde{\pi}} \end{bmatrix} \quad (13)$$

or

$$G\Theta_{t+1} = C^{PRI}\Theta_t + D^{PRI}\Delta_t + \alpha_{t+1} \quad (14)$$

$G, C^{PRI}, D^{PRI}$  and  $\alpha_{t+1}$  are presented in detail in the appendix.

In the inflation targeting case, the private-sector agent observes the interest rate and the inflation target, so the observation equation is

$$\begin{bmatrix} r_t \\ \tilde{\pi}_t \end{bmatrix} = H^{PRI}\Theta_t + \begin{bmatrix} \varepsilon_t^r \\ \varepsilon_t^{\tilde{\pi}} \end{bmatrix} \quad (15)$$

or

$$p_t = H^{PRI}\Theta_t + \kappa_t \quad (16)$$

---

be positive semidefinite symmetric (rxr) and (nxn) matrices, respectively. Let  $\{P_{t+1|t}\}_{t=1}^T$  be the sequence of MSE matrices calculated by the Kalman filter. Then  $\{P_{t+1|t}\}_{t=1}^T$  is a monotonically nonincreasing sequence and converges as  $T \rightarrow \infty$  to a steady-state matrix  $P$ . Moreover, the steady-state value for the Kalman gain matrix, defined by

$$K \equiv FPH (H'PH + R)^{-1}$$

has the property that the eigenvalues of  $(F - KH')$  all lie on or inside the unit circle.

<sup>14</sup>Svensson and Woodford (2004) assume a structural form for the expectations and they do not differentiate between the expectations of the Central Bank and the private sector.

$H^{PRI}$  is displayed in the appendix. Applying Kalman filter to the state-space representation formed by Eq.14 and Eq.16 provide us the optimal expectations of the private sector under inflation targeting.

$$E(\Theta_{t+1} | \Omega_{t+1}^{PRI}) = (C_G^{PRI} - K_t^{PRI} H^{PRI} C_G^{PRI}) E(\Theta_t | \Omega_t^{PRI}) + (D_G^{PRI} - K_t^{PRI} H^{PRI} D_G^{PRI}) \Gamma_t + K_t^{PRI} p_t \quad (17)$$

Eq. 17 present the relationship between the private-sector agent's expectations and the actions of the CBI.

### 5.2.2 Expectation Dynamics Without Inflation Targeting

When the CBI is not exercising inflation targeting, there still is an inflation target of the CBI but the CBI does not announce that to the public. Thus, the private-sector agent needs to deduce the inflation target of the CBI from the policy actions of the CBI, in other words the interest rate determined by the CBI. Compared to the model in 5.2.1 the state equation is the same but the observation equation only contains the interest rate.

When the Central Bank does not follow an inflation target then it only determines the interest rate using its private information. The only signal that the private-sector agent receives is the interest rate. Thus, the expectations of the private-sector agent is determined by the following equation after applying the Kalman filter.

State equation (Eq.14):

$$G\Theta_{t+1} = C^{PRI}\Theta_t + D^{PRI}\Delta_t + \alpha_{t+1}$$

The private-sector agent only observes the interest rate , so the observation equation is

$$[r_t] = I^{PRI}\Theta_t + [\varepsilon_t^r] \quad (18)$$

or

$$p_t = I^{PRI}\Theta_t + \kappa_t \quad (19)$$

$I^{PRI}$  is displayed in the appendix. Applying Kalman filter to the state-space representation formed by Eq.14 and Eq.19 provide us the optimal expectations of the private sector without inflation targeting as in Eq. 17. The generic economic dynamics and the optimal expectations of the CBI and the private-sector agent complete our model. In the next section we define reputation and credibility of the CBI in the context of our model.

## 6 Reputation and Credibility of the Central Bank of Iraq

Many studies like Cukierman and Meltzer (1986) and Faust and Svensson (2001) investigate credibility and reputation of a central bank. These studies conclude that credibility and reputation of a central bank significantly effects the policy outcomes. Since the CBI will be newly established the credibility and reputation of the CBI is far more important than other older central banks. In this section we define reputation and credibility of the CBI which we analyze in the context of our model.

### 6.1 Reputation

Faust and Svensson (2001) develop and solve a similar control-theoretic model for a central bank. They show that in equilibrium the private-sector agent's best guess (optimal expectation) as to the CBI's output expectation summarizes everything the private-sector agent has learned about the central-bank preferences from economic outcomes. Thus, the private sector's output expectation,  $E(x_t | \Omega_t^{PRI})$ , summarizes the CBI's reputation at time  $t$ . When comparing the reputation of the CBI under alternative regimes, we use the private sector's output expectation,  $E(x_t | \Omega_t^{PRI})$ , as the reputation measure.

### 6.2 Credibility

As Blinder (1999) and Faust and Svensson (2001) emphasize, there are several different definitions of credibility. Cukierman and Meltzer (1986) and Faust and Svensson (2001) prefer and use the definition "average credibility of announcements". In other words, the difference of the inflation target of the central bank and the inflation expectation of the private-sector agent. Cukierman and Meltzer (1986) and Faust and Svensson (2001) assume the inflation target to be zero. Since inflation targeting is one of the monetary policy regimes that we are investigating, we follow an approach closer to reality and remove this assumption. The credibility of the CBI is defined as

$$cre_t = \tilde{\pi}_t - E(\pi_t | \Omega_t^{PRI}) \quad (20)$$

$\tilde{\pi}_t$  is the inflation target of the CBI as defined in Eq. 7.

## 7 Calibration of the Time Series Dynamics and Comparison of Alternative Regimes:

In this section, we investigate the implications of the theoretical results by representing the economy in a vector autoregression (VAR) format. The VAR format allows us to use impulse response functions. We examine the response of the system from an initial steady state to a positive, one-unit increase in the

specified variable's innovation at time  $t$ , i.e. the impulse response of the system to a specified shock. We analyze and compare the dynamics of macroeconomic variables like inflation and output and dynamics of the reputation and credibility of the CBI under alternative monetary policy regimes which are explained in section 3, discretion, inflation targeting, currency board and dollarization. The VAR representation of the whole economic dynamics is defined and calibrated under alternative regimes and impulse responses of these structural VARs are compared.

## 7.1 An Independent Central Bank with and without Inflation Targeting

Discretion and inflation targeting only differ in the transparency of the CBI, whether the CBI announces its inflation target to the public or not. Thus, the structural VAR representations of both systems are the same but the expectation equations differ as shown in section 5. To save space and avoid unnecessary repetitions we represent the same VAR format for both systems with different companion matrices. Superscript *disc* defines the coefficient matrices for discretion and *target* defines the coefficient matrices for inflation targeting.

$$[T^{disc,target}] \begin{bmatrix} \Psi_{t+1} \\ E(\Theta_{t+1} | \Omega_{t+1}^{PRI}) \\ E(\Psi_{t+1} | \Omega_{t+1}^{CBI}) \\ p_t \end{bmatrix} = [A^{disc,target}] \begin{bmatrix} \Psi_t \\ E(\Theta_t | \Omega_t^{PRI}) \\ E(\Psi_t | \Omega_t^{CBI}) \\ p_{t-1} \end{bmatrix} + [error_{t+1}] \quad (21)$$

$\Psi_{t+1}$ ,  $E(\Theta_{t+1} | \Omega_{t+1}^{PRI})$ ,  $E(\Psi_{t+1} | \Omega_{t+1}^{CBI})$  and  $p_t$  are as defined in equations 8, 13, and 15. The independent central bank also maintains a floating exchange rate compared to a pegged exchange rate.

## 7.2 Currency Board

Hanke and Sekerke (2003) explains the currency board as the following:

A currency board issues domestic currency at a fixed exchange rate with a reserve currency such as the U.S. dollar or the euro. The domestic currency is convertible on demand into the reserve currency at the fixed exchange rate, and convertibility is guaranteed because the currency board maintains 100 percent reserve currency backing of the domestic monetary base.

As explained above currency board is a pegged exchange rate and very similar to dollarization. A currency board dictates the exchange rate to be constant. So, under a currency board regime the exchange rate equation becomes,

$$ex_{t+1} = \bar{ex} \quad (22)$$

We solve and calibrate the model using the constant exchange under the currency board. The central bank is responsible for the constant exchange rate. To take into account this responsibility and constraint on the central bank, we introduce exchange rate

### 7.3 Dollarization

Many economists like Summers (2000) and Fischer (2001) proposed hard pegs for emerging economies. *Dollarization*, in the sense that the country should abandon its national currency and adopt an advanced nation’s currency as legal tender (US Dollar for Ecuador), has been implemented by many countries<sup>15</sup>. Hanke and Sekerke (2003) argue that “Two alternative monetary regimes that would work well to introduce sound money in postwar Iraq are a currency board regime and official “dollarization.””. Herrendorf (1999) investigates reputation and credibility under pegged exchange rates. He indicates that under pegging the exchange rate equals zero. The domestic money supply is endogenous and foreign inflation is imported. Thus, inflation equation is different than the independent central bank case.

$$\begin{aligned} ex_{t+1} &= 0 \\ \pi_{t+1} &= \pi_{t+1}^f \\ \pi_{t+1}^f &= \beta_f \pi_t^f + \varepsilon_{t+1}^f \end{aligned} \tag{23}$$

## 8 Impulse Response Functions

The VAR format shown above provides a convenient way of examining the response of the system from an initial steady state to a positive, one-standard-deviation impulse in specified economic shocks at date 1. Using impulse responses with calibrated coefficients<sup>16</sup> we compare reputation and credibility under alternative regimes.

### 8.1 Credibility

The simulation results of credibility is shown in figure 1. Credibility is calculated as defined in section 6.2.

<sup>15</sup>Edwards and Magendzo (2003) lists 13 independent and 15 non-independent countries for the 1970-1998 period. Ecuador undertook dollarization in 2000 and ElSalvador undertook dollarization in 2001.

<sup>16</sup>Since macroeconomic data for post-war Iraq is not available we calibrate the coefficients using studies in the literature.

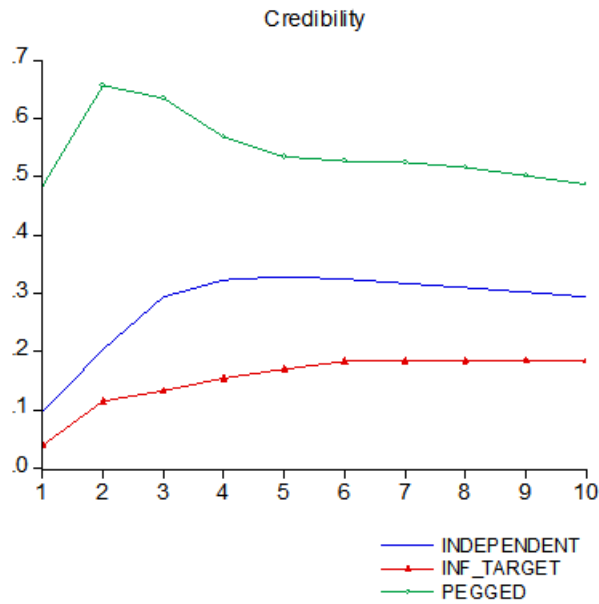


Figure 1: Credibility of Central Bank of Iraq

Higher value in the graph indicates that expectations of the private sector agent is different than the target of the CBI. Thus, the simulation results show that pegged exchange rate regime has the lowest credibility and inflation targeting regime has the highest credibility. This result is caused by the fact that the CBI can not control inflation and imports inflation of the other countries.

## 8.2 Reputation

The simulation results of reputation is shown in figure 2. Credibility is calculated as defined in section 6.1.

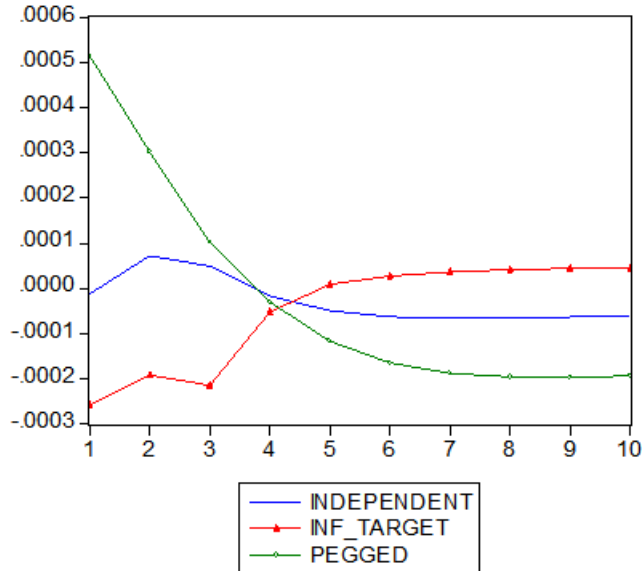


Figure 2: Reputation of Central Bank of Iraq

The simulation results give inconclusive results about the reputation of the CBI. But we can say that under pegged regime the CBI is considered to have negative emphasis on the output.

## 9 Conclusion

We construct a detailed and realistic model of macroeconomic structure and expectation (learning) dynamics for post-war Iraq to investigate optimal monetary policy regime for post-war Iraq. We analyze and compare the theoretical implications of three alternative monetary policy regimes on inflation, growth, expectations, credibility and macroeconomic stability. The analyzed monetary policy alternatives are: An independent central bank with and without inflation targeting, a currency board and Dollarization. The simulation results indicate that an independent central bank with inflation targeting achieves credibility and reputation. The model constructed in this paper can be used to investigate oil producing open countries. Future research should include the effects of monetary policy on macroeconomic factors.

## A Detailed Display of Equations

$$C = \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{15} & \beta_{17} & \rho^\pi & 0 \\ \beta_{21} & \beta_{22} & \beta_{25} & \beta_{27} & 0 & \rho^x \\ 0 & 0 & \beta_{35} & 0 & 0 & 0 \\ 0 & 0 & 0 & \beta_{47} & 0 & 0 \\ 0 & 0 & 0 & 0 & \rho^\pi & 0 \\ 0 & 0 & 0 & 0 & 0 & \rho^x \end{bmatrix}$$

$$D = \begin{bmatrix} \beta_{13} & \beta_{14} & 0 & 0 & 0 \\ \beta_{23} & \beta_{24} & \beta_{26} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \beta_{46} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$K = (CP_{t-1}C' + Q)H'(HP_{t-1}H' + R)^{-1}$$

$$P_t = E \left[ (\Psi_t - E \{ \Psi_t | \Omega_t^{PRI} \}) (\Psi_t - E \{ \Psi_t | \Omega_t^{PRI} \})' \right]$$

$$C^{PRI} = \begin{bmatrix} C & 0_{6 \times 6} \\ KH & (C - KHC) \end{bmatrix}$$

$$D^{PRI} = \begin{bmatrix} D \\ (D - KHD) \end{bmatrix}$$

## References

- [1] Aoki, Kosuke, 2000, Optimal commitment policy under noisy information, Journal of Monetary Economics 50, pp501-523.
- [2] Bayoumi, Tamim and Barry Eichengreen, 1994, One money or many? analyzing the prospects for monetary unification in various parts of the world, Princeton Studies in International Finance, 76
- [3] Blinder, Alan S., Central Bank Credibility: Why Do We Care? How Do We Build It?(June 1999). NBER Working Paper No. W7161.
- [4] Clarida, Richard, Jordi Gali and Mark Gertler, 1999, The Science of Monetary Policy - A New Keynesian Perspective, The Journal of Economic Literature, December 1999.

- [5] Cukierman, Alex, and Allan H. Meltzer (1986b), A Theory of Ambiguity, Credibility, and Inaction under Discretion and Asymmetric Information, *Econometrica* 54, 1099-1128.
- [6] Edwards, Sebastian, and I. Igal Magendzo. (2003), Dollarization and Economic Performance: What do we really know?, *International Journal of Finance and Economics*, 8: 351–363.
- [7] Faust, Jon and Lars Svensson, 2001, Transparency and Credibility: Monetary Policy with Unobservable Goals, *International Economic Review*, 42, 369-397
- [8] Fischer, Stanley. 2001, “Exchange Rate Regimes: Is the Bipolar View Correct?” *Finance and Development* 38, no. 2 (June 2001): 18–21.
- [9] Frankel, Jeffrey, 2005, Contractionary Currency Crashes in Developing Countries, NBER Working Paper No. 11508, July 2005.
- [10] Frankel, Jeffrey and Ayako Saiki, 2002, A Proposal to Anchor Monetary Policy by the Price of the Export Commodity, *Journal of Economic Integration*, 17, 417 - 448.
- [11] Goodfriend, Marvin, 1991, Interest rates and the conduct of monetary policy, *Carnegie-Rochester Conference Series on Public Policy* 34, 7-30.
- [12] Gurkaynak, Refet S., Brian Sack, and Eric Swanson, 2005, The excess sensitivity of long-term interest rates: Evidence and implications for macroeconomic model, *American Economic Review*, 95(1), 425-36.
- [13] Hamilton, James D., 1994. *Time Series Analysis*, Princeton: Princeton University Press.
- [14] Hanke, Steve H. and Matt Sekerke, 2003, Monetary Options for Postwar Iraq, *Foreign Policy Briefing*, No: 80.
- [15] Herrendorf, Berthold, 1999, Transparency, reputation and credibility under floating and pegged exchange rates, *Journal of International Economics*, 49, 31-50.
- [16] Joseph E. Gagnon and Jane Ihrig, 2004, Monetary policy and exchange rate pass-through, *International Journal of Finance & Economic*, 9: 315-338.
- [17] Looney, R (2005), “Postwar Iraq’s Financial System: Building From Scratch”, *Middle East Policy*, Spring
- [18] Rautava, Jouko, 2004, The role of oil prices and the real exchange rate in Russia’s economy—a cointegration approach, *Journal of Comparative Economics* Volume 32, Issue 2, Pages 315-327

- [19] Romer, Christina D., and David H. Romer, 2000 Federal reserve private information and the behavior of interest rates, *American Economic Review* June 90, 429-457.
- [20] Roubini, Nouriel and Brad Setser, 2003, Should Iraq dollarize, adopt a currency board or let its currency float? A policy analysis, unpublished manuscript.
- [21] Rudebusch, Glenn D., 1995, Federal reserve interest rate targeting, rational expectations, and the term structure, *Journal of Monetary Economics* 35, 245-274.
- [22] Taş, Bedri K. O., 2008a, An Explanation for the Price Puzzle: Asymmetric Information, unpublished manuscript.
- [23] Taş, Bedri K. O., 2008b, Asymmetric information, stock returns and monetary policy, unpublished manuscript.
- [24] Townsend, Robert M., 1983, Forecasting the forecasts of others, *The Journal of Political Economy* 91, 546-588.
- [25] Sack, Brian, 1997, Uncertainty and gradual monetary policy, Board of Governors of the Federal Reserve System, mimeo.
- [26] Setser, Brad, 2007, The Case for Exchange Rate Flexibility in Oil-Exporting Economies, Peterson Institute for International Economics Policy Brief, No: PB07-8.
- [27] Summers LH. 2000. International financial crises: causes, prevention, and cures. *American Economic Review* 90(2): 1-16.
- [28] Svensson, Lars, E. O., and Michael Woodford, 2004, Indicator variables for optimal policy under asymmetric information, *Journal of Economic Dynamics and Control*, 28, 661-690.