The natural rate of interest: a benchmark for the stance of monetary policy in Bolivia

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Abstract

This aim of this paper is to estimate Bolivia's natural rate of interest considering quarterly data for the period 1996 - 2017 during which changes occurred in the economic climate, affecting monetary policy and possibly the natural rate of interest, in particular an accelerated and substantial de-dollarization and strongly expansionary monetary policy over the last few years. A semi-structural model developed by Laubach and Williams (2003) is estimated, defining the natural rate of interest as the real interest rate consistent with stable inflation and output at its natural rate. In keeping with Holston, Laubach and Williams (2016), the methodology is enriched by analyzing the natural rate of interest as a time-varying process using the Kalman filter. The results reveal changes over time in the natural rate of interest, mainly from 2006, including a drop in recent years. These results have implications for monetary policy decision-making.

Key words: Natural rate of interest, monetary policy, Kalman filter.
JEL Classification: C32, E43, E52, O40.

1. INTRODUCTION

As a result of the recent economic climate, a great deal of attention was paid to monetary policy and its effects; in this regard one variable that grew in importance was the interest rate. Expansionary monetary policies led to significant interest rate drops; for years central banks closely followed benchmark rate

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fluctuations in the US, Europe and certain Asian countries. In Bolivia, adverse external circumstances led to the implementation of a countercyclical monetary policy with major unconventional or unorthodox characteristics. The expansionary approach pursued by Banco Central de Bolivia (BCB), in coordination with the government, allowed Financial System liquidity to grow to historical levels, leading to substantial decreases in monetary interest rates that were then passed on to the Financial System's interest rates.

In this regard, the big question for central banks is whether interest rates are close to (below or above) their natural rate. The answer is crucial because it sets a benchmark for the direction of monetary policy. The aim of this paper is to estimate the natural rate of interest for Bolivia for the 1996–2017 period using quarterly data, during which changes occurred in the economic climate, affecting monetary policy and possibly the natural rate of interest.

To this end, a semi-structural model developed by Laubach and Williams (2003) is estimated, defining the natural rate of interest as the real interest rate consistent with stable inflation and output at its natural rate. Following Holston, Laubach and Williams (2016), the methodology is enriched by analyzing the natural rate of interest as a time-varying process using the Kalman filter. Similarly, given the absence of a benchmark rate for monetary policy in Bolivia, a quantity-based weighted monetary interest rate (WMIR) is determined using the interest rates for monetary regulation security issues.

This paper is structured as follows: Section 2 describes the referential framework with papers written on the subject and providing a brief analysis of Bolivia's case, Section 3 describes the methodology and results of the estimations, and Section 4 contains conclusions.

2. REFERENTIAL FRAMEWORK

The natural rate of interest is a variable that is not directly observable; however, it is important for a central bank's decision-making process because it provides a benchmark for measuring the direction of monetary policy. If the short-term real interest rate is below its natural rate (negative natural rate gap), then monetary policy is expansionary. This rate provides a benchmark for measuring the direction of monetary policy, with expansionary (contractionary) policies if the real short-term interest rate is below (above) its natural rate.

There are three ways to estimate the natural rate of interest (Fuentes, 2008). Firstly, a semi-structural model and state-space analysis can be used to relate latent variables (natural rate of interest) with the ones observed using an IS curve and a Phillips curve. Laubach and William (2003) follow this strategy and are later followed by other authors for Latin American countries.

A second estimation method relies on market information, expecting the natural rate of interest to equal the market rate at some point in time. Studies such as Bomfin (2001) and Basdevant et al (2004) have been conducted in this regard. The first one uses a weighted average of rates for different terms, while the second one estimates the actual rate and a term premium (with a Kalman filter) using equations with rates for different terms.

A third option involves estimating a ratio that guarantees that the present value of capital in a certain moment in time (t, when it tends to infinity) must be zero (transversality condition). This is done using an asset approach or an estimation of the marginal product of capital from which a risk premium is subtracted.

An exercise for Chile using all three methodologies is outlined in Fuentes and Gredig (2008). The authors show that the neutral rate of interest can be calculated using a semi-structural model with information on the domestic financial market; each estimation produces similar results, despite the disparities in the methodologies.

3. METHODOLOGY AND EMPIRICAL RESULTS

3.1 Theoretical description of the model

The semi-structural model developed by Laubach and Williams (2003) is enriched by Holston, Laubach and Williams (2016) by analyzing the natural rate of interest as a process that varies over time (time-varying process) using the Kalman filter (Roberts, 2001; Edge et al., 2007; Kahn and Rich, 2007).

A useful starting point for modeling the natural rate of interest is the neoclassical growth model. As described in Galí (2008), for a representative household with CES preferences, this model implies that the natural rate of interest varies over time in response to changes in the growth rate of output and preferences. In a stationary state, the intertemporal maximization of household utility gives rise to the ratio between the real interest rate of a stationary period:

$$r^* = \frac{1}{\sigma} g_c + \theta$$

The value σ is the intertemporal elasticity of consumption substitution, g_c is the growth rate of per capita consumption, and θ is the time preference rate.

The foregoing is based on the dynamics of inflation and the product gap described by the open economy version of the neo-Keynesian model (Galí, 2008). These dynamics are summarized by a Phillips curve and an IS curve, the notation is usual and the canonical model is derived from its microfoundations by Galí (2008):

$$\pi_{H,t} = \beta E_t \left\{ \pi_{H,t+1} \right\} + \kappa \tilde{y}_t$$

$$\tilde{y}_t = E_t \left\{ \tilde{y}_{t+1} \right\} - \frac{1}{\sigma_\alpha} \left(i_t - E_t \left\{ \pi_{H,t+1} \right\} - r_t^n \right)$$

Where r_t^n is the natural rate of interest for a small, open economy:

$$r_t^n \equiv \rho - \sigma_\alpha \Gamma_a \left(1 - \rho_a \right) a_t + \frac{\alpha \Theta \sigma_\alpha \varphi}{\sigma_\alpha + \varphi} Et \left\{ \Delta y_{t+1}^* \right\}$$

However, the equations to be estimated relax certain restrictions of the neo-Keynesian model (Holston, Laubach and Williams, 2016). The equations are estimated in a reduced form; the specification incorporates shocks affecting inflation and the product gap, but not the natural rate of interest.

$$\tilde{y}_t = \sum_{j=1}^{u} a_{y,j} \tilde{y}_{t-j} + \frac{a_r}{2} \sum_{j=1}^{u} \left(r_{t-j} - r_{t-j}^* \right) + \epsilon_{\tilde{y},t}$$

$$\pi_t = b_\pi \pi_{t-1} + \left(1 + b_\pi\right)\pi_{t-2,4} + b_\pi \tilde{y}_{t-1} + \epsilon_{\pi,t}$$

$\tilde{y}_t = 100 * (\tilde{y}_t - y_t^*)$, $\tilde{y}_t$ and y_t^* are logarithms of real GDP and the unobserved natural rate of output, respectively; r_t is the real short-term interest rate, π_t is inflation and $\pi_{t-2,4}$ is the average of its second to its fourth gap. The presence of stochastic terms $\epsilon_{\tilde{y},t}$ and $\epsilon_{\pi,t}$ captures transient shocks to the product gap and inflation, while variations in r_t^* reflect persistent changes in the ratio between the real short-term interest rate and the product gap (Williams 2003).

Holston, Laubach and Williams (2016) assume a law of motion for the natural rate of interest that links it to growth in output (or consumption):

$$r_t^* = \delta g_t + z_t$$

Where g_t is the rate of growth trend of the natural rate of output and z_t groups together the set of determinants of r_t^*. Laubach and Williams (2003), among others, documents estimate δ, finding a coefficient close to one.

z_t also follows a random path:

$$z_t = z_{t-1} + \epsilon_{z,t}$$

The model follows the estimation indicated in Holston, Laubach and Williams (2016); the methodology is enriched by analyzing the natural rate of interest as a time-varying process using the Kalman filter. For this purpose, the space state specification is:

$$y_t = A' \cdot x_t + H' \cdot E_t + v_t$$

$$\varepsilon_t = F \cdot \varepsilon_{t-1} + \epsilon_t$$

Where y_t is the vector of contemporary endogenous variables, x_t is the vector of exogenous variables (including their gaps), and E_t is the unobservable states vector. Errors v_t and ϵ_t are distributed as normal, uncorrelated zero mean and covariance matrices R (diagonal matrix) and Q, respectively.

$$y_t = \left[y_t, \pi_t \right]'$$

$$y_t = \left[y_{t-1}, y_{t-2}, r_{t-1}, r_{t-2}, \pi_{t-1}, \pi_{t-2,4} \right]'$$

$$\varepsilon_t = \left[y_t^*, y_{t-1}^*, y_{t-2}^*, g_{t-1}, g_{t-2}, z_{t-1}, z_{t-2} \right]'$$

$$H' = \begin{bmatrix} 1 & -a_{y,1} & -a_{y,2} & \frac{-a_r}{2} & \frac{-a_r}{2} & \frac{-a_r}{2} & \frac{-a_r}{2} \\ 0 & -b_y & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

$$A' = \begin{bmatrix} a_{y,1} & a_{y,2} & \frac{a_r}{2} & \frac{a_r}{2} & 0 & 0 \\ b_y & 0 & 0 & 0 & b_\pi & 1-b_\pi \end{bmatrix},$$

$$F' = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix},$$

$$Q=\begin{bmatrix} \left(1+\lambda_g^2\right)\sigma_{y^*}^2 & 0 & 0 & \left(\lambda_g\sigma_{y^*}\right)^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \left(\lambda_g\sigma_{y^*}\right)^2 & 0 & 0 & \left(\lambda_g\sigma_{y^*}\right)^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \left(\dfrac{\lambda_z\sigma_{\tilde{y}}}{\sigma_r}\right)^2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

The parameters to be estimated are:

$$\phi=\left[a_{y,1},a_{y,2},a_r,b_\pi,b_y,\sigma_{\tilde{y}},\sigma_\pi,\sigma_{y*}\right]$$

3.2 The variables of the Bolivian case in the model

A relevant monetary policy-based interest rate is required in order to apply the methodology. Bolivia does not have a monetary policy rate. However, the financial system takes interest rates of monetary regulation security issues as reference. A quantity-weighted monetary interest rate (WMIR) is calculated using information from all monetary regulation operations (traditional OMOs, direct BCBs, etc.)[1]. Prior to 2006 there were securities denominated in foreign currency (FC) and in Housing Development Units (Unidad de Fomento a la Vivienda or UFV), whose rates were initially expressed in Bs (Bolivariano). The effective rate of each security was weighted by the amount issued for one month, following the rule below:

$$WMIR_t=\sum_{i=1}^{I}\omega_{i,t}*TEA_{i,t}$$

Where:

$TEA_{i,t}$: effective rate of security i expressed in Bs in month t.

[1] The instruments included are: Traditional Open Market Transactions in MN, FC and UFV, Reclaimable Securities in MN, Monetary Regulation Deposits in MN, Supplementary Reserves in MN, Certificates of Deposit in MN, Direct BCB Securities in MN (which include Christmas, Anniversary and traditional direct BCB bonds).

$$\omega_{i,t} = \frac{A_{i,t}}{\sum_{i=1}^{I} A_{i,t}}$$: weighting factor of quantity of security i in month t.

$A_{i,t}$ corresponds to the quantity of security i issued at time t.

The results show the trend of WMIR which corresponds to the direction followed by monetary policy, especially since 2006 when monetary policy implementation improved. This situation can be seen more clearly in Figure 1 when contrasted with monetary regulation securities.

Economic activity in recent years has been characterized by buoyant domestic demand, due mainly to increased public spending. At the same time, revenues from natural gas and mineral exports have been relevant. Inflation remained stable at low levels, except for some episodes of inflationary pressure in 2008 and 2011 due to supply factors that were later corrected (Figure 2). One of the factors that affected the Bolivian economy's performance in recent years is the accelerated process of remonetization starting since the mid-2000s. This situation affected monetary policy; since 2006 securities were issued in national currency which, together with the accelerated de-dollarization of deposits and loans, helped improve the implementation of monetary policy (Figure 1).

The model does not include monetary policy equations because both the weighted interest rate and inflation already incorporate monetary policy measures.

3.3 Results

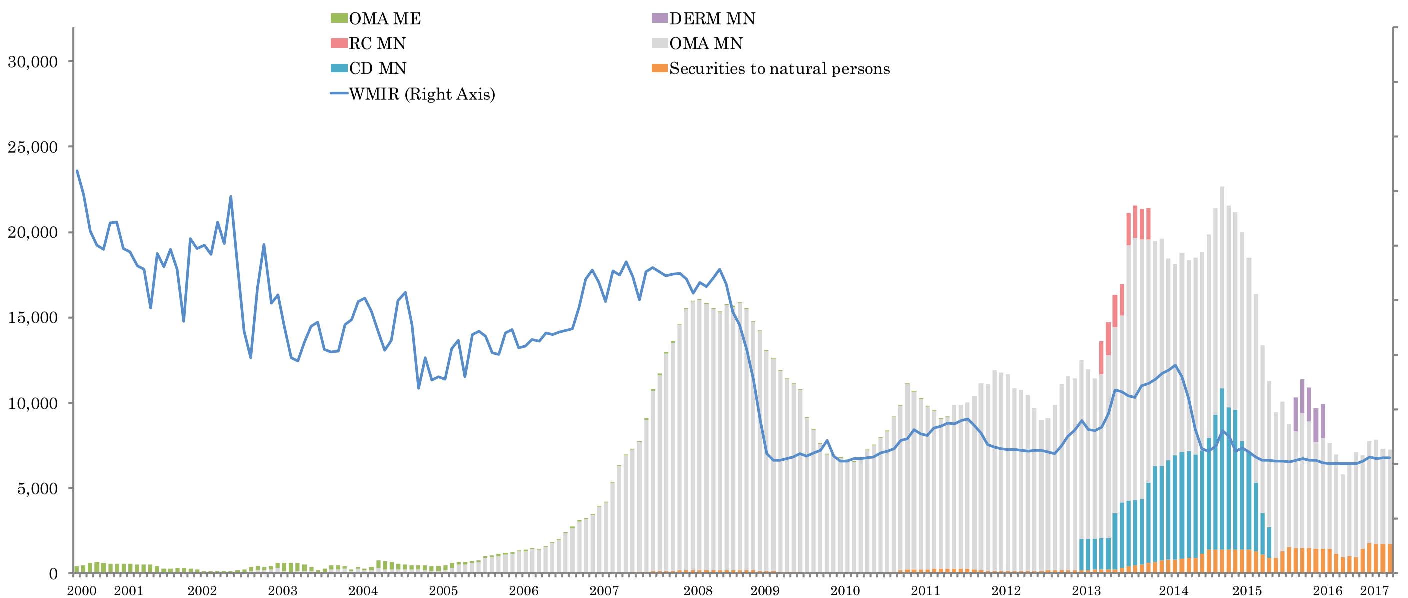
The results indicate that the real natural interest gap in recent years was negative. In the 1990s and early 2000s, the interest rate was above the natural rate; it seems that monetary policy was too contractionary. The explanation is that monetary policy implementation was weak due to high dollarization, among other factors. During those years the Central Bank issued securities in FC, and deposits and loans in the Financial System were mostly FC-denominated. This behavior deprived the Central Bank of a significant degree of freedom to direct monetary policy.

In recent years the rate gap indicates the expansionary slant of monetary policy, especially since the end of 2014 when growth led to historical levels of liquidity in the Financial System that turned into available resources to continue vitalizing private credit. During the same period,

Figure 1

WEIGHTED MONETARY INTEREST RATE (WMIR) AND MONETARY REGULATION SECURITIES

Percentages and millions of Bs

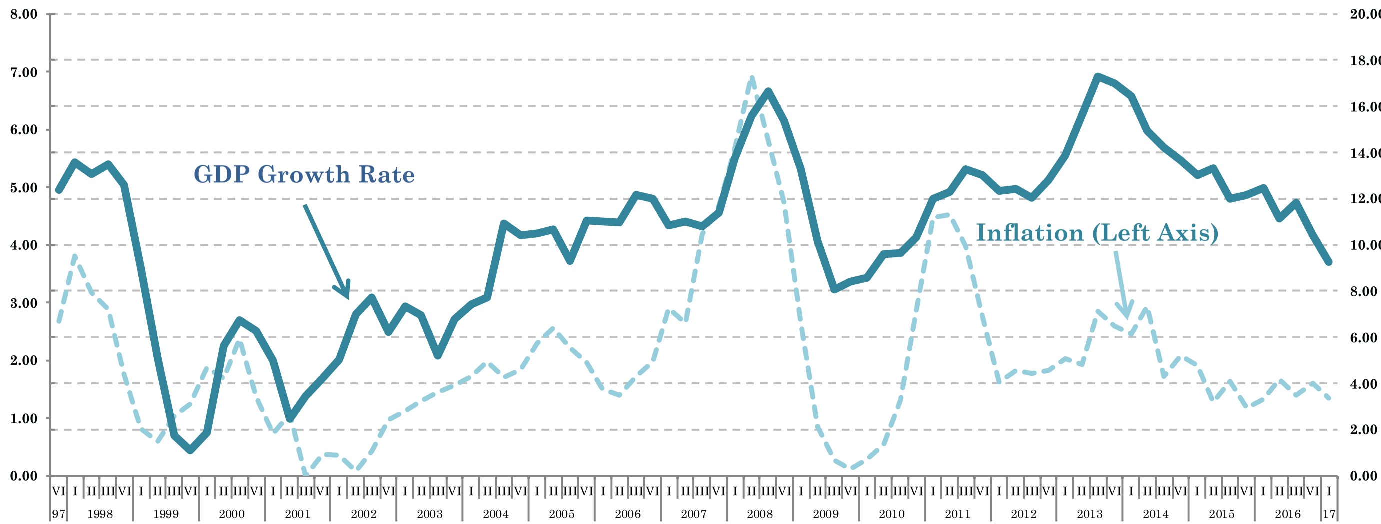


Source: Banco Central de Bolivia - Instituto Nacional de Estadística (National Statistics Institute).

Figure 2

YEAR-ON-YEAR GDP AND INFLATION GROWTH RATES

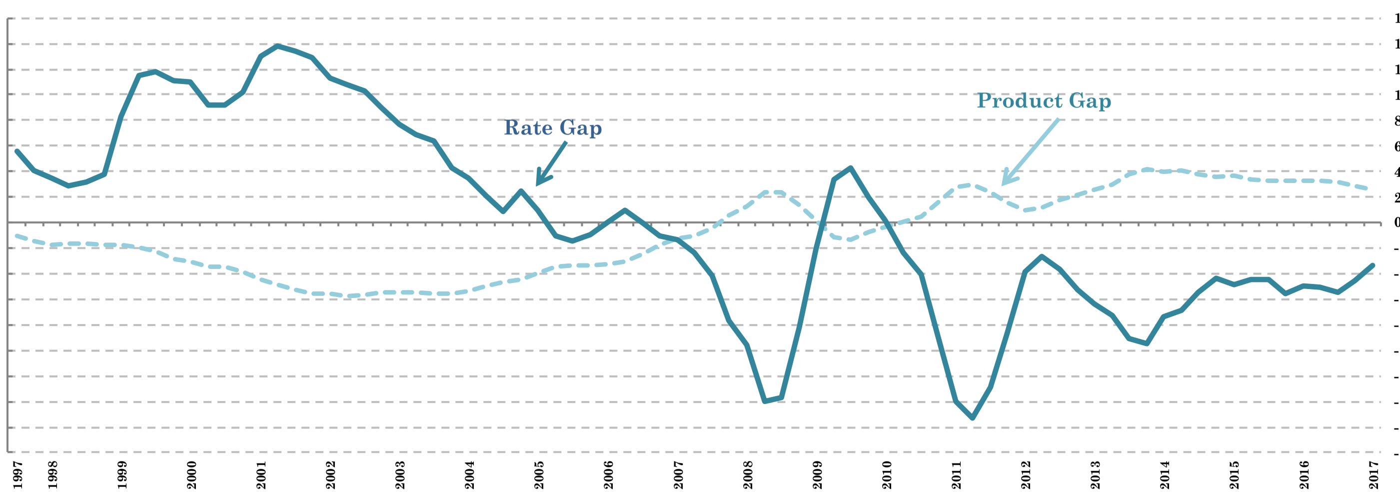
Percentage



Source: Banco Central de Bolivia – Instituto Nacional de Estadística.

Figure 3

NATURAL RATE OF INTEREST AND PRODUCT GAP
Percentage points



Source: Results from the estimated model.

credit increased significantly, even considering the new regulations that set credit goals for each financial institution in the granting of loans for the productive sector and social housing. At the beginning of 2017 the rate gap began to close, although the Central Bank's expansionary position remained unchanged.

An inverse relation is revealed when compared with the product gap; the natural interest rate gap decreased to the extent the product gap increased. The results of the estimations are shown in the Appendix. During periods of increased inflation, it tended to decrease, thereby suggesting a contractionary monetary policy.

4. CONCLUSIONS

The estimation of the natural rate of interest is significant insofar as it provides a benchmark for measuring the direction of monetary policy. If the short-term real interest rate is below its natural rate (negative natural rate gap), then monetary policy is expansionary. The recent backdrop of low interest rate levels highlights the importance of estimating the natural rate of interest to help central banks make decisions.

In this paper a semi-structural model is estimated following Holston, Laubach and Williams (2016), in which the natural rate of interest is defined as the real interest rate consistent with stable inflation and output at its natural rate. The results indicate that the Central Bank has held an expansionary monetary policy position in recent years, especially since late 2014, when growth caused historic levels of liquidity in the Financial System that turned into available resources to continue vitalizing private credit.

An inverse relation is revealed when compared with the product gap; the natural rate of interest gap decreased to the extent the product gap increased.

One important implication is that the natural rate of interest reveals the expansionary position of monetary policy, consistent with the aim of fostering liquidity in the Financial System in order to inject resources into the economy through private credit.

References

Fuentes, Rodrigo (2008) “Tasa de Interés Real Neutral: Definiciones y Evidencia para Economías Latinoamericanas”. Centro de Estudios Monetarios Latinoamericanos (CEMLA).

Fuentes, R. y Gredig, F. (2008). “La tasa de interés neutral: estimaciones para Chile”. Centro de Estudios Monetarios Latinoamericanos (CEMLA).

Galí, Jordi (2008). “Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework”. Princeton University Press.

Holston, Kathryn; Laubach, Thomas & Williams, John C. (2016). “Measuring the Natural Rate of Interest: International Trends and Determinants”. Federal Reserve Bank of San Francisco. Working Paper 2016-11. http://www.frbsf.org/economic-research/publications/workingpapers/wp2016-11.pdf.

Laubach, Thomas (2001). “Measuring the Nairu: Evidence From Seven Economies”. The Review of Economics and Statistics, Vol. 83, No. 2 (May, 2001), pp. 218-231. http://www.jstor.org/stable/3211601.

Laubach, Thomas & Williams, John C. (2003). “Measuring the Natural Rate of Interest”. The Review of Economics and Statistics, Vol. 85, No. 4 (Nov., 2003), pp. 1063-1070. http://www.jstor.org/stable/3211826.

Laubach, Thomas & Williams, John C. (2016). “Measuring the Natural Rate of Interest Redux”. Finance and Economics Discussion Series 2016-011. Washington: Board of Governors of the Federal Reserve System, http://dx.doi.org/10.17016/FEDS.2016.011.

Stock, James H. & Watson, Mark W. (1998). “Median Unbiased Estimation of Coefficient Variance in Time-Varying Parameter Model”. Journal of the American Statistical Association. March 1998, Vol. 93, No. 441, Theory and Methods.

APPENDIX

Table 1

ESTIMATED PARAMETERS

$a_{y,1}$	$a_{y,2}$	a_r	b_π	b_y	$\sigma_{\tilde{y}}$	σ_π	σ_{y^*}	$a_{y,1}+a_{y,2}$
1.44	−0.46	−0.03	1.31	0.13	0.25	1.36	0.20	0.97
T statistics								
5.24	1.69	1.26	24.11	2.03	2.08	11.14	1.55	

Table 2

AVERAGE STANDARD ERROR

y^*	r^*	g
1.502	2.953	0.254

Table 3

INITIAL VARIANCE AND COVARIANCE MATRIX

0.443	0.200	0.000	0.200	0.200	0.000	0.000
0.200	0.200	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.200	0.000	0.000	0.000	0.000
0.200	0.000	0.000	0.200	0.200	0.000	0.000
0.200	0.000	0.000	0.200	0.200	0.000	0.000
0.000	0.000	0.000	0.000	0.000	1.187	0.200
0.000	0.000	0.000	0.000	0.000	0.200	0.200