The Welfare Effects of Inflation Volatility and Institutions: Implications for Emerging Market Economies

Noha Emara

Abstract
Using a microfoundation based monetary Small Open Economy (SOE) model of McCandless (2008) with a cash-in-advance constraint, a capital adjustment cost, foreign bonds, and a trade sector, the study quantifies the welfare implications under two policy scenarios: (a) a reduction in inflation volatility and (b) an improvement in institutions. The monetary small open economy model is calibrated using quarterly data from 1989 to 2006 for an emerging market economy, Mexico, a country that, by the study’s measure has poor financial institutions and moderately high inflation volatility. The results of the model suggest that decreasing inflation volatility leads to about 8 percent increase in welfare, at most, while improving institutions leads to an increase in welfare by about 10 percent, at most. Furthermore, when the decrease in inflation volatility is coupled with the improvement in institutions the welfare increase is in the range of around 11–19 percent, depending on the degree of the drop in inflation volatility and the level of development in financial institutions. Finally, the study analyzes the impact of the reduction in inflation volatility versus the impact of the improvement in institutions on the behavior of the endogenous variables along the transition path. One policy implication of these results is that an emerging market economy, like Mexico, with relatively high inflation volatility and underdeveloped financial institutions, can get large welfare gains from either reducing inflation volatility or improving their institutions, with the largest gains coming from the latter. A long-run sustainable economic development policy will lean more towards the improvement in institutions rather than the reduction of inflation volatility.

Keywords
Institutions, inflation volatility, small open economy, welfare, transition path

Introduction
A growing strand of literature focuses on the role of macroeconomic policies versus the role of institutions in generating growth in developing countries. While the “policy view” does not undermine the role of institutions in economic growth, it argues that the most important factor for the divergence in growth between countries of the world today stems from the differences in the policies implemented by their governments.
On the other hand, the “institutions’ view” argues that the level of development in institutions is the main factor explaining the divergence in growth between countries. This view does not consider that macroeconomic policy in itself is an important factor affecting growth. Instead macroeconomic policy is considered a channel through which institutions affect growth. According to this view, bad macroeconomic policy is simply a result of poor institutions in the economy.

This article contributes to this debate of “policies or institutions” by separately quantifying the long-run welfare effects of policy— in particular monetary policy— versus the long-run welfare effects of financial institutions for the Mexican economy. The results show that although institutions were found to contribute a bit more to welfare in the long run, the significant role of monetary policy in Mexico cannot be undermined. In addition, the results show that this significant role of monetary policy does not stem from the underlying institutions.

Numerous studies have underlined the effect of inflation and institutions on the level of a country’s output. However, few studies have focused on the effect of the volatility of inflation on a country’s welfare. In this study, this issue is addressed by quantifying the effect of the reduction in inflation volatility on a country’s level of welfare, and comparing this to the effect of the improvement in a country’s level of financial institutions on welfare. Emara (2010) concluded that the reduction in inflation volatility will finally lead to a drop in the average long-term bond yield; accordingly the effect upon economic welfare is expected to be positive. Additionally, since the improvement in financial institutions will finally lead to a drop in the average long-term bond yield, this is expected to have a positive impacts on economic welfare, especially since improving institutions has two effects on welfare: the first leads to a direct increase in welfare, and the second leads to an indirect increase in welfare through its interaction term with inflation volatility.

This study uses a deterministic monetary SOE model of McCandless (2008) with a cash-in-advance constraint, a capital adjustment cost, foreign bonds, and a trade sector. The model incorporates a type of financial friction that occurs because of poor financial institutions. These bad institutions are assumed to affect the premium that a country pays on its borrowings from the international market and thereby affects the nation’s ability to pay. It is important to note that overseas borrowing and the ability to export and import goods in this model will likely reduce the impact of either domestic or international shocks on an SOE.

The monetary SOE model is calibrated for the Mexican economy which over the period of the study, 1989–2006, is characterized by relatively high average inflation volatility (in the 90th percentile) and relatively underdeveloped financial institutions (in the 40th percentile of the LEGAL2 index) (Emara 2010). Following the Mexican financial crisis of 1994–1995, the primary objective of the Mexican monetary policy was to maintain the stability of the peso measured in purchasing power parity. Holding foreign prices constant, any increase in domestic prices in Mexico leads to a devaluation of the peso, and the opposite is true. In order to achieve the objective of a stable peso, the Central Bank of Mexico used an inflation targeting policy by quantitatively targeting the growth of the monetary base and net domestic credit.

The inflation targeting policy by the Central Bank of Mexico succeeded in pushing down the inflation rate from over 50 percent in 1995 to about 4 percent early 2011. As argued in Galindo and Ross (2005), with a lower level of inflation and increased credibility of the Central Bank of Mexico, the impact of the exchange rate pass-through may decline.
The exchange rate volatility is expected to lead to inflation volatility through two main channels: a direct channel and an indirect one. On one hand, the direct channel is expressed by the impact of the exchange rate on the price of imported goods which is taken into consideration when computing the consumer price index. On the other hand, the indirect channel is expressed through the impact of the exchange rate volatility on the price of exported goods which is ultimately reflected in the computation of the gross domestic product or aggregate demand. As shown in Ball (1998), Taylor (1999), Rudbusch (2000), and Alexandre et al. (2002), the exchange rate volatility affects output, interest rates, and the inflation rate through a system of aggregate demand and aggregate supply.

In the SOE model presented in this study, it is assumed that the exchange rate is computed by purchasing power parity which is equal to unity and assumed to be fixed. The impact of exchange rate volatility on inflation volatility, or the pass-through effect, is thus not modeled in our framework. The exogenous monetary shock in the model, the inflation volatility shock, is assumed to be only related to the shock in the money supply, as explained in the appendices.

Assuming that the exchange rate is purchasing power unity and fixed, the monetary SOE model is used to analyze the impact of different policy scenarios on economic welfare in Mexico. In particular, the model compares the welfare implications of the decrease in the volatility of inflation (given the level of institutions) versus the welfare implications of an improvement in financial institutions (given the level of inflation volatility). The results show that decreasing inflation volatility leads to an increase of about 8 percent in welfare, at most, while improving institutions leads to an increase in welfare by 10 percent, at most. Finally when the decrease in inflation volatility is coupled with the improvement in institutions, this leads to an increase in welfare in the range of about 11–19 percent—depending on the degree of the drop in inflation volatility and the level of development in financial institutions.

Furthermore, the study analyzes the long-run behavior of the endogenous variables along the transition path in response to the decrease in the volatility of inflation (given the level of institutions) versus the improvement in financial institutions (given the level of inflation volatility). The model suggests that along the transition path, an SOE chooses to get rid of its foreign bonds or, in other words, to increase its foreign debts. In this situation, production, capital, hours worked, and exports have to increase along the path for the country to get the foreign exchange required to pay foreign debts.

It is important to note that models of SOEs have been known for their computational problems, due to the fact that the interest rate is taken by these countries as exogenously determined from abroad. The exogeneity of the interest rate in the SOE models makes finding the steady state in these models almost impossible. In order to overcome this computational problem, various modifications to the base SOE model have been proposed, which are discussed in detail in Schmitt-Grohe and Uribe (2003). The Schmitt-Grohe and Uribe analysis includes endogenizing the discount factor (Uzawa (1968)), the debt elastic interest rate premium, convex portfolio adjustment costs, and complete asset markets.

Following Senhadji (1994), Mendoza and Uribe (2000), and Schmitt-Grohe and Uribe (2001), this study uses the debt elastic interest rate premium as the technique for inducing the model to have a single steady state. This is done by making the foreign interest rate a function of foreign bonds. Furthermore, following Mendoza (1991) and Schmitt-Grohe and Uribe (2003) among others, the model includes capital adjustment costs (under some restrictions) to resolve the high variability of investment problem stemming from the fact that capital can be freely accumulated from abroad to fill the gap between domestic savings and domestic investments in response to productivity shocks facing the SOE.
Within the context of the New Open Economy Models (NOEM), most of the models calibrated or estimated are SOE models. For instance, Del Negro and Obiols-Homs (2001) estimate a SOE Vector Autoregression (VAR) model for Mexico. The study finds that the most important shocks affecting the Mexican economy originate from the US business cycle, while the exogenous shocks originated from monetary policy have a smaller effect.

Bergin (2003) used the maximum likelihood method to estimate the structural parameters of an SOE model using data from Australia, Canada, and UK. Although the model showed some predictive ability for prices and output, it did not show any predictive ability for the exchange rate or the current account. Additionally, in contrast with the results of Obstfeld and Rogoff (2000), Bergin (2003) did not find any support for wage stickiness but rather for price stickiness. In line with Betts and Devereux (1996, 2000), Bergin (2003) found support for stickiness in local currency prices rather than that in the producer currency.

Similarly, Dib (2003) estimated and compared the structural parameters in both a closed economy model and a small open economy model with nominal rigidities in the import sector and with capital adjustment costs. The structural parameters are estimated using the maximum likelihood procedure with the Kalman filter for Canada and the US. In addition, this study compared the impulse response functions of both economies to the monetary, technology, and world interest rate shocks. This study concludes that both economies showed very similar behaviors in response to the shocks.

Justiniano and Preston (2004) estimated the structural parameters of a SOE model using the Bayesian methodology to fit data on inflation, output, interest rates and real exchange rates for Australia, Canada, and New Zealand under varying degrees of exchange rate pass-through and in the presence of one or more mechanisms of endogenous persistence. In contrast to Betts and Devereux (1996, 2000), the study finds limited evidence for the local currency pricing assumption, and no evidence for price indexation.

Adlfonson et al. (2004) estimated a DSGE model using the Bayesian estimation technique for the Euro area. The model incorporates various types of nominal and real frictions including sticky prices, sticky wages, variable capital utilization, capital adjustment costs, and habit persistence. Among other findings, the study concludes that markup shocks, inflation target shocks, and technology shocks are the most important shocks affecting inflation fluctuation. As for output fluctuation, the study finds that supply shocks and technology shocks are the most prominent. Finally, import and export markup shocks are mainly responsible for the real exchange rate fluctuations.

More recently, Del Negro and Schorfheide (2008) estimated a DSGE model and a Bayesian VAR of the Lubik and Schorfheide (2005) model (using Chilean data) on a group of macroeconomic variables. The results show that the Chilean Central Bank did not respond significantly to exchange rate and terms of trade movements. Both the DSGE and the VAR showed that the observed inflation variability is due largely to domestic shocks.

Against this background, this article extends the SOE model of McCandless (2008) by adding to it a parameter reflecting poor institutions. The objective is to analyze and compare the impact of reducing inflation volatility versus the impact of enhancing institutions on real variables and economic welfare. Welfare comparisons are then examined under three different policy scenarios: (a) a reduction of inflation volatility holding institutions constant; (b) an improvement in financial institutions holding volatility of inflation constant; and (c) inflation volatility reduction with an improvement in financial institutions. To the best of our knowledge, this study is the first to address the role of institutions within the context of NOEM.
An important policy implication of this study suggests that an economy like Mexico can get slightly larger welfare gains from improving their institutions than from reducing inflation volatility. This policy implication does not undermine the role that can be played by monetary policy in growth, but improving institutions has a couple of positive effects: (a) a direct effect on welfare by reducing resource waste in the economy; and (b) an indirect effect on welfare that acts through the financial institutions’ impact on reducing the harmful impacts of inflation volatility on growth. This policy implication is intuitive in the sense that reducing inflation volatility is costly on output, while improving financial institutions is a cost-free policy.

This article is organized as follows: the next section discusses the calibration of the parameters. The section after that presents the results. The section “The Transition Path—A Deterministic Model” analyzes the transition path of the real variables out of the steady state. The section after that concludes this study. Appendix 1 and Appendix 2 present the model and the estimation of the model parameter $\sigma_g$.

**Calibration of the SOE Model**

The details of the SOE model are presented in Appendix 1. This section calibrates the model for Mexico, an emerging economy that is characterized by moderately high average inflation volatility and relatively poor financial institutions over the period of the study (1989–2006). Following Emara (2010), among the sample of 37 countries, Mexico together with Turkey and Uruguay fall in the 90th percentile of average log of inflation volatility and in the 40th percentile of the financial institutional index.

Furthermore, Figure 1 depicts a negative relationship between financial institutions index, or LEGAL2 index, and the average over the period log inflation volatility. If the top 10 percent of the log inflation volatility distribution is discarded from the sample, three countries (Argentina, Peru, and Brazil) are excluded from the estimation and we are left with a group of countries where Turkey, Uruguay, and Mexico are at the top of the list in terms of the highest volatility and bad institutions. Since Mexico is located at the lowest end of the investment grade in the first quarter of the year 2000 while Turkey and Uruguay are located in the speculative grade, studying the case of Mexico was deemed to be the most interesting case study compared with the other two countries.

Based on the above discussion, the model is calibrated using Mexico quarterly data over the period 1989–2006. The parameters of the model are calibrated using the values shown in Table 1. The value of the income share of physical capital is taken from Mankiw et al. (1992) as $\theta = 0.3$. The discount rate $\beta$ is set equal to the value commonly used in the literature to be equal to 0.99. The value for the depreciation of physical capital, $\delta = 0.03$, is taken from Aguiar and Gopinath (2004). Following Emara (2010), the value of the cost of borrowing $r_f$ is set equal to 12.21 percent per year (or 3.05 percent per quarter), which is calibrated as the average of the annual five-year bond yield of all countries that belong to the sovereign debt rating of 12 rating points, or “Baa3,” at the first quarter of the year 2000 and to which Mexico belongs.

The capital adjustment cost parameter $\kappa$ is taken from Mendonza (1991) and is calculated to match the percentage deviation of the investment data in Mexico. The parameter $B$ is taken from McCandless (2008). The parameter “$d$” represents the positive constant of the foreign interest rate equation and is taken from McCandless (2008) but divided by four to match the quarterly data. The parameter $g$ represents
the growth of money supply in steady state and is calculated as average inflation over the period 1989–2006 divided by four. In a steady state, money supply grows by one plus this number. The parameter $r^*$ represents the cost of borrowing paid by the highest rated countries and assumed to be 0.01 per quarter (1 percent per quarter or 4 percent per year).

Concerning the parameter of bad institutions, $\tau$, this parameter is a tax on the economy. To the best of our knowledge, no one has attempted to calibrate this value before and there is a good reason why this is the case given the difficulties in calibrating a value for it. Accordingly, the study assumes that the worst level of institutions will cost the economy about 20 percent of GDP, or $\tau = 0.2$ at the maximum. This assumed value is not big when compared to the study of Wei (2000), where a one-grade increase in the corruption level is associated with a 26 percent reduction in the stock of foreign direct investment.

The parameters $\rho_z$ and $\sigma_z$ are calibrated using the quarterly data of the log of Mexico’s real gross domestic product (GDP) by first filtering the series using the HP filter with smoothness parameter $\lambda = 1600$. The deviation of the series is separated from the trend of the series. The deviation of the series is then regressed on an AR (1) model to estimate the parameter $\rho_z$. The parameter $\sigma_z$ is then computed using the square of the residual of the model, divided by the sample size.

Similarly, the parameter of the growth in money supply is computed as the growth of Mexico’s inflation (given that they are equivalent in the model). Accordingly $\rho_g$ and $\sigma_g$ are computed using the quarterly data of the difference of the log of the CPI of Mexico. Finally, the parameters $\rho_{g^*}$ and $\sigma_{g^*}$ are computed using the quarterly data of the log of USA consumer price index.

Figure 1. Inflation Volatility and LEGAL2 Index

Source: Author’s research.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta$</td>
<td>0.33</td>
<td>Income share of physical capital—Mankiw (1992)</td>
</tr>
<tr>
<td>$1 - \theta$</td>
<td>0.67</td>
<td>Income share of human capital—Mankiw (1992)</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.03</td>
<td>Depreciation of physical capital—Aguiar &amp; Gopinath (2004)</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.99</td>
<td>Discount rate—value as usually found in the literature</td>
</tr>
<tr>
<td>$r_t^*$</td>
<td>0.0305</td>
<td>Average cost of borrowing (3.05 percent per quarter or 12.21 percent per year) for all the countries on the Baa3 level of sovereign debt rating to which Mexico belongs—Emara (2010)</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.026</td>
<td>Parameter of the quarterly capital adjustment cost taken from Mendonza (1991). Calculated to match the percentage of the standard deviation of investment</td>
</tr>
<tr>
<td>$B$</td>
<td>-2.5805</td>
<td>Parameter in the utility function. Where $B = A \ln(1-h_0)/h_0$ McCandless (2008)</td>
</tr>
<tr>
<td>$a$</td>
<td>0.0025</td>
<td>Reflects the changes in foreign interest rate to changes in real bonds. Taken from McCandless (2008) ($a = 0.01$/annual data)</td>
</tr>
<tr>
<td>$a^*$</td>
<td>0.01</td>
<td>Average quarterly premium by lowest rated countries ($a = 0.04$/annual data)</td>
</tr>
<tr>
<td>$g^*$</td>
<td>1.036362</td>
<td>Quarterly average inflation. Annual average inflation divided by four ($0.145448/4 = 0.036362$)</td>
</tr>
<tr>
<td>$r^*$</td>
<td>0.0125</td>
<td>Average quarterly interest rate paid by highest rated countries ($r^*_{h0} = 0.05$/annual data)</td>
</tr>
<tr>
<td>$\tau$</td>
<td>0.2 → 0.15</td>
<td>Assumed values for the cost on the economy that is due to bad institutions</td>
</tr>
<tr>
<td>$0.15 \rightarrow 0.10$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$0.10 \rightarrow 0.05$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$0.05 \rightarrow 0.01$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho_{e_t}$</td>
<td>0.911333</td>
<td>From estimating an AR(1) model of the Y deviation (log of Mexico’s real GDP)</td>
</tr>
<tr>
<td>$\sigma_{e_t}$</td>
<td>8.2031E-05</td>
<td>Variance of the residual of the regressing Y deviation on an AR(1) model</td>
</tr>
<tr>
<td>$\rho_{p_t}$</td>
<td>0.456541</td>
<td>From estimating an AR(1) model of P deviation (difference in log of Mexico’s CPI)</td>
</tr>
<tr>
<td>$\sigma_{e_t}$</td>
<td>[0.0023,0.0082]</td>
<td>Calibrated to match the interval of the quarterly average inflation volatility. Details are provided in Appendix 2.</td>
</tr>
<tr>
<td>$\rho_{p^*_t}$</td>
<td>0.771140</td>
<td>From estimating an AR(1) model of $P^*$ deviation (CPI of USA)</td>
</tr>
<tr>
<td>$\sigma_{e^*_t}$</td>
<td>1.78426E-06</td>
<td>Variance of the residual of regressing $P^*$ deviation on an AR(1) model</td>
</tr>
</tbody>
</table>

**Source:** Author’s research.
Calculating the Welfare Implications of the Reduction in Inflation Volatility and the Improvement in Institutions

Using the above calibrated values for the parameters of the monetary SOE model, this section presents the results of the welfare implications under three experiments; (a) a reduction in inflation volatility holding bad institutions constant (a drop in $\sigma_g$ holding $\tau$ constant); (b) improving institutions holding inflation volatility constant (a drop in $\tau$, holding $\sigma_g$ constant); and (c) a reduction in inflation volatility coupled with improving institutions (a drop in both $\tau$ and $\sigma_g$).

Table 2 reports the results of the first experiment, where the welfare effect of a drop in the average quarterly inflation volatility $\sigma_g$ is computed for different values of $\tau$ as an initial level. Welfare is defined as the new steady state of output per worker as a ratio of its initial level. For example in column 2 in Table 2 with the initial levels of $\sigma_g$ and $\tau$ equal to 0.0082 and 0.2, respectively, a reduction in $\sigma_g$ to 0.0053 leads to about an increase in welfare of about 6.1 percent. Moreover, column 6 shows that with initial levels of $\sigma_g$ and $\tau$ equal to 0.0082 and 0.01, respectively, the increase in welfare due to the drop of $\sigma_g$ to 0.0053 is only 4.3 percent. Furthermore, a bigger drop in $\sigma_g$ from 0.0082 to 0.0023 leads to higher welfare levels of about 8.6 percent and 6.1 percent for $\tau$ equal 0.2 and 0.01 respectively. These numbers suggest that the bigger the drop in inflation volatility, the higher is economic welfare. Additionally, these numbers suggest that improving inflation volatility will be more rewarding for countries with relatively bad institutions, as compared to those with relatively good ones.

Table 2. Effect of the Drop in $\sigma_g$ Holding $\tau$ Constant (at Different Values) on the New Steady State of Output per Worker (as a Ratio to its Initial Level)

<table>
<thead>
<tr>
<th></th>
<th>(1) Average Quarterly Inflation Volatility $\sigma_g$</th>
<th>(2) $\tau = 0.2$</th>
<th>(3) $\tau = 0.15$</th>
<th>(4) $\tau = 0.10$</th>
<th>(5) $\tau = 0.05$</th>
<th>(6) $\tau = 0.01$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$y^*$</td>
<td>$y^*$</td>
<td>$y^*$</td>
<td>$y^*$</td>
<td>$y^*$</td>
</tr>
<tr>
<td>$\sigma_g$</td>
<td></td>
<td>$\tau = 0.2$</td>
<td>$\tau = 0.15$</td>
<td>$\tau = 0.10$</td>
<td>$\tau = 0.05$</td>
<td>$\tau = 0.01$</td>
</tr>
<tr>
<td>0.0082 to 0.0053</td>
<td></td>
<td>1.061</td>
<td>1.055</td>
<td>1.051</td>
<td>1.046</td>
<td>1.043</td>
</tr>
<tr>
<td>0.0082 to 0.0023</td>
<td></td>
<td>1.086</td>
<td>1.078</td>
<td>1.071</td>
<td>1.065</td>
<td>1.061</td>
</tr>
</tbody>
</table>

Source: Author’s research.

In the second experiment, the direct welfare impact of the improvement in institutions is computed under different initial levels of $\tau$. As shown in column 2 of Table 3, when the initial levels of $\tau$ and $\sigma_g$ are 0.2 and 0.0082 respectively, a drop in $\tau$ to 0.15 leads to roughly a 10 percent increase in welfare. Moreover, as the last row of Table 3 shows, for more institutionally developed countries where the initial level of $\tau$ is only 5 percent of real output, a drop in $\tau$ from 0.05 to 0.01, given the level of $\sigma_g$, leads to a smaller welfare effect of only about 6 percent. This implies that economies with less developed institutions have a higher response to drops in inflation volatility as compared with institutionally developed economies.

Finally, the third experiment is undertaken where the drop in $\sigma_g$ is coupled with a drop in $\tau$. As shown in Table 4, the welfare magnitudes are much higher when compared with those in Table 2 and Table 3.

When the drop in $\sigma_g$ from 0.0082 to 0.0023 is coupled with a drop in $\tau$ from 0.20 to 0.15, welfare increases by about 16 percent. Furthermore, if the drop in from 0.0082 to 0.0023 is accompanied by a
The Welfare Effects of Inflation Volatility and Institutions

Table 3. Effect of the Drop in $\tau$ Holding $\sigma_g$ Constant (at 0.0082) on the New Steady State of Output per Worker (as a Ratio to its Initial Level)

<table>
<thead>
<tr>
<th>$\tau$ range</th>
<th>$\bar{y}'/\bar{y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2 → 0.15</td>
<td>1.10</td>
</tr>
<tr>
<td>0.15 → 0.10</td>
<td>1.09</td>
</tr>
<tr>
<td>0.10 → 0.05</td>
<td>1.08</td>
</tr>
<tr>
<td>0.05 → 0.01</td>
<td>1.06</td>
</tr>
</tbody>
</table>

Source: Author’s research.

Table 4. Effect of the Drop in $\sigma_g$ Coupled with the Drop in $\tau$ on the New Steady State of Output per Worker (as a Ratio to its Initial Level)

<table>
<thead>
<tr>
<th>Average Quarterly Inflation Volatility, $\sigma_g$</th>
<th>(1) $\tau$ 0.20 to 0.15</th>
<th>(2) $\bar{y}'/\bar{y}$</th>
<th>(3) $\tau$ 0.15 to 0.10</th>
<th>(4) $\bar{y}'/\bar{y}$</th>
<th>(5) $\tau$ 0.10 to 0.05</th>
<th>(6) $\bar{y}'/\bar{y}$</th>
<th>(7) $\tau$ 0.05 to 0.01</th>
<th>(8) $\bar{y}'/\bar{y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0082</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0053</td>
<td>1.164</td>
<td>1.161</td>
<td>1.141</td>
<td>1.114</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0023</td>
<td>1.189</td>
<td>1.174</td>
<td>1.161</td>
<td>1.133</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Author’s research.

drop in $\tau$ from 0.05 to 0.01, then welfare increases by about 13 percent, as shown in column 5 of Table 4. These numbers suggest that in economies with initially relatively good institutions (small values of $\tau$), improving institutions will have a smaller welfare effect as compared with economies that have initial relatively bad institutions.

The Transition Path—A Deterministic Model

The long-run versus the short-run behavior of real endogenous variables in response to changes in inflation volatility or changes in institutional development can be very different. This section analyzes and compares the transition path of the steady states of all real endogenous variables in the model under the three previous experiments: (a) a decrease in inflation volatility; (b) an improvement in institutions; and (c) a decrease in inflation volatility coupled with an improvement in institutions.

Using the transition path permits analyzing how the economy moves from the old steady state to the new steady state. More specifically, it permits us to analyze how each endogenous variable behaves along the transition path, whether there will be no change, an overshooting, or an undershooting in response to an exogenous shock.

The first experiment analyzes how a decrease in inflation volatility (given the level of institutions) will move the economy from an initial steady state to a new steady state. The initial steady states of real variables are computed using the calibrated parameters of Table 1 with $\sigma_g = 0.0082$. The new steady
states are computed using $\sigma_g = 0.0053$ and $\sigma_g = 0.0023$, keeping $\tau = 0.2$. Figure 2 shows the transition path of this experiment, where in this figure and thereafter, “$y$” refers to real output, “$c$” refers to consumption, “$k$” refers to capital, “$h$” refers to hours worked, “$x$” refers to exports, “$b$” refers to foreign bonds, “$p$” refers to domestic prices, “$m$” refers to money supply, and “$y/h$” refers to output per worker.

**Figure 2.** Transition Path for the Drop in $\sigma_g$ from 0.0082 to 0.0023% (Holding $\tau$ Constant at 0.20)

Figure 1 reflects the result reducing inflation volatility holding the institution parameter constant. A bigger drop in $\sigma_g$, from 0.0082 to 0.0023 versus 0.0082 to 0.0053, holding $\tau$ constant, leads to a bigger absolute change in the magnitude of all the variables of the model.

The drop in inflation volatility, $\sigma_g$, which ultimately leads to a drop in the cost of borrowing, is a negative demand shock where both output and prices decrease initially. As the interest rate drops, the returns from holding foreign bonds decreases, so the economy receives less income from holding these bonds, and accordingly the amount of foreign bonds held by the economy decreases. With the initial increase in consumption, exports experience an undershooting initial response. The drop in the interest rate, coupled with the decrease in bonds (or the increase in debts), is the main reason for this undershooting in the short run.
Furthermore, the drop in income leads to a drop in prices next period as consumers spend less. But since the drop in prices is large, given no change in the money supply, consumption in real terms increases. Also, the hours worked decrease and in response, wages increase.

This short-run behavior of consumption and prices in response to the drop in the cost of borrowing explains the liquidity effect of the cash-in-advance constraint. With a limited amount of cash that households hold, as domestic prices decrease in response to the output decreases, households instantly become wealthier in real terms, with no initial extra hours worked, with the result that they increase their consumption and reduce their working hours.

In the long run with the drop in the cost of borrowing, a small open economy that accumulates foreign debt needs to increase its exports over the long run in order to acquire the foreign exchange needed to pay its debts. This happens in addition to the need to increase its output, capital, and hours worked to meet both the interest rate payments and to smooth out its consumption over time: The economy will borrow more; capital will accumulate until it reaches a new higher steady state level, which in turn leads to a new higher steady state level of output and hours worked. As for consumption, although it increases initially in response to the drop in $\sigma_g$, over time consumption declines, back to its initial steady state level following the rise of prices back to its initial level.

In addition, in the long run, foreign bonds decrease along the transition path in response to the decrease in the cost of borrowing, as the country gets rid of foreign bonds and chooses to borrow under the lower cost of borrowing. Foreign bonds keep decreasing along the transition path until they reach a new steady state value that is lower than the initial steady state. Exports also increase along the transition path from the initial undershooting value and reach a steady state higher than the initial one.

Next, the second experiment is undertaken to analyze the impact of the effect of the improvement in institutions, holding inflation volatility parameter constant, on the behavior of the endogenous real variables along the transition path. As shown in Figure 3, holding $\sigma_c$ constant at 0.0082, the bigger the drop in $\tau$, from 0.20 to 0.01 versus 0.20 to 0.1, the higher is the absolute magnitude of the response for all the endogenous variables of the model.

Over the long run, with the improvement in institutions, the economy accumulates more capital and output increases until they both reach new higher steady state levels. With the increase in capital and income, consumption reaches a new higher steady state level. Moreover, as income increases, exports increase and the economy accumulates foreign bonds (becomes a net lender), until they both drop to their initial steady state levels.

It is worth noting that when the second experiment is repeated for drops in $\tau$ from 0.20 to 0.15, from 0.10 to 0.05, and from 0.05 to 0.01, the behavior of the variables along the transition paths is very similar in Figure 2, however the response of the variables to the drop in $\tau$ decreases with smaller values of $\tau$.

Finally, the third experiment is undertaken to analyze the impact of the improvement in inflation volatility coupled with the improvement in institutions. The initial values of the transition paths of this experiment are calculated using $\sigma_c = 0.0082$ and $\sigma_g = 0.2$. As Figure 4 shows, the bigger the simultaneous drop in $\sigma_g$ and $\tau$, to 0.0023 and 0.01 versus 0.0053 and 0.10 respectively, the bigger the absolute change in the magnitudes of all variables in the model.

As Figure 4 shows, when the drop in the cost of borrowing is coupled with a decrease in $\tau$, the behavior of this economy is very similar to the first experiment; however, the responses of the real variables are much larger in this case. All the variables in this economy including consumption, exports, and foreign bonds, will have a new steady state different from the old one. The monetary SOE gets rid of the
foreign bonds it had accumulated at the initial steady state and starts accumulating foreign debt in response to the drop in the interest rate. Over the long run, with the reduction in foreign bonds held by the economy, income from these bonds decreases, so output decreases slightly in the long run from its overshooting short-run steady state value. Prices respond by an initial drop, leading to an initial increase in consumers’ real wealth. Accordingly, consumption initially increases and hours worked initially decreases, and in response wages initially increases.

In the long run, in response to the decrease in the cost of borrowing and the increase in \( \tau \), bonds decrease until they reach a new lower steady state level. Exports increase from their undershooting value until a new higher steady state level is reached. Additionally, the economy accumulates more capital until it reaches a new higher steady state value. Hours worked also increase to a new higher steady state level in response to the increase in capital. Output therefore increases to a new higher steady state level in response to the increase in capital and hours worked. Finally, as prices increases back to the initial steady state level, consumption decreases from its overshooting value until a new higher steady state level is reached. In the long run, the economy has to increase its production, hours worked, and exports to meet the increasing interest payments and the increasing consumption.

*Figure 3. Transition Path for the Drop in \( \tau \) from 0.20 to 0.15 (Holding \( \sigma_g \) Constant at 0.0082)*
Conclusion

One of the greatest problems facing the Mexican economy is the difficulty that businessmen have in obtaining financing because of the relatively underdeveloped financial institutions, including the low protection of creditors’ rights, low protection of shareholders’ rights, nontransparency of company accounts, and poor enforcement of laws. For instance, the lack of respect for creditors’ rights in the Mexican legal system, in particular, the right of creditors to rapidly obtain control over goods given as collateral by debtors after the debtors default on their loan obligations. In contrast, in the US, creditors can enforce their rights more rapidly and easily, thus increasing their ability and desire to loan funds.

Another challenge the Mexican economy faced after the 1994–1995 financial crisis was relatively high inflation, as well as relatively high inflation volatility. This monetary instability urged the Mexican economy to put quantitative targets on the growth of the monetary base, as well as the domestic credit.
To provide a policy suggestion for Mexican policymakers regarding these two major challenges for economic growth, that is, high inflation volatility and underdeveloped financial institutions, the study compares the welfare implications of reducing inflation volatility versus the welfare implications of improving institutions. The results show that decreasing inflation volatility leads to about 8 percent increase in welfare at the most, while improving institutions leads to a 10 percent increase in welfare at the most. Furthermore, when a decrease in inflation volatility is coupled with an improvement in institutions, it leads to an increase in welfare in the range of about 11–19 percent, depending on the degree of the drop in inflation volatility and the level of the improvement in financial institutions. Accordingly, one policy implication for a country like Mexico, is that a short-run policy to boost economic growth would entail reducing inflation volatility, but a long-run sustainable development policy would necessitate improving financial institutions.

To examine the last point further, the study examined the long-run behavior of the endogenous real variables along the transition path. The long-run behavior of these variables might be very different from its short-run behavior in response to policy changes. The results from the monetary SOE model suggest that a sustainable development policy through the improvement of financial institutions has a bigger impact on the steady state values of the capital, hours worked, output, and exports, as compared with the improvement in inflation volatility. A SOE chooses to get rid of its foreign bonds and therefore must increase its production, capital, hours worked, and exports along the transition path to get the foreign exchange required to pay foreign debts.

The study concludes that for a country with relatively bad institutions and relatively high inflation volatility, the welfare effect of improving institutions and of reducing inflation volatility is large, with the largest and most sustainable effect caused by an improvement in financial institutions. One policy implication of these results is that the Mexican economy can realize larger long-run sustainable welfare gains from improving its institutions rather than from reducing inflation volatility. The impact of improving institutions has two positive effects: a direct effect on welfare through reducing the resource waste in the economy, and an indirect effect on welfare that acts through the financial institutions’ effect on the sovereign debt rating. This result is intuitive in the sense that reducing inflation volatility is costly on output, while improving financial institutions is a cost free policy.

Appendix 1

Monetary Small Open Economy Model

In this section a monetary SOE model of McCandless (2008) with cash-in-advance constraint and capital adjustment cost is presented. The model is extended by incorporating two things; a type of financial friction expressed by poor financial institutions and a premium function that depends on inflation volatility.

Households

The economy is characterized by an indivisible labor and cash in advance constraint. The utility function takes the following form where a family $i$ one of a continuum of a unit mass of households, maximizes,

$$
\max_{\{c_i, h_i, A_i, I_i\}} E \sum_{j=0}^{\infty} \beta^j \left[ \ln c_{i+j}^l + Bh_{i+j}^l \right],
$$

where $c_t$ is the consumption at time $t$ and $h_t$ is the average hours worked at time $t$ and the parameter $B$ is equal to $A \ln(1 - h_0)$, where $A > 0$ and $0 < h_0 < 1$.

Given the cash in advance condition for family $i$ in period $t$ is $P_t c_i^t = m_i^t + (g_i - 1)M_{i,t-1}$, a family $i$ maximizes the above utility function subject to the budget constraint,

$$c_i^t + d_i^t + e_i h_i^t + k_{i,t+1} = e_i h_i^t + r_i k_i^t + (1 - \delta) k_i^t - \frac{\kappa}{2} (k_{i,t+1} - k_i^t)^2 + \frac{e_i (1 + r_{i,t-1}) h_i^t}{P_t} + \frac{m_i^t}{P_t} + (g_i - 1)M_{i,t-1},$$

where $P_i$ is the domestic price level, $m_i^t$ is the real money balances held by each family in period $t$, $b_i^t$ is the nominal value of foreign bonds, $k_i^t$ is the physical capital that a family brings in period $t$, $h_i^t$ is the amount of hours worked per family in period $t$, $w_i$ is the real wage, $r_i$ is the rental rate, $e_i$ is the exchange rate is purchasing power unity where $e_i = \frac{P_{i,t}}{P_{i,t-1}}$, $\delta$ is the depreciation of capital parameter, and $g_i$ is the rate of growth in money supply. The parameter $\kappa$ is the capital adjustment cost parameter and is added to the model to avoid the high variability of domestic interest in response to changes in foreign interest rates.

By substituting the cash in advance constraint condition, the budget constraint can equivalently be written as,

$$c_i^t + \frac{m_i^t}{P_t} + e_i h_i^t + k_{i,t+1} + \frac{\kappa}{2} (k_{i,t+1} - k_i^t)^2 = e_i h_i^t + r_i k_i^t + (1 - \delta) k_i^t + \frac{e_i (1 + r_{i,t-1}) h_i^t}{P_t},$$

where any change in the amount of capital held per family will cost each family a capital adjustment cost of $\frac{\kappa}{2} (k_{i,t+1} - k_i^t)^2$. It is important to note that despite the exchange rate used in the model is a simple purchasing power parity one, the domestic monetary shocks can still have dynamic effects.

Firms

The impact of the enhancement in financial institutions on economic welfare will be quantified by including a parameter “$\tau$” in the model. Following Barro et al. (1995b), this $\tau$ parameter refers to the rate of a proportional tax on output that is to be paid by the firms. In Barro et al. (1995b), $\tau$ is assumed to reflect the various elements that affect the incentive to accumulate that including risk of expropriation by the government, strong labor union, or foreign invaders. In this study it is assumed that again $\tau$ reflects the various elements that inhibit the incentive to accumulate including low protection to creditors’ rights, low protection of shareholders’ rights, weak enforcement of laws, and in-transparency of the companies account.

The parameter $\tau$ is added to the Cobb-Douglas production function as follows to reflect the impact of poor institutions on an economy,

$$Y_i = z_i (1 - \tau) K_i^\theta H_i^{1-\theta},$$

where $z_i$ refers to the random technology variable that follows a stochastic process $z_i = \rho z_{i,t-1} + \varepsilon_{i,t}$ with $0 < \rho < 1$, $\varepsilon_{i,t} > 0$, and $E \varepsilon_{i,t} = 1 - \rho$.

The equilibrium conditions of the labor and the capital markets are $w_i = (1 - \tau)(1 - \theta) z_i K_i^\theta H_i^{1-\theta}$ and $r_i = (1 - \tau) \theta z_i K_i^{\theta-1} H_i^{1-\theta}$ respectively.
Real output, wages and capital returns depend in each period on the stock of capital, hours worked, and the level of institutional development in the economy which are all taken as given to each household.

**Open Economy Conditions**

The open economy condition guarantees that any increase in the foreign interest rate that has to be paid on debts of period $t-1$, has to be met by an equal increase in exports so that the economy can generate the foreign exchange needed to pay for its interest on foreign debts.

The Open Economy clearing condition states that the nominal value of foreign bonds expressed in foreign currency and held at period $t$ minus the amount of interest that has to be paid on the debts of period $t-1$ is equal to the nominal value of exports expressed again in foreign currency,

$$B_t - (1 + r_{t-1}^f)B_{t-1} = P_t^* X_t,$$

where $B_t$ refers to the nominal quantity of foreign bonds measured in foreign currency. The variables $r_t^f$, $P_t^*$, and $X_t$ refer to the foreign interest rate (interest rate on foreign assets), the foreign price level, and the total net exports respectively.

At this point it is important to note that models of SOE have been known for their computational problem which is due to the fact that the interest rate is taken by these countries as exogenously determined from abroad. The equilibrium will then possess a random walk dynamic which makes the unconditional variance of the endogenous variables infinite. Accordingly, finding a steady state in this model is not possible. To overcome this problem, the model used in this study included a capital adjustment cost and an endogenous rate of return on foreign assets that is a function of the country’s foreign debt.

The foreign interest rate $r_t^f$ is in turn a function of the world interest rate $r^*$, the premium rate $\phi$ that an indebted country pays over the world interest rate, and the real value of the quantity of nominal foreign bonds possessed by the home country. Furthermore, any changes in the domestic monetary policy affects the $r_t^f$ through the premium function. A fall in inflation volatility, for instance, reduces the premium and thereby reduces the foreign interest paid on foreign debts.

$$r_t^f = r^* + \phi - \frac{B_t}{P_t^*}$$

such that,

$$\phi = \frac{a^*}{1 + \eta \exp(-\Psi (\sigma_g - \sigma_g))}$$

where $a^*$ refers to the average quarterly interest rate premium paid by the worst rated countries $\sigma_g \in [\sigma_g, \sigma_g]$, and $\sigma_g$ and $\sigma_g$ refers to the highest and the lowest values of the standard deviation of the quarterly average inflation. Finally, the values of the parameters $\eta$ and $\Psi$ are chosen in such a way to govern the shape and height of the premium function.

The foreign price level follows the following stochastic process $P_t^* = (1 - \rho_{P^*}) + \rho_{P^*} P_{t-1}^* + \varepsilon_{P^*}$, where $\varepsilon_{P^*} \sim N(0, \sigma_{P^*})$ and $\varepsilon_{P^*}$ is bounded from below by $-(1 - \rho_{P^*})$ and bounded above.

Defining the Equilibrium

The equilibrium is defined for the household’s problem as a list of sequences \( \{c^i_t\}, \{m^i_t\}, \{b^i_t\}, \{h^i_t\} \) and \( \{k^i_t\} \) such that, given \( r_t \) and \( w_t \) the household chooses to maximize the utility function,

\[
\max_{\{c_t, b_t, k_t, h_t\}} E_t \sum_{j=0}^{\infty} \beta^j \left[ \ln c^i_{t+j} \right] + Bh^i_{t+j},
\]

Subject to the two budget constraints, first to the cash in advance condition,

\[
P_t c^i_t = m^i_{t-1} + (g_t - 1)M_{t-1}.
\]

And second to the flow budget constraint for each household,

\[
c^i_t + \frac{m^i_t}{P_t} + e_i k^i_{t+1} + k^i_t (k^i_t - k^i_{t+1})^2 = w_t h^i_t + r_t k^i_t + \frac{e_t (1 + r^t_{t-1}) k^i_{t-1}}{P_t},
\]

where \( c^i_t \geq 0, k^i_t \geq 0, 0 < h^i_t < 1 \), and the transversality (limit) condition hold such that \( \lim_{t \to \infty} \frac{h^i_t}{(1 + r^t_j)^t} = \lim_{t \to \infty} \beta h^i_t = 0 \).

Worth noting that, given the indivisibility of labor assumption, the flow budget constraint shows that all the households will receive the same income whether they are working or not.

Next, the Equilibrium definition for the firm’s problem is defined as a list of sequence of \( \{r_t\}, \{w_t\}, \{k^i_t\} \) and \( \{h^i_t\} \) such that the firm chooses \( \{k^i_t\} \) and \( \{h^i_t\} \) to maximize

\[
\max_{r_t, k^i_t, h^i_t} (1 - \tau) K^0_t H^1_t - r_t K_t - w_t H_t,
\]

Given that the aggregation conditions hold such that

\[
C_t = c^i_t,
\]

\[
M_t = m^i_t,
\]

\[
B_t = b^i_t,
\]

\[
H_t = h^i_t,
\]

and

\[
K_t = k^i_t.
\]

This is in addition to the money supply rule \( M_t = g M_{t-1} \) as noted in McCandless (2008).

Characterizing the Equilibrium

Assuming that all the conditions for defining the equilibrium hold, the full model will then consists of the following set of equations which are derived from the first order conditions of the model. Solving for the first order condition
for the aggregate consumption and then substituting the results in the first order condition of foreign bonds, the equilibrium condition is shown below,

\[
E_t \left[ \frac{e_t}{P_{t+1}C_{t+1}} \right] = \beta E_t \left[ \frac{e_{t+1}(1 + r_t^f)}{P_{t+2}C_{t+2}} \right].
\]

Also, from solving the first order condition of capital the following equilibrium condition is found,

\[
E_t \left[ \frac{P_t}{P_{t+1}C_{t+1}} \left[ 1 + \kappa(K_{t+1} - K_t) \right] \right] = \beta E_t \left[ \frac{P_{t+1}}{P_{t+2}C_{t+2}} \left( r_{t+1} + (1 - \delta) + \kappa(K_{t+2} - K_{t+1}) \right) \right].
\]

And from the first order condition with respect to hours worked the equilibrium condition will be,

\[
\frac{B}{w_t} = \beta E_t \left[ \frac{P_t}{P_{t+1}C_{t+1}} \right].
\]

The aggregate cash in advance equilibrium condition is,

\[
P_tC_t = M_t.
\]

And the equilibrium condition of the flow budget constraint is,

\[
M_t + \frac{e_t B_t}{P_t} + K_{t+1} + \kappa \frac{K_{t+1}}{2} (K_{t+1} - K_t)^2 = w_tH_t + r_tK_t + (1 - \delta)K_t + \frac{e_t(1 + r_t^f)B_{t-1}}{P_t}.
\]

The equilibrium condition for the labor market,

\[
w_t = (1 - \theta)z_t(1 - \tau)k^{\theta}_t H_t^{-\theta}.
\]

And equilibrium condition in the capital market,

\[
r_t = \theta z_t(1 - \tau)k^{\theta - 1}_t H_t^{1-\theta}.
\]

Assuming purchasing power parity, the exchange rate is defined as the number of units of the domestic currency that each one unit of the foreign currency can buy. The equilibrium condition of the exchange rate will then be written as,

\[
e_t = \frac{P_t}{P_t^*}.
\]

And the money supply rule is,

\[
M_t = g_t m_{t+1}.
\]
The equilibrium condition for the stochastic processes of technology, monetary policy, and foreign price can be written as shown in the following three equations respectively.

\[ z_t = (1 - \rho_z) - \rho_z z_{t-1} - \varepsilon_{z,t}, \]
\[ g_t = (1 - \rho_g) - \rho g g_{t-1} - \varepsilon_{g,t}, \]
\[ P_t^* = (1 - \rho_p) - \rho_p P_{t-1}^* - \varepsilon_{p,t}. \]

**Steady States**

In steady state the foreign price level \( P^* \) is assumed to be equal to one. Also in steady state the level of inflation \( \pi = \frac{P_t}{P_t} \) is assumed to be equal to the constant growth rate of money \( \bar{g} \), or \( \pi = \bar{g} \). It is also important to note here that since the capital adjustment cost is a function of the changes in capital, in steady state the capital adjustment cost will be equal to zero.

By computing the steady states values of all the endogenous real variables in the model using the set of equations of the full model, the steady state values of the variables are as follows:

The steady state value for the foreign interest rate is found to be,
\[ \bar{r} = \frac{1}{\beta} - 1. \]  
(2)

The amount of foreign bonds held by the country in the steady state will depend on the world interest rate \( r^* \) and the premium rate \( \phi \) where,
\[ \bar{b} = (r^* + \phi + 1/\beta)/\alpha. \]  
(3)

As the steady state value of foreign bonds decreases (increase in debts) in response to any decrease in the cost of borrowing \( r^* + \phi \), the steady state value of export will increase. The foreign exchange returns from exports has to be enough to pay for the foreign interest on international borrowings,
\[ \bar{x} = -r \bar{b}. \]  
(4)

The steady state value of the net return to domestic capital,
\[ \bar{\pi} = \frac{1}{\beta} - (1 - \delta). \]  
(5)

Also from the equilibrium condition of the capital markets, the following equation can be derived in steady state:
\[ \frac{\bar{\pi}}{\theta(1-\tau)} = \left( \frac{\bar{K}}{\bar{H}} \right)^{\beta-1}. \]

And from the previous equation, the steady state value of capital/hour worked can be found as,
\[ \Rightarrow \frac{\bar{K}}{\bar{H}} = \left[ \frac{\theta(1-\tau)}{\bar{\pi}} \right]^{1-\beta}. \]  
(6)
Now Equation (6) above is substituted in the labor market equilibrium condition to get the following steady state of wages,

\[ w = (1 - \tau)(1 - \theta) \left( \frac{\theta(1 - \tau)}{r} \right)^{1 - \theta}. \] (7)

The steady state of consumption depends on the steady state of wages and the steady state value of inflation in the economy,

\[ \bar{C} = \frac{\beta \bar{w}}{-B \pi}. \] (8)

And the cash in advance constraint would entail that consumption has to be equal to the real value of money balances,

\[ \frac{\bar{M}}{P} = \bar{C}. \] (9)

The steady state value of capital would then directly depend on the steady state values of the real money balances and steady state value of foreign bond holdings,

\[ \bar{K} = \frac{\theta(M/P - \bar{F}^{1}B)}{\bar{F} - \theta S}. \] (10)

Next, hours worked in steady state would be negatively affected by the steady state value of wages, capital returns and capital held in the economy,

\[ \bar{H} = \frac{\bar{F}(1 - \theta)}{\bar{S}} \bar{K}, \] (11)

The steady state value of real output is a function of the steady state values of both capital and hours worked,

\[ \bar{Y} = (1 - \tau) K^{\theta} \bar{H}^{1 - \theta}. \] (12)

The steady state value of the aggregate utility would then depend on the steady state values of consumption and hours worked,

\[ \bar{U} = \frac{\log \bar{C} + \beta \bar{H}}{1 - \beta}. \] (13)

A monetary shock to this model, expressed by an exogenous change in inflation volatility expressed by \( \sigma \), which in turn affects the foreign interest rate \( r^f \), the changes in \( r^f \) in turn leads to new steady state values of foreign bonds, exports, physical capital, hours worked, output, and utility as expressed by Equations (3), (4), (10), (11), (12), and (13) respectively. In addition, as in Table 13.1 of McCandless (2008), any change in \( r^f \),
does not lead to any changes in the steady state value of consumption. In this case the steady state value of utility will only be affected by the increase in the steady state value of hours worked as obvious from Equation (13) above. Moreover, the steady state value of consumption will only change if the steady state value of money growth rate \( \bar{g} \) (which is equal to the steady state value of gross inflation rate) changes.

On the other hand, any change in the value of \( \tau \) is expected to affect the economy through its effect on the steady state value of output in Equation (12), and the steady state value of real wages in Equation (7). The changes in the steady state value of wages in turn affects the steady state value of consumption (which is equal real money balances) Equation (9) and the steady state value of hours worked in Equation (11). The changes in the steady state value of consumption in turn leads to changes in the steady state value of capital and utility, Equations (10) and (13) respectively. Finally, the new values for both capital and hours worked lead to new steady state values for both output and output per hours worked. The changes in \( \tau \), on the other hand, do not have any effect on the steady state values of both foreign bonds and exports.

**Appendix 2**

The range of the parameter \( \sigma_\pi = [0.0023, 0.0082] \) is derived as follows. Let \( \pi \) reflects the annual inflation rate, and let \( \pi^Q \) reflects the quarterly inflation rate.

\[
\pi = 400 \pi^Q \\
\text{var}(\pi) = 400^2 \text{var}(\pi^Q) \\
\sigma_\pi = 400 \sigma_{\pi^Q} \\
\log \sigma_\pi = \log 400 + \log \sigma_{\pi^Q}
\]

Since the average of the annual data on the log of inflation volatility (log \( \sigma_\pi \)) is in the interval \([0.02, 1.3]\), this implies that the average of the quarterly data on the log of inflation volatility, log \( \sigma_{\pi^Q} \), is in the following interval,

\[
[0.02–\log(400), 1.3–\log(400)] \\
= [-5.97, -4.69]
\]

By taking exponential we get the following interval \([0.0026, 0.0092]\) which is the interval of \( \sigma_{\pi^Q} \).

Given that:

\[
g = (1 - \rho) \bar{g} + \rho (g - 1) + \varepsilon_t \\
\text{var}(g) = \text{var}(\pi) = \sigma_{\pi^Q} = \frac{\text{var} \varepsilon}{1 - \rho^2} \\
\sigma_{\pi^Q} = \frac{\sigma_\pi}{\sqrt{1 - \rho^2}}
\]

And given that \( \sigma_{\pi^Q} = [0.0026, 0.0092] \) and since we have a calibrated value for \( \rho = 0.46 \) (From estimating an AR(1) model of P deviation), then we can solve for \( \sigma_\pi \).

Accordingly, \( \sigma_\pi \) is found to lie in the interval \([0.0023, 0.0082]\).
Notes

1. Following Chinn and Ito (2005), the LEGAL2 index is the principal component of creditors’ rights, shareholders’ rights, transparency of the companies’ accounts, and law enforcement indices. It depicts the overall development of the legal system governing financial transactions.

2. The SOE model, its equilibrium, and characterization of its steady states are all presented in Appendix 1.


4. More details on the computation of this interval are available in Appendix 2.

References


**Noha Emara**, Assistant Professor (Term), Economics Department, Barnard College, Columbia University. E-mail: nme2109@columbia.edu