Chapter 3: A Model of ERBS for Turkey

I work with a variant of the model developed in Atolia and Buffie (2005), which is a currency substitution model of a small open economy that operates under an open capital account and a crawling peg exchange rate. My model differs in two respects, however: First, I relax the assumption that traded and nontraded durables are consumed in fixed proportions. Second, I analyze a heterodox program where bond sales finance the fiscal deficit and money growth occurs only through capital inflows.

There are three financial assets in the model: domestic currency M, foreign currency F, and indexed treasury bonds. Both domestic and foreign currencies provide liquidity services. Considering the fact that Turkey has been a highly dollarized economy I prefer foreign currency rather than a foreign bond as the foreign asset. Over the 1990s, the ratio of foreign currency deposits to broad money has been 45-47 percent on average in Turkey. The share of foreign currency deposits in total deposits rose from 25.5 percent in 1990 to 45.9 percent in 1999 and reached 57.6 percent by the end of 2001 even though the average real rates of return on TL denominated assets were generally higher than those on

\[1\] Bahmani-Oskooee and Domac (2002)
foreign currency denominated deposits. The collapse of the ERBS program in February 2001 promoted currency substitution further. The level of foreign currency deposits which was $36 billion at the end of 2000 continued to increase and reached $45 billion in 2003. A recent study by the Fed also confirms that Turkey has been one of the highly dollarized economies in the world. In that study, Turkey ranks as the fifth largest US currency holder with an estimated $10 billion in circulation as of 2002. Another reason for choosing foreign currency rather than a foreign bond is to make sure that foreign and domestic currency assets are not perfect substitutes. In an optimizing, perfect-foresight model with an open capital account, domestic and foreign bonds are perfect substitutes and the domestic interest rate differs from the foreign rate only by the percentage depreciation of the exchange rate. Thus is not consistent with the data from developing countries.

The economy produces a nontraded good and a traded good. Real output in the tradables sector is fixed whereas it is demand determined in the nontradables sector. The nontraded good can be consumed either as a durable or a nondurable

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2 Between 1990 and 2000, the average real rates of return on TL denominated deposits were 20 percent while the same rate were about 3 percent for foreign currency denominated deposits. See Civcir (2003).
good. The private sector also consumes an imported durable good. World prices equal unity, so the domestic price of the tradable good is set by the nominal exchange rate $e$. $P$ is the overall price level (i.e., consumer price index). $P_n$ and $\gamma$ denote the relative price of the nontraded good and its share in aggregate consumption respectively. $Q_i$ is output in sector $i$. $F$, $m$, and $E$ are the stock of foreign currency, real money balances, and real nondurables expenditure measured in units of the traded good (i.e., measured in dollars).

**Prices**

The overall price level $P$ is a geometric average of the prices of the traded and nontraded goods. Since the nominal exchange rate sets the domestic price of the traded good,

$$P = e P_n^\gamma$$

The inflation rate is

$$\pi = (1 - \gamma) \chi + \gamma \pi_n$$

where $\gamma \equiv \gamma_{nd} \gamma_d + \gamma_{nc} \gamma_c$; $\gamma_d$ and $\gamma_c$ are the respective weights of durables and nondurables in the CPI; $\gamma_{nj}$ is the share of nontradables in total spending on consumer good of type j; $\chi$ is the rate of currency depreciation; and $\pi_n$ is the rate
of price growth in the nontradables sector.

The Nontradables Sector

The nontraded good can be consumed either as a nondurable or a durable good. Consumption on nontraded nondurables is given by the Marshallian demand function $C_n(P_n,E)$ and the demand for durables is given by gross new purchases of the nontraded durables, $S_i$. Since consumer purchases are the only source of demand, the nontradables market clears when

$$C_n(P_n,E) + S_i = Q_n$$

Prices in the nontradables sector are sticky a la Calvo and Vegh (1993). Firms adjust prices only when they receive a random “price-change signal”. Firms that receive a signal choose a new price by forecasting the future paths of the price level and excess demand. Therefore, price adjustment is forward-looking. Forward-looking price setting is also consistent with the price setting behavior in the Turkish economy. Although part of public wage and price setting involves ex-post inflation indexation, wages have been determined flexibly in the private sector. Shiller (1997) as a matter of fact, shows Turkey as a surprising example of a country that has lived with persistently high inflation for such a long time.
without widespread indexation. Empirical findings in Celasun, Gelos, and Prati (2003), and Celasun and McGettigan (2005) also fit with the limited evidence of indexation. Back to the model, Calvo (1983) shows that when the price-change signal obeys a Poisson process

\[ P_n = (\pi_n - \chi)P_n \]  \hspace{1cm} (4)

\[ \dot{\pi}_n = -\alpha \left[ C_n(P_n, E) + S_t - \ddot{Q}_n \right], \quad \alpha > 0, \]  \hspace{1cm} (5)

where \( \ddot{Q}_n \) denotes notional output (i.e., the level of output associated with a normal capacity utilization rate) and a dot signifies a time derivative (i.e., \( \frac{dx}{dt} \)).

Equation (4) follows from the fact that, at any point in time, the nominal price of the nontraded good is fixed by past price quotations. (More precisely, at any time \( t \) the set of firms that adjust their prices is of measure zero.) Equation (5) is a higher-order Phillips Curve. It says that the change in \( \pi_n \), the inflation rate in the nontradable sector, is a decreasing function of excess demand. The parameter \( \alpha \) is larger the shorter the length of the average price quote.
The Private Agent’s Optimization Problem

All economic activity in the private sector is undertaken by a representative agent who possesses an instantaneous utility function of the form,

\[
\frac{C(C_n, C_T)^{1 - \frac{1}{\tau}}}{1 - \frac{1}{\tau}} + \frac{D_1^{1 - \frac{1}{\psi}}}{1 - \frac{1}{\psi}} + k_4 \frac{D_2^{1 - \frac{1}{\psi}}}{1 - \frac{1}{\psi}} - R_1 \left( \frac{\dot{D}_1}{D_1} \right) D_1 - R_2 \left( \frac{\dot{D}_2}{D_2} \right) D_2,
\]

where \(D_1\) is the stock of nontraded durables, \(D_2\) is the stock of imported durables, \(C(C_n, C_T)\) is an index of nondurables consumption and \(k_4\) is a constant which determines the ratio of nontraded durables to imported durables at the initial steady state equilibrium. \(R_i(\cdot)\), introduces a friction that prevents durables purchases from being too volatile. It captures the costs incurred when consumers adjust their durables stock through new durables purchases. As Bernanke emphasizes, new durables purchases are not easy or automatic. In contrast to nondurables spending, the decision to buy a durable often involves time consuming search and careful deliberation. The utility cost of worrying and lost leisure time is assumed to be increasing, symmetric, and convex in net purchases of durable goods: \(R_i(0) = 0, R_i'\) as \(\dot{D}_i\) and \(R_i'' > 0\).

The representative agent has homothetic preferences and possesses perfect
foresight. The private agent’s optimization problem is solved in two stages. In the first stage, \( C_n, C_T \) are chosen to maximize \( C(C_n, C_T) \) for given values of \( P_n \) and \( E \).

Write this part of solution as \( C^* = V(P_n, E) \). \( V(P_n, E) \) is a standard indirect utility function that measures felicity gained from consumption of nondurables \( (V_E > 0, V_{P_n} < 0) \). In the second stage, the private agent chooses \( m, F, b, S_1, S_2 \) and \( E \) to maximize,

\[
U = \int_{0}^{\infty} \left\{ V(P_n, E) + k_4 \frac{D_2}{1 - \frac{1}{\psi}} + \frac{D_1}{1 - \frac{1}{\psi}} - R_1 \left( \frac{S_1}{D_1} - c \right) D_1 - R_2 \left( \frac{S_2}{D_2} - c \right) D_2 \right\} e^{-\psi t} dt, \quad (6)
\]

subject to the wealth constraint

\[
A = m + F + P_n^Y b, \quad (7)
\]

the budget constraint,

\[
\dot{A} = P_n Q_n + Q_r + \tilde{g} + r P_n^Y b + (\pi - \chi) P_n^Y b - \chi m - Y \left[ 1 + \frac{\phi(m, F)}{Y} \right], \quad (8)
\]

and,
\[
\begin{align*}
\dot{D}_1 &= S_1 - cD_1, \\
\dot{D}_2 &= S_2 - cD_2,
\end{align*}
\]

(9) \hspace{1cm} (10)

where \( \rho \) is the time preference rate, \( c \) is the depreciation rate for durables, \( m = \frac{M}{e} \) is the real domestic money balances, \( b = \frac{B}{P} \) is the real stock of bonds, \( r \) is the real interest, \( S_1 \) and \( S_2 \) represent the new purchases of nontraded and imported durables, \( Y = E + P_n S_1 + S_2 \) is aggregate spending and \( \bar{g} \) is lump sum transfers. Domestic and foreign currencies are held to reduce transactions-costs.\(^3\)

Transactions costs, \( YL \left[ \frac{\phi(m,F)}{Y} \right] \), are assumed to be decreasing in the ratio of liquidity services \( \phi \) to aggregate spending. Liquidity services are generated by domestic and foreign currency. \( \phi(\cdot) \) is homogeneous of degree one, increasing and strictly concave in \( m \) and \( F \left( \phi_m, \phi_F > 0, \phi_{mm}, \phi_{FF} < 0 \right) \). \( L(\cdot) \) is decreasing and strictly convex \( \left( L(\cdot) < 0, L'(\cdot) > 0 \right) \). In the budget constraint, \( P_n^\gamma \) multiplies \( b \) because wealth is measured in dollars but bonds are indexed to the price level.

\(^3\) See Rebelo and Vegh (1995), Reinhart and Vegh (1995), and Uribe (2002) for the same specification of transactions costs.
Let $\omega_1, \omega_2,$ and $\omega_3$ be the multipliers attached to the constraints (8), (9) and (10).

The first order conditions are

$$V_k(P_n,E) = \omega_l \left( 1 + L - \frac{\phi}{Y} \right), \quad (11)$$

$$-L\phi_m = r + \pi, \quad (12)$$

$$-L\phi_F = r + \pi - \chi, \quad (13)$$

$$\omega_2 = \omega_l P_n \left( 1 + L - \frac{\phi}{Y} \right) + R_1, \quad (14)$$

$$\omega_3 = \omega_l \left( 1 + L - \frac{\phi}{Y} \right) + R_2, \quad (15)$$

and the co-state equations are

$$\dot{\omega}_1 = \omega_l \left( \rho + \chi - r - \pi \right), \quad (16)$$

$$\dot{\omega}_2 = \omega_2 (\rho + c) + R_1 - R_2 \frac{S_1}{D_1} - D_1^{-1} \psi, \quad (17)$$

$$\dot{\omega}_3 = \omega_3 (\rho + c) + R_2 \frac{S_2}{D_2} - D_2^{-1} \psi, \quad (18)$$
Equation (11) states that the marginal utility of consumption of nondurables equals the shadow price of wealth times the effective price of nondurables consumption. Effective price consists of the market price of the good plus the transactions costs incurred by purchasing an additional unit of the good. Equations (12) and (13) are straightforward arbitrage conditions. Consumer equates, at the margin, the reduction in transaction costs that result from real holding of an additional domestic (or foreign) currency to its opportunity cost which is nominal interest rate for domestic currency. Equations (14), (15), (17) and (18) define a Tobin’s q model of durables purchases.

\[ \frac{\omega_i}{\omega_i P_n (1 + L - \frac{\phi}{Y})} = \frac{\omega_i}{V E P_n}, (i = 2, 3) \]

is the ratio of the demand price (or shadow price) of a durable to its supply price. \( R_i \) captures the additional adjustment costs incurred by increasing \( S_i \) a small amount. And equation (16) is simply an Euler equation.

The Public Sector

The public sector is composed of the government and the central bank. The central bank issues high powered money \((M)\) in order to finance the fiscal deficit
of the government and holds foreign exchange reserves \(Z\). I assume that the foreign exchange reserves do not bear interest. The central bank’s balance sheet is

\[ M = DC + eZ \quad (19) \]

where \(DC\) is the central bank’s domestic credit to the government.

Money is injected into the economy whenever the central bank accumulates foreign exchange reserves or runs the printing press to finance the fiscal deficit.

\[ m + zm = \frac{DC}{e} + Z, \quad (20) \]

The government makes lump sum transfers to the private agent and collects fees, \(YL(\cdot)\), for liquidity services. Fees are then returned to the private sector through transfers. Therefore, lump sum transfers have two components: True transfers, \(P^\gamma_n g\) and rebated fees, \(YL \left[ \frac{\phi(m, F)}{Y} \right] \).

\[ \ddot{g} = P^\gamma_n g + YL \left[ \frac{\phi(m, F)}{Y} \right], \quad (21) \]
\( P^f_n \) multiplies \( g \) because \( \tilde{g} \) is measured in dollars but transfers are indexed to the price level.

In addition to paying out lump-sum transfers, the government makes unproductive purchases of \( X \) units of the traded good. The government also issues indexed domestic bonds which are held by the private agent. The government budget constraint is thus

\[
\frac{\dot{D}C}{e} + P^f_n \dot{b} = \tilde{g} + rP^f_n b + X - Y_L,
\]

or,

\[
\frac{\dot{D}C}{e} + P^f_n \dot{b} = P^f_n g + rP^f_n b + X, \tag{22}
\]

Combining equations (20) and (22) yields the consolidated public sector budget constraint

\[
\dot{m} + P^f_n \dot{b} = P^f_n g + rP^f_n b + X + \dot{Z} - \chi m, \tag{23}
\]

**Crawling Peg and Bond-Financed Fiscal Deficit During ERBS**

At the pre-ERBS steady-state equilibrium, seigniorage pays for the entire fiscal deficit, the current account deficit is zero, the real interest rate equals the time
preference rate, the real money supply and the real stock of bonds are constant.

That is

\[ \pi = \pi_n = \chi_0, \quad \text{(Pre-ERBS phase)} \]

\[ \dot{m} = \dot{b} = \dot{Z} = \dot{F} = 0, \quad \text{(Pre-ERBS phase)} \]

\[ \frac{\dot{DC}}{e} = \chi'_0 m, \quad \text{(Pre-ERBS phase)} \]

\[ \chi_0 m_0 = P^r_n g + \rho P^r_n b_0 + X \quad \text{(Pre-ERBS phase)} \]

When the government lowers the rate of crawl from \( \chi_0 \) to \( \chi_1 \), the rate of domestic credit creation is set equal to the lower rate of crawl \( \chi_1 \), and bond sales adjust as needed in order to cover the rest of the fiscal deficit.

\[ \frac{\dot{DC}}{e} = \chi_1 m, \quad 0 \leq t < t_1 \quad \text{(ERBS phase)} \quad (24) \]

Therefore, during the ERBS phase \( b \) and \( m \) evolve according to

\[ \dot{m} = Z, \quad 0 \leq t < t_1 \quad \text{(ERBS phase)} \quad (25) \]

\[ \dot{b} = g + rb + \frac{X - \chi_1 m}{P^r_n}, \quad 0 \leq t < t_1 \quad \text{(ERBS phase)} \quad (26) \]
As it is pointed out in Rebelo and Vegh (1995) many ERBS programs got off the track quickly due to insufficient fiscal adjustment\(^4\). As comes to the 2000-2001 Turkish ERBS, the program rested on an upfront fiscal adjustment worth of 6.5 percent of GNP in order to reduce the WPI inflation from 63 percent to 20 percent by the end of 2000. Although fiscal benchmarks were attained successfully the economy was hit by a severe currency crisis in November and the program collapsed after a couple of months. As in many other failed stabilization episodes post crisis fiscal policy relied on sharp fiscal adjustments. In 2001, government consumption expenditures fell by 8.5 percent in real terms. Given the circumstances, doubts arise about the sufficiency of initial fiscal adjustment to support a permanently lower crawl in Turkey. Accordingly, I assume that the reduction in the rate of crawl from \(\chi_0\) to \(\chi_1\) is not supported by a fiscal adjustment.

**Net Foreign Asset Accumulation and the Current Account Balance**

Adding consolidated public sector and private agent budget constraints yields

\[
\dot{Z} + \dot{F} = P_nQ_n + Q_T - E - P_nS_1 - S_2 - X,
\]

\(^4\)For instance Argentine 1978 tablita, and 1986 Brazilian Cruzado.
or,

\[ m + F = P_n Q_n + Q_T - E - P_n S_1 - S_2 - X \]

since

\[ m = Z \]

Under a crawling peg, the money supply adjusts endogenously through the capital account in order to satisfy money demand. But while domestic currency can be swapped for foreign currency at the central bank, the total dollar value of currency holdings is predetermined. Thus we need to define \( J = m + F \) as a state variable in the dynamic system. That is

\[ J = P_n Q_n + Q_T - E - P_n S_1 - S_2 - X, \quad (27) \]

**The Post-ERBS Period**

At time \( t_1 \), the program collapses, bond sales stop and the deficit is fully monetized. From \( t_1 \) onward, therefore, \( b = 0 \) and

\[ m = P_n^g + r P_n^g b(t_1) + X + Z - \chi m, \quad t \geq t_1. \quad \text{(Post-ERBS phase)} \quad (28) \]

When the program collapses, the government raises the crawl by the amount \( K \)
and curtails lump sum transfers \( g \) by the amount \( W \). I assume that the first adjustment in the crawl is inadequate and followed by further increases at the rate

\[
\dot{\chi} = \nu(\chi_0 - \chi), \quad \nu > 0, \quad t \geq t_1, \quad (29)
\]

The path for the crawl is described by (29) and the exogenous adjustment at time \( t_1 \) is

\[
\chi(t) = \chi_1 + K + (\chi_0 - \chi_1 - K)[1 - e^{-\nu(t-t_1)}], \quad t \geq t_1. \quad (30)
\]

Since the inflation will go to its original level \( \chi_0 \) in the long run, any increase (or decrease) in domestic debt has to be offset by permanently lower (or higher) transfers. Therefore, after the program fails, \( g \) goes toward its post-stabilization level \( \bar{g} \), associated with permanently higher domestic debt. The path for \( g \) is

\[
\dot{g} = y(\bar{g} - g), \quad y \geq 0, \quad t \geq t_1. \quad (31)
\]

\[
g(t) = \bar{g} + \left( g(t_1) - \bar{g} \right) e^{-y(t-t_1)} \quad t \geq t_1. \quad (32)
\]

where

\[
\bar{g} = \chi_o m_o - \rho b(t_1) - X_o
\]
The Solution Procedure

Since the perfect foresight solution to the model generates a dynamic system with characteristic equation of a high-order polynomial there is no hope of deriving a closed-form solution. It is necessary therefore to rely on a mix of numerical and analytical methods. The first step in the solution procedure is to eliminate the unobservable shadow prices from the dynamic system. Differentiating (11) with respect to time and substituting for $\omega_t$ from (16) gives

$$\left[1 - \frac{\tau}{\beta} a_i Y_c \right] \frac{\dot{E}}{E} = \left[ \tau r - \gamma_{nd} (\tau - 1) + \frac{\tau}{\beta} a_i Y_{nd} \right] \left( \pi_a - \chi \right) + \frac{\tau}{\beta} a_i Y_{nd} \frac{\dot{S}_1}{S_1} + \frac{\tau}{\beta} a_i (1 - \gamma_{nd}) \frac{\dot{S}_2}{S_2}$$

$$- \frac{\tau}{\beta} a_i \left( 1 - \theta_F \frac{J}{F} \right) \frac{m}{m} - \frac{\tau}{\beta} a_i \theta_F \frac{J}{J} + \tau (r - \rho) \quad (33)$$

where

$$\tau = -\frac{V_{EE}}{V_{EE}} \frac{E}{E}$$ is the intertemporal elasticity of substitution for nondurables,

$$\beta = -\frac{L}{L} \frac{\phi}{Y}$$ is the inverse of the elasticity of marginal utility of real liquidity holding,

$$\theta_F = \frac{\phi_F F}{\phi}$$ is the share of liquidity services generated by foreign
currency, and \( a_1 = \frac{L \phi}{Y} \). \( 1 + L - L \frac{\phi}{Y} \).

In order to replace the term involving second partial derivatives \( V_{EP} \) with something meaningful assume homothetic preferences and note from Roy’s identity \( C_n = -\frac{V_p}{V_E} \) that \( \frac{V_{EP}}{V_{EE} C_n} = \tau - 1 \).

Differentiating (14) with respect to time and substituting for \( \omega_2 \) from (17) gives

\[
\begin{align*}
\frac{R_i'}{D_i} S_1 &= \frac{R_i'}{D_i^2} S_1 (S_1 - cD_1) + \rho R_i' + R_i' \left( c - \frac{S_1}{D_1} \right) - \frac{1}{D_1} + V_E P_n (r + c) \\
+ V_E P_n \frac{a_1}{\beta} \gamma_d \gamma_d \frac{S_1}{S_1} + V_E P_n \left( \gamma - 1 \right) \frac{a_1}{\beta} \gamma_d \gamma_d \left( \pi_n - \chi \right) - V_E P_n \frac{a_1}{\beta} \left( 1 - \theta_F \frac{J}{F} \right) \frac{m}{m} \\
- V_E P_n \frac{a_1}{\beta} \theta_F \frac{J}{F} \frac{J}{J} + V_E P_n \frac{a_1}{\beta} \gamma_c \frac{E}{E} + V_E P_n \frac{a_1}{\beta} \gamma_d \left( 1 - \gamma_d \right) \frac{S_2}{S_2} (34)
\end{align*}
\]

Differentiating (15) with respect to time and substituting for \( \omega_3 \) from (18) gives
During the ERBS phase the dynamic system involves $P_n, \pi_n, D_1, D_2, S_1, S_2, E, J, b$. Equations (33), (34), and (35) have variables $(m, r, \pi_n)$ that change on the transition path although they are not part of the dynamic system. Therefore, we need to relate these to all other variables which belong to the system. To accomplish this, use (12) and (13) from the first order conditions and assume $\phi(m, F)$ is a linearly homogeneous CES function with $\sigma$ being the elasticity of substitution between $m$ and $F$. In this case (12) and (13) yield

\[
\frac{\sigma \theta m + \beta \theta F}{\sigma} \dot{m} + \frac{(\sigma - \beta)}{\sigma} \theta_e \dot{F} = \dot{\gamma} - \frac{\beta}{i} (dr + d\pi), \quad (36)
\]

\[
\frac{(\sigma - \beta)}{\sigma} \theta m \dot{m} + \frac{(\sigma \theta + \beta \theta_m)}{\sigma} \dot{F} = \dot{\gamma} - \frac{\beta}{(i - \chi)} (dr + d\pi - d\chi), \quad (37)
\]
where a circumflex indicates a percentage change (i.e., $\hat{x} = \frac{dx}{x}$), $i = r + \pi$ is the nominal interest rate, and

$$
\theta_m \equiv \frac{\phi_m m}{\phi} = \frac{\phi_m m}{\phi_m m + \phi_F F}, \quad \theta_F \equiv \frac{\phi_F F}{\phi} = \frac{\phi_F F}{\phi_m m + \phi_F F}
$$

are the shares of liquidity services provided by domestic and foreign currency. By using $Y = E + P_n S_1 + S_2$, $J = m + F$, and $\pi = (1 - \gamma) \chi + \gamma \pi_n$ (36) and (37) yield

$$
A_1 \dot{m} + (1 - A_1) \dot{J} = \gamma_c \hat{E} + \gamma_n \gamma_d \hat{P}_n + \gamma_n \gamma_d \hat{S}_1 + \gamma_d (1 - \gamma_n) \hat{S}_2 - \frac{\beta}{i} \left[ dr + (1 - \gamma) d\chi + \gamma d\pi_n \right]
$$

and

$$
A_2 \dot{m} + (1 - A_2) \dot{J} = \gamma_c \hat{E} + \gamma_n \gamma_d \hat{P}_n + \gamma_n \gamma_d \hat{S}_1 + \gamma_d (1 - \gamma_n) \hat{S}_2 - \frac{\beta}{i - \chi} \left[ dr - \gamma d\chi + \gamma d\pi_n \right]
$$

where

$$
A_1 = 1 - \frac{(\sigma - \beta)}{\sigma} \theta_F \frac{J}{F} \quad A_2 = 1 - \frac{(\sigma \theta_F + \beta \theta_m)}{\sigma} \frac{J}{F}
$$
These two can be solved for \( m \) and \( r \) as a function of \( E, P_n, S_1, S_2, J, \pi_n, \chi \). That is

\[
m = f^1(E, S_1, S_2, J, P_n, \chi), \quad r = f^2(E, S_1, S_2, J, P_n, \chi, \pi_n) \quad (38), (39)
\]

Anticipating future needs, evaluate the solutions (38) and (39) at a steady state where \( r = \rho \) and \( \pi = \pi_n = \chi \).

\[
\hat{m} = \frac{\gamma_c}{A_3} \hat{E} + \frac{\gamma_n \gamma_d}{A_3} \hat{S}_1 + \frac{\gamma_d (1 - \gamma_n)}{A_3} \hat{S}_2 + \frac{(A_3 - 1)}{A_3} \hat{J} + \frac{\gamma_n \gamma_d}{A_3} \hat{P}_n - \frac{\beta}{A_3} \hat{\chi}, \quad (38)
\]

\[
dr = \gamma_n n_1 \hat{E} + \gamma_n \gamma_d n_1 \hat{P}_n + \gamma_n \gamma_d n_1 \hat{S}_1 + \gamma_d (1 - \gamma_n) n_1 \hat{S}_2 + \frac{\gamma - 1 + n_1 \sigma F}{\rho J A_3} d\chi \quad (39)
\]

where

\[
n_1 = \frac{1}{A_3} \frac{\rho + \chi}{\chi} \frac{\rho J}{\sigma F}, \quad A_3 = 1 + \left[ \frac{\beta (\rho + \chi)}{\sigma} - \frac{(\sigma \theta_F + \beta m)}{\sigma} \right] \frac{J}{F}
\]

After substituting for \( \frac{m}{m} \) from (38), equations (33), (34), and (35) will be as the following
\[
\left(1 - \frac{\tau}{\beta} a_{\gamma_{d}} A_{4}\right) \frac{\dot{E}}{E} = \left(\frac{\tau}{\beta} a_{\gamma_{nd}} A_{4}\right) \frac{\dot{S}_1}{S_1} + \left(\gamma_{w} + \tau (\gamma - \gamma_{w}) + \frac{\tau}{\beta} a_{\gamma_{nd}} A_{4}\right) \frac{\pi_{n} - \chi}{\chi} - \frac{\tau}{\beta} a_{\gamma_{d}} A_{4} \frac{\dot{J}}{J}
\]

\[+ \beta_{t} (1 - A_{d}) \frac{\dot{\chi}}{\chi} + \tau (r - \rho) + \left(\frac{\tau}{\beta} a_{\gamma_{d}} (1 - \gamma_{nd}) A_{4}\right) \frac{\dot{S}_2}{S_2}, \quad (33)\]

\[
\left(\frac{R_{1}}{D_{1}} S_{1} - V_{E} P_{n} \frac{a_{\gamma_{d}}}{\beta} \gamma_{nd} A_{4}\right) \frac{\dot{S}_1}{S_1} = \left(V_{E} P_{n} \frac{a_{\gamma_{d}}}{\beta} A_{4}\right) \frac{\dot{E}}{E} + \left(V_{E} P_{n} \frac{a_{\gamma_{d}}}{\beta} (1 - \gamma_{nd}) A_{4}\right) \frac{\dot{S}_2}{S_2} - V_{E} P_{n} \frac{a_{\gamma_{d}}}{\beta} A_{4} \frac{\dot{J}}{J}
\]

\[+ \left(V_{E} P_{n} (\gamma - 1) + V_{E} P_{n} \frac{a_{\gamma_{d}}}{\beta} \gamma_{nd} A_{4}\right) (\pi_{n} - \chi) + V_{E} P_{n} a_{1} (1 - A_{d}) \frac{\dot{\chi}}{\chi} + \frac{R_{1}}{D_{1}} S_{1} (S_{1} - c D_{1}) + \rho R_{1} + R_{2} + R_{3}\left(c - \frac{S_{1}}{D_{1}}\right)
\]

\[- D_{1} \beta_{t} (r + c), \quad (34)\]

\[
\left(\frac{R_{2}}{D_{2}} S_{2} - V_{E} \frac{a_{\gamma_{d}}}{\beta} (1 - \gamma_{nd}) A_{4}\right) \frac{\dot{S}_2}{S_2} = \left(V_{E} \frac{a_{\gamma_{d}}}{\beta} A_{4}\right) \frac{\dot{E}}{E} + \left(V_{E} \frac{a_{\gamma_{d}}}{\beta} \gamma_{nd} A_{4}\right) \frac{\dot{S}_1}{S_1} - V_{E} \frac{a_{\gamma_{d}}}{\beta} A_{4} \frac{\dot{J}}{J}
\]

\[+ \left(V_{E} (\gamma - 1) + V_{E} \frac{a_{\gamma_{d}}}{\beta} \gamma_{nd} A_{4}\right) (\pi_{n} - \chi) + V_{E} a_{1} (1 - A_{d}) \frac{\dot{\chi}}{\chi} + \frac{R_{2}}{D_{2}} S_{2} (S_{2} - c D_{2}) + \rho R_{2} + R_{2} + R_{3}\left(c - \frac{S_{2}}{D_{2}}\right)
\]

\[- D_{2} \beta_{t} (r + c), \quad (35)\]

where

\[A_{4} = 1 - \frac{1}{A_{3}} \left(1 - \frac{J}{F}\right)\]
Before linearizing the system around the steady state associated with the low rate of crawl we need to solve equations (33)', (34)', and (35)' simultaneously in order to obtain solutions that isolate $E_1, S_1, S_2$ on the left side. The derivatives of the adjustment cost functions, however, enter into the solution. Since the linearized system needs to be expressed in a suitable form for calibration and simulation, we have to relate the curvature of $R(\cdot)$ to observable magnitudes. Note that $R'(\cdot) = R''(\cdot) = 0$ at a stationary equilibrium. The only parameter of the adjustment cost functions that affects the outcome is $R''(\cdot)$. To tie down this parameter return to (14) and (15). Observing that $\omega / V_E$ is effectively the demand price of capital. Thus

$$\frac{R_1'(S_1/D_1 - c)}{V_E} = q_1$$

$$\frac{R_2'(S_2/D_2 - c)}{V_E} = q_2$$

where
\[ q_1 = \frac{\omega_1}{V_E P_n} \quad \text{and} \quad q_2 = \frac{\omega_2}{V_E} \]
denote Tobin’s q for nontraded and traded durables. Differentiation now yields

\[ \frac{R_1''}{D_1 V_E P_n} \frac{\hat{S}_1}{q} = \frac{1}{c D_1} \quad \text{and} \quad \frac{R_2''}{D_2 V_E} \frac{\hat{S}_2}{q} = \frac{1}{c D_2} \]

Define \( \Omega_i \equiv \frac{\hat{S}_i}{q} \). Under the neutral assumption that \( \Omega_i = \Omega \), the q-elasticity of durables spending is the same for both durables,

\[ \frac{R_1'}{D_1 V_E P_n} = \frac{1}{c D_1 \Omega} \quad \text{and} \quad \frac{R_2'}{D_2 V_E} = \frac{1}{c D_2 \Omega} . \]

After simplification and collection of terms the solutions for \( \dot{E}, \dot{S}_1, \dot{S}_2 \) emerge as the following:

\[
\frac{\dot{E}}{E} = (N_1 \tau - (\tau - 1) \gamma \pi_n) (\pi_n - \chi) - N_2 \frac{\tau \pi c \omega J}{\hat{c} \Omega \chi} (R_n Q_n + Q_r - E - P_n S_i - S_2 - X) + N_3 \frac{\tau}{c \Omega \chi} \dot{\chi} + \frac{\tau}{A_3} \\
+ N_4 - N_5 \frac{\tau D_1}{c V_E P_n} - N_6 \frac{\tau D_2}{c V_E} + N_7 \frac{\tau}{c \Omega \chi} \left( \frac{S_1}{D_1} - c \right) + N_8 \frac{\tau}{c \Omega \chi} \left( \frac{S_2}{D_2} - c \right) \\
+ N_9 \frac{\tau}{c V_E P_n} \left( \rho R_1 + R_1 \left( c - \frac{S_1}{D_1} \right) \right) + N_6 \frac{\tau}{c V_E} \left( \rho R_2 + R_2 \left( c - \frac{S_2}{D_2} \right) \right) , \quad (40)
\]
\[
\dot{S}_1 = (N_1 - 1)c\Omega D_1 (\pi_n - \chi) - N_2 D_1 \frac{1}{J} (P_n Q_n + Q_T - E - P_n S_1 - S_2 - X) + N_3 D_1 \frac{\chi}{\chi} + \frac{c\Omega}{A_5} D_1 r \\
+ N_4 D_1 - (N_5 + c)\Omega \frac{D_1^{1, \frac{1}{\psi}}}{V_E P_n} - \Omega N_6 \frac{D_1 D_2}{D_2 V_E} + \left( \frac{N_5}{c} + 1 \right) S_1 \left( S_1 - c \right) + N_6 D_1 \left( S_2 - c \right)
\]
\[+ (N_5 + c)\Omega \frac{D_1}{V_E P_n} \left( \rho R_1' + R_1 + R_1 \left( c - \frac{S_1}{D_1} \right) \right) + N_6 \Omega \frac{D_1}{V_E} \left( \rho R_2' + R_2 + R_2 \left( c - \frac{S_2}{D_2} \right) \right), \]
\[(41)\]

\[
\dot{S}_2 = N_1 c\Omega D_2 (\pi_n - \chi) - N_2 D_2 \frac{1}{J} (P_n Q_n + Q_T - E - P_n S_1 - S_2 - X) + N_3 D_2 \frac{\chi}{\chi} + \frac{c\Omega}{A_5} D_2 r \\
+ N_4 D_2 - N_5 \Omega \frac{D_2}{D_1} \frac{D_1^{1, \frac{1}{\psi}}}{V_E P_n} - \Omega (N_6 + c) \frac{D_2^{1, \frac{1}{\psi}}}{V_E} + N_5 D_2 \left( S_1 - c \right) + \left( \frac{N_6}{c} + 1 \right) S_2 \left( S_2 - c \right)
\]
\[+ N_5 \Omega \frac{D_2}{V_E P_n} \left( \rho R_1' + R_1 + R_1 \left( c - \frac{S_1}{D_1} \right) \right) + (N_6 + c)\Omega \frac{D_2}{V_E} \left( \rho R_2' + R_2 + R_2 \left( c - \frac{S_2}{D_2} \right) \right)
\]
\[(42)\]

where

\[A_5 = 1 - \frac{a_1}{\beta} A_4 (\gamma_\tau + \gamma_\Omega),\]
\[ n_2 = \frac{a_1}{\beta} A_3 \gamma_n \frac{1}{A_5}, \quad n_3 = \frac{a_1}{\beta} A_4 \gamma_e \frac{1}{A_5}, \]

\[ N_1 = (1 - \Omega) \gamma_{nd} n_2 - (1 - 1) \gamma_{ne} n_3 + \frac{\gamma}{A_5}, \]

\[ N_2 = \frac{a_1}{\beta} A_4 c \Omega, \quad N_3 = \frac{a_1}{\beta} \frac{(1 - A_4)}{A_5} c \Omega, \]

\[ N_4 = \frac{c^2 \Omega}{A_5} - c \Omega (\rho + c) n_3 \tau \]

\[ N_5 = \Omega \gamma_{nd} n_2 c, \quad N_6 = \Omega (1 - \gamma_{nd}) n_2 c, \]

\[ N_7 = \left( \frac{\Omega (\rho + c) n_2 - \rho}{A_5} \right) \tau, \]

Equations (4), (5), (9), (10), (26), (27), (40), (41), (42) together with (38) and (39) control the equilibrium path during the stabilization period where the rate of crawl is constant. In order to make this system self-contained we also need to solve equation (3) for \( Q_n \) as a function of \( S_1, P_n, E \). After obtaining the solution for the \( Q_n \) and choosing units so that \( E = P_n = 1 \) initially, the system that is linearized around the steady state associated with the lower rate of crawl, \( \chi_1 \). In this \( 9 \times 9 \) system \( J, P_n, D_1, D_2, b \) are predetermined and \( E, S_1, S_2, \pi_n \) are jump
variables. Once the solutions for $E, S_1, S_2, P_n, \pi_n, J$ are in hand, the paths for $m$ and $r$ can be retrieved via (38) and (39).

In the post-ERBS period, $b$ (equation 26) drops out, and $\chi$ and $g$ enter through (29) and (31) as additional state variables ($\chi$ and $g$ jump at $t_i$, but the jumps are exogenous.) This produces a $10 \times 10$ system in which $J, P_n, D_1, D_2, \chi, g$ are predetermined and $E, S_1, S_2, \pi_n$ are jump variables. Thus, the dynamic system that takes over at time $t_i$ is saddlepoint stable iff six of the system’s ten eigenvalues are negative.

**Solving for the Transition Path**

I assume that the reduction in the rate of crawl catches the public by surprise. The subsequent policy reversal at $t_i$, however, is perfectly anticipated. The public knows from the outset that ERBS is not sustainable and the government will eventually abandon the policy at time $t_i$. From $t = 0$ up to time $t_i$, the economy follows a nonconvergent path of the system associated with the low rate of crawl, $\chi_1$. The general form for this nonconvergent path is
\[
\begin{bmatrix}
E(t) - E^* \\
J(t) - J^* \\
P_n(t) - P_n^* \\
\pi_n(t) - \chi_1 \\
S_1(t) - S_1^* \\
S_2(t) - S_2^* \\
D_1(t) - D_1^* \\
D_2(t) - D_2^* \\
b(t) - b^*
\end{bmatrix} = L \begin{bmatrix}
h_1 e^{\lambda t} \\
h_2 e^{\lambda t} \\
h_3 e^{\lambda t} \\
h_4 e^{\lambda t} \\
h_5 e^{\lambda t} \\
h_6 e^{\lambda t} \\
h_7 e^{\lambda t} \\
h_8 e^{\lambda t} \\
h_9 e^{\lambda t}
\end{bmatrix}, \quad 0 \leq t < t_1, \quad (43)
\]

where \( L \) is a \( 9 \times 9 \) matrix with eigenvector \( L^j \) in column \( j \); \( \lambda_1 - \lambda_9 \) are eigenvalues; \( h_1 - h_9 \) are constants determined by boundary conditions and the * superscript refers to the value of the variable at the steady state for \( \chi_1 \). After the policy reversal, \( \chi \) and \( g \) join the system and the economy follows the saddle path that leads back to pre-ERBS equilibrium. The general form for this convergent path is
where $\lambda_{i0} - \lambda_{i5}$ are the system’s negative eigenvalues; $N$ is the associated matrix of eigenvectors; and $h_{i0} - h_{i5}$ are six additional constants.

**Boundary Conditions**

In order to pin down the constants $h_i - h_{i5}$ in (43) and (44) and the level of domestic debt at the end of ERBS phase, sixteen boundary conditions are required. Evaluating the solution paths for state variables at $t = 0$ and $t = t_1$ provides 11 restrictions: At $t = 0$

$$J_0 - J^* = L_2[h_1, \ldots, h_9], \quad (45)$$

$$P_{n,0} - P_n^* = L_3[h_1, \ldots, h_9], \quad (46)$$
\[ D_{1,0} - D^*_1 = L_7 h_{11} \cdots h_{12} \], \quad (47) \\
\[ D_{2,0} - D^*_2 = L_8 h_{12} \cdots h_{13} \], \quad (48) \\
\[ b_0 - b^* = L_{10} h_{14} \cdots h_{16} \], \quad (49) \\

where \( L_i(N_i) \) picks out the row \( i \) from matrix \( L(N) \). Since \( J, P_n, D_1, D_2 \) are predetermined, their solutions at \( t = t_1 \) must be the same as in (43). This provides

\[ J^* + L_2 h_1 e^{\lambda t_1} \cdots h_9 e^{\lambda t_1} = J_0 + N_2 h_{10} e^{\lambda t_1} \cdots h_{15} e^{\lambda t_1}, \] \quad (50) \\
\[ P_n^* + L_3 h_1 e^{\lambda t_1} \cdots h_9 e^{\lambda t_1} = P_{n0} + N_3 h_{10} e^{\lambda t_1} \cdots h_{15} e^{\lambda t_1}, \] \quad (51) \\
\[ D_1^* + L_7 h_1 e^{\lambda t_1} \cdots h_9 e^{\lambda t_1} = D_{10} + N_7 h_{10} e^{\lambda t_1} \cdots h_{15} e^{\lambda t_1}, \] \quad (52) \\
\[ D_2^* + L_8 h_1 e^{\lambda t_1} \cdots h_9 e^{\lambda t_1} = D_{20} + N_8 h_{10} e^{\lambda t_1} \cdots h_{15} e^{\lambda t_1}. \] \quad (53)

We also know the values of \( \chi \) and \( g \) at time \( t_1 \)

\[ \chi_1 + N_9 h_{10} e^{\lambda t_1} \cdots h_{15} e^{\lambda t_1}, \] \quad (54) \\
\[ g - W = g + N_{10} h_{10} e^{\lambda t_1} \cdots h_{15} e^{\lambda t_1}, \] \quad (55)

At \( t = t_1 \), the stock of domestic debt settles at its new steady state level. That is

\[ b(t_1) - b^* = L_{10} h_1 e^{\lambda t_1} \cdots h_9 e^{\lambda t_1}, \] \quad (56)
The other four boundary conditions place restrictions on the paths of the jump variables at the time of the policy reversal, \( t = t_1 \). The solution paths for \( E, S_1 \), and \( S_2 \) link up through a jump in spending at the time of policy reversal. To determine the jump, note that optimizing behavior and perfect foresight imply that multipliers are constant at time \( t = t_1 \); jumps occur only when the private agent adjusts in response to the arrival of new information. In the case under examination, new information arrives only at \( t = 0 \) since the public believes that the cut in the rate of crawl is temporary. Therefore, optimizing behavior demands that first order conditions (11), (14) and (15) hold at \( t = t_1 \) with \( \omega_1, \omega_2, \omega_3 \) unchanged. Since multipliers are constant, \( E \) in (11), \( S_1 \) in (14), and \( S_2 \) in (15) jump to preserve the first-order conditions (11), (14) and (15). The jumps in \( E, S_1, \) and \( S_2 \) can be found from the first-order conditions (11), (12), (13), (14), (15) and the co-state equations (17) and (18). After working on a tedious algebra, the jumps turn out to be proportional to the jump in crawl, \( K \), at time \( t_1 \)

\[
E(\text{jump}) = E(t_1^+ - t_1^-) = C_1 K
\]

\[
S_1(\text{jump}) = S_1(t_1^+ - t_1^-) = C_2 K
\]
\[ S_2 (\text{jump}) = S_2 (t_1^+ - t_1^-) = C_3 K \]

where \( C_i \)'s are quite long and complicated terms involving a lot of parameters and variables.

The path of \( \pi_n \) is smooth as it is shown in Calvo (1983). Therefore, the other four boundary conditions are;

\[ E^* + L_1 \left[ h_1 e^{\lambda_1 t_1}, \ldots, h_9 e^{\lambda_9 t_1} \right] + E(\text{jump}) = E_0 + N_1 \left[ h_{10} e^{\lambda_{10} t_1}, \ldots, h_{15} e^{\lambda_{15} t_1} \right], \quad (57) \]

\[ \chi_1 + L_4 \left[ h_1 e^{\lambda_1 t_1}, \ldots, h_9 e^{\lambda_9 t_1} \right] = \chi_0 + N_4 \left[ h_{10} e^{\lambda_{10} t_1}, \ldots, h_{15} e^{\lambda_{15} t_1} \right], \quad (58) \]

\[ S_1^* + L_5 \left[ h_1 e^{\lambda_1 t_1}, \ldots, h_9 e^{\lambda_9 t_1} \right] + S_1(\text{jump}) = S_{1,0} + N_5 \left[ h_{10} e^{\lambda_{10} t_1}, \ldots, h_{15} e^{\lambda_{15} t_1} \right], \quad (59) \]

\[ S_2^* + L_6 \left[ h_1 e^{\lambda_1 t_1}, \ldots, h_9 e^{\lambda_9 t_1} \right] + S_2(\text{jump}) = S_{2,0} + N_6 \left[ h_{10} e^{\lambda_{10} t_1}, \ldots, h_{15} e^{\lambda_{15} t_1} \right], \quad (60) \]

**Model Calibration**

In order to prepare the model for calibration I use the following functional forms in order to describe preferences, the production of liquidity services, transactions costs and deliberation costs

\[ \phi(m, F) = \left[ k_2 m^{\frac{\sigma - 1}{\sigma}} + k_3 F^{\frac{\sigma - 1}{\sigma}} \right]^{\frac{\sigma}{\sigma - 1}} \]
\[ V(P_n, E) = \frac{E^{1 - \frac{1}{\tau}} (1 + k_1 P_n^{1 - \delta})^{\frac{\tau - 1}{\tau(\delta - 1)}}}{1 - \frac{1}{\tau}}, \]

\[ L \left( \frac{\phi}{E + P_n S_1 + S_2} \right) = k_6 \left( \frac{\phi}{E + P_n S_1 + S_2} \right)^{\frac{1}{1 - \beta}}, \quad k_6 > 0, \quad 0 < \beta < 1, \]

\[ R_i \left( \frac{S_i}{D_i} - c \right) = \frac{k_5 \left( \frac{S_i}{D_i} - c \right)^2}{2}, \quad k_5 > 0, \]

where \( k_1 - k_6 \) are distributional parameters and \( \tau, \delta, \sigma \) are, respectively, the intertemporal elasticity of substitution for nondurables, the elasticity of substitution between traded and nontraded nondurable, and the elasticity of substitution between domestic and foreign currency. Deliberation costs are a quadratic function of new durables purchases. The specification of transactions costs is the same as in Reinhart and Vegh (1995) and Uribe (2002), with liquidity services generated by a CES aggregate of domestic and foreign currency. The computer needs the number for substitution parameters, initial asset holdings, the rate of crawl before and after ERBS, etc., in order to solve the model. Table 12 lists the values for the base case and the alternative simulations. With respect to the choices:
Intertemporal elasticity of substitution for nondurables ($\tau$) and durables($\psi$). Estimates for LDCs place the elasticity of intertemporal substitution between 0.20 and 0.50 (Agenor and Montiel, 1999, Table 12.1). I used therefore 0.25 and 0.50 as the low and high values for the intertemporal elasticity of substitution.

The elasticity of substitution between traded and nontraded nondurables ($\delta$). The value set for this parameter agrees with the empirical studies that the scope for substitution is limited at high levels of aggregation.

The elasticity of substitution between foreign and domestic currency ($\sigma$). Estimates for Latin America range from one to six. I decided to set $\sigma$ at 2 which is also close to the estimate for Turkey (1.4) in Selcuk (2003). Then I used 0.50 in the alternative run.

Convexity of the transactions costs function ($\beta$). Reinhart and Vegh (1995), Rossi (1989), and Arrau et al. (1995) have estimated interest elasticity of money demand by using money demand functions of the type used in this model. Ignoring Arrau et al.’s estimate for Brazil (3.26 is implausibly high) the average of the estimated interest elasticities for Chile, Argentina, Brazil, Israel, Mexico, and Uruguay is 0.36. Including Arrau et al.’s estimate for Brazil, it is 0.72. Setting $\beta$ at 0.25 makes the interest elasticity of money demand 0.56 in the base run which is consistent with the simple average of 0.36 and 0.72. For Turkey, the estimates of inflation elasticity of money demand range from 2.62 to 2.9 (Ozmen, 1998; Selcuk, 2001; Ozdemir and Turner, 2004) that makes interest elasticity of money demand around 2.25 which is unreasonably high.

Depreciation rate for durables ($c$). There is no data for LDCs. Following Buffie and Atolia (2005) I fix this parameter at 0.10.

Time preference rate ($\rho$). Time preference rate plays two roles in the model: it discounts future utility and determines the steady state real rate of return on domestic bonds. Therefore I chose 0.10 for $\rho$ which is actually still low given that the real interest rates have been in the range of 12%-16% in Turkey over the nineties.
Speed of price adjustment in the nontradables sector ($\alpha$). I let $\alpha$ to vary between 3 and 1. The value assigned in the base case implies that price adjustment is fast but not instantaneous.

Length of the ERBS program ($t_c$). The low crawl lasts one year to be consistent with Turkey.


Rate of crawl before vs. during ERBS ($\chi_0, \chi_1$). I cut the rate of crawl from an initial value of 60% to 20% during ERBS.

Ratio of foreign currency to national income ($F_o$). The number for ratio of foreign currency to national income (0.12) is in line with the data. Dollarization ratio, the ratio of foreign currency deposits to broad money, has been 45%-47% on average in Turkey over the 1990s. Besides, a significant portion of liquid assets is held in foreign currency, which is labeled as “under the mattress dollars”. Therefore, 45%-47% should be considered only as a lower bound for dollarization in Turkey.

Ratio of domestic currency to national income ($m_o$). The number for the sum of currency held by the public plus reserves of commercial banks as % of GDP (0.08) is in line with the data.

Ratio of domestic debt to national income ($b_o$). Central government debt held by the private sector was 29.3% in Turkey at the end of 1999.
Consumption share of durables ($\gamma_d$). Following Buffie and Atolia (2005) I set this at 0.20. Weight of durables in the Turkish CPI is 0.073. This figure however, imputes a service flow to housing and excludes it. Adding the CPI share of housing, which is 0.258, raises the CPI share of durables to 0.33, which is also consistent with the value assigned to the consumption share of durables.

Share of nontradables in nondurables expenditure and in durables expenditure ($\gamma_{nd}, \gamma_{ne}$). Share of nontradables in the Turkish CPI is 0.58. According to the data in Burnstein, Neves, and Rebelo (2001), tradable consumer goods include a large nontraded distribution component and distribution costs amount to 60% of the retail price for durable and nondurable goods in Argentina. Taking this into account raises the weight of nontradables in the Argentine CPI to 0.71. Since there is no data for Turkey regarding to distribution costs, I used the share of nontradables in the Argentine CPI in order to set the initial shares for $\gamma_{nd}$ and $\gamma_{ne}$.

Paths of currency depreciation and government spending in the post-ERBS period (the two slope parameters $\nu$ and $y$, and the two jumps $K$ and $W$). At the end of ERBS the rate of crawl jumps from 20% to 40% and government spending (lump-sum transfers) is cut by 6% of initial GDP. Following the initial adjustment, crawl rate and lump sum transfers rise steadily at rates controlled by $\nu$ and $y$. The two jumps at the end of the program and the slope parameters $\nu$ and $y$ were chosen to be consistent with post-crisis period Turkey: Following the float of the domestic currency on February 22th, exchange rate depreciated very fast in the second and third quarters and stabilized as of November 2001. Fiscal adjustment was very fast therefore, I set the slope parameter so that lump-sum transfers are at the new long-run level 6 months after the program collapsed.

\[\gamma_d = \frac{P_n S_1 + S_2}{E + P_n S_1 + S_2}\]
Numerical Solutions

Figures 1-8 present the solution paths for the base case and for the cases where intertemporal substitution is stronger for nondurables ($\tau = 0.50$) or for durables ($\psi = 0.50$), domestic and foreign currencies are not close substitutes ($\sigma = 0.75$), interest elasticity of money demand is smaller ($\beta = 0.10$), q-elasticity of durables spending is higher, price adjustment is faster ($\alpha = 3$), and prices are stickier ($\alpha = 1$). The paths track the percentage deviation of the stated variable from its pre-ERBS value. Total consumption is nondurables consumption plus total durables purchases, the current account balance is measured as a percentage of GDP, and the positive values for the change in the real exchange rate signify appreciation. For an easy comparison, Table 13 collects the results of the consumption paths.

Despite the shortness of the ERBS period\(^6\), almost all of the runs capture the stylized facts. Equally important, the numbers for the consumption boom, the current account deficit, and the appreciation of the real exchange rate are of the same order of magnitude as observed in the aftermath of the ERBS program in Turkey. Led by an eye-catching surge in durables purchases, total consumption

\(^6\) Average length is three year in Calvo and Vegh (1999) data set for major ERBS episodes.
spending increases 7-8% on average. Current account deficit soars to 3-5.5% of GDP. The real exchange rate appreciates 16-20% before the end of the program. Both the boom and the contractionary phases in consumption are driven by durables. During the boom phase, the percentage increase in durables expenditure is 3-4 times larger than the increase in total consumption spending. When the recession hits, spending on durables contracts 2-3 times more than spending on total consumption.

While the results generally fit the empirical regularities associated with ERBS, they display some variation in terms of the magnitude of the consumption boom, the amount of real exchange rate appreciation and the severity of the recession. Below I comment on the logic underlying these variations.

*The consumption boom:* The magnitude of the initial boom displays variations across the runs. In the best run (β = 0.10) for instance, total consumption spending and total durables purchases increase 10% and 37% respectively and current account deficit swells to 5.5% of GDP. Because reducing β makes interest elasticity of money demand smaller, the temporary windfall gain delivered by the lower crawl rate is larger. Specifically, the decline in the inflation tax following the announcement of the low crawl increases the private disposable
income. Since the program is believed to be abandoned at some point in the future, the private agent will try to save his temporarily higher disposable income by making large purchases of durables. Increasing intertemporal elasticity of substitution of durables does not deliver a larger increase in durables spending. Conversely, the increase in durables is slightly smaller when $\psi$ is 0.50. The reason is that spending on durables is driven mainly by “intertemporal price speculation” rather than intertemporal elasticity of substitution. Durable goods generate services long after the date of purchase, so irrespective of the magnitude of intertemporal elasticity of substitution there is always an incentive to make large purchases of durables when its price is temporarily lower. Strong intertemporal elasticity of substitution of nondurables ($\tau = 0.50$) makes the percentage increase in nondurables at least two times larger. In terms of its effect on the increase in total consumption spending however, making $\tau$ bigger does not deliver a considerable difference since the heavy lifting belongs to durables.

Ease of currency substitution: A well known fact about inflation stabilization episodes is that slowdown in inflation is typically accompanied by strong money demand and reverse currency substitution. Note from the first-order conditions (12) - (13), at the initial steady state $\rho + \chi$ is the opportunity of cost of holding
domestic currency while $\rho$ is the opportunity cost of holding foreign currency. A reduction in crawl obviously reduces the opportunity cost of domestic currency hence stimulates a reverse currency substitution. From the same first-order conditions it is easily seen that one unit of domestic currency provides more liquidity services than one unit of foreign currency does\(^7\). Therefore, the private agent ends up with more liquidity services by simply swapping foreign for domestic currency. If that’s the case then the private agent may increase his consumption of liquidity services by holding more domestic currency but less total currency (domestic plus foreign) and meanwhile consume part of his stock of broad money assets. As long as domestic and foreign currencies are close substitutes ($\sigma = 2$) this is true. In all of the runs, except $\sigma = 0.75$, total currency holding declines considerably during ERBS. This is what Buffie and Atolia (2005) call “spending down of wealth” effect and it operates in seven of the eight simulations. Compared to the other simulations the results of the run with $\sigma = 0.75$ are poor and unrealistic; suggesting that $\sigma = 0.75$ is too low for an economy like Turkey where capital inflows/outflows are extremely fast.

\[ \phi_m = \frac{\rho + \chi}{-L} \quad \text{vs.} \quad \phi_F = \frac{\rho}{-L}. \]
Speed of price adjustment: Stickier prices in the nontraded goods sector leads to a larger real exchange rate appreciation (24% vs. 19% in the base case); and more severe and prolonged recession. Total consumption spending is still 2.34% below its pre-ERBS value two years after the collapse of the program.

In addition to replicating the general qualitative effects of a currency peg, the model can also account quantitatively for the responses of consumption and current account balance observed in Turkey. Table 14 provides a quantitative comparison of the numerical simulation results with the actual numbers observed during the ERBS episode in Turkey. The model does very well at replicating the magnitude of the current account deficit (5.5% of GDP predicted vs. 5% of GNP actual), the peak in total consumption spending (10.08% predicted vs. 9.6% actual), average growth rate in total consumption spending (6.7% predicted vs. 6% actual), the peak in durables spending (37.06% predicted vs. 39.5% actual), and the average growth rate in durables spending (24% predicted vs. 27.4% actual).

Habit Formation

The model can account reasonably well for the empirical regularities observed in Turkey after the implementation of ERBS in January 2000. But it does a poor job
of accounting for the timing of how consumption responds: In all of the numerical simulations, there’s a once-and-for-all increase in consumption at the time the lower crawl rate is announced, and then the consumption declines steadily. During ERBS episodes, however, consumption first increases gradually for a while, reaches a peak at some point before the abandonment of the currency peg, and then declines. Another problem is that the rate of growth in consumption drops below its pre-ERBS level before the program collapses which is not consistent with actual ERBS episodes where the consumption growth does not drop below its pre-ERBS level until after the policy collapse.

The results in Atolia and Buffie (2006) suggests that a model with habit affecting deliberation costs may induce hump-shaped profiles for durables spending and total consumption spending which agrees with the data. Following Atolia and Buffie (2006), the private agent experiences psychological unease when durables spending, $S_i$ ($i = 1, 2$), varies from its customary level. In other words, deliberation costs depend on how fast the stock of habit changes

$$R_i(S_i, H_i) = k_5 \frac{\left(S_i/H_i - 1\right)^2}{2} H_i$$
\[
\dot{H}_i = \nu (S_i - H_i), \quad \nu > 0
\]

where \(\nu\) indicates the rate at which the habit stock catches up with durables spending.

Since habit-forming agents dislike changes in their habit-adjusted durables spending levels, habit formation moderates durables spending growth and thereby total consumption spending in the early and late stages of ERBS. For habit-forming agents, a once-and-for all increase in durables spending at the time of policy announcement is not optimal because the increase in habit stock that results from higher durables spending makes future marginal utilities of durables consumption larger than today’s. Habit-formation thus mitigates the intertemporal substitution effect brought about by currency peg and induces private agents to increase their path of durables spending gradually. Habit-forming agents also start reducing their stock of habit by cutting back durables spending before the program collapses and the relative price of consumption goes back to its pre-ERBS level.

Figures 9-18 shows the solution paths when \(\nu = 6.5^8\); and Table 15 collects the results of the consumption paths. Results reveal a marked improvement in the

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8 The stock of habit covers 80% of the distance to its new long-run level within one quarter.
model’s performance regarding the timing of the response of durables spending and total consumption spending. Both durables and total consumption spending display hump-shaped paths with the downturn coming usually towards the end of the first quarter after the program is implemented. Durables spending does not drop below its pre-ERBS level until after the collapse whereas the total consumption growth drifts into negative figures at the time the program ends. In the model without habit, the recovery in consumption starts right at the time the program ends. Allowing for habit makes both durables spending and total consumption spending follow their contractionary trend throughout the year after the currency peg is abandoned, which is also more consistent with the Turkish ERBS episode. Another fact that stands out in the results is that in every case, durables and nondurables behave like Edgeworth substitutes: booming durables in the wake of ERBS are always accompanied by declining nondurables.

Habit incorporated model does a reasonably good job at accounting for both the qualitative and quantitative effects of ERBS program. Compared to the 2000-2001 ERBS episode in Turkey however, it has a single shortcoming: In all of the runs, the turning points come toward the end of the first quarter following the implementation of the program whereas the downturn in consumption boom came
at the end of the third quarter in Turkey. Although I tried to move the turning points in consumption forward by changing parameters, the results suggest that the timing of the downturn is quite robust.

**Concluding Remarks**

In this chapter I have analyzed the real effects of a temporary heterodox ERBS program where bond sales finance the fiscal deficit and money growth occurs only through capital inflows. The model allows for consumption of both durables and nondurables. In order to assess the model’s quantitative performance; it is calibrated by using data restrictions mainly from the Turkish economy. Results show that adding consumer durables improves the quantitative performance of weak credibility hypothesis considerably. Without appealing to high intertemporal elasticity of substitution, the model can generate consumption boom, the current account deficit, and real exchange rate appreciation that are comparable to those observed in Turkey in the aftermath of 2000-2001 ERBS program. The single major shortcoming is regarding the timing of the response of consumption. Instead of displaying an inverted-U shape, consumption declines steadily after a one time jump at the time the policy is announced. Following Atolia and Buffie (2006), I incorporated habit formation in deliberation costs in order to overcome
the problem regarding the shape of consumption. In the numerical simulations with habit affecting deliberation costs, the paths of durables spending and total consumption spending are hump-shaped but the timing of the downturn is not quite right. In all of the runs, the turning points come at the end of the first quarter following the implementation of the program whereas the downturn in consumption boom came at the end of the third quarter in Turkey. Despite this shortcoming, habit incorporated model does a reasonably good job at accounting for both the qualitative and quantitative effects of ERBS program.