Investor Sentiment in the Foreign Exchange and Initial Public Offering Markets

by

Larina Frances Muecke

B.A., University of Washington (1992)

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Signature of Author

Certified by

Department of Economics
May 1, 1998

Jerry A. Hausman
Professor of Economics
Thesis Supervisor

Andrew W. Lo
Professor of Finance
Thesis Supervisor

Accepted by

Chairperson, Department Committee on Graduate Students

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ABSTRACT

Chapter 2 develops a new general equilibrium model of exchange rates in the fragile emerging markets context. A collapsing exchange rate regime à la Dornbusch (1987) is embedded within a portfolio balance framework. To capture the financial fragility of emerging markets a modified ‘cash-in-advance' constraint and asymmetric financing constraints are imposed. The optimal portfolio allocation and the optimal consumption-wealth profile are derived as the solution to a log-linear approximation of the model. The consumption and asset demands incorporate investor’s unconditional expectation of depreciation, which relies on the investor’s assessment of the likelihood of a currency regime shift. Hence, the real equilibrium exchange rate incorporates investor’s views of government credibility. We consider the comparative static effects of changes in government policies. Changes in fundamentals alter the probability of crisis; thereby, affecting investor’s unconditional expectation of depreciation which serves as the transmission mechanism to influence consumption and asset demands and the real equilibrium exchange rate.

Chapter 3 applies the model of Chapter 2 to Mexico. The structural equations for the probability of crisis, the demand for Mexican real balances, and the real equilibrium exchange rate are estimated simultaneously using Full Information Maximum Likelihood. The historical probability series estimated by the model proves superior to the step-ahead forecasts from a probit model, providing a ‘crisis warning' framework. The model real equilibrium exchange rate deviates substantially from purchasing power parity and is positively correlated with, but smoother than the real interest rate differential. The investor’s unconditional and conditional expectations of depreciation generated by the model provide critical insight into the sustainability of the currency arrangement over time. We find the model assumptions fit the Mexican environment well. A declining probability of crisis cannot be explained by an inappropriate deficit financing condition, but possibly due to economic and structural reforms of the past decade enacted by Mexican authorities in response to earlier crises. Interestingly,
investors, for lower probability of crisis, anticipate higher future depreciation as the price of this stability.

Chapter 4 reconciles investment in the initial public offering (IPO) market with the ‘under-performance’ results of long-run performance studies. Reconciliation is achieved by casting the inquiry into the dimension of the investor. We gain insight into the new issues market by loosening the restriction on the investment horizon and investment trading strategies. We model investment in the initial public offering market with uninformed, positive feedback traders and informed, rational traders. Allowing for the opportunity to rebalance implies the existence of significant short run profit-taking. These short run dynamics are overlooked by performance studies which impose long-run buy and hold strategies. This restriction, we find, is only valid in a few circumstances such that the derived returns are biased downwards. In contrast, our modeling scenario requires only that uninformed, non-preferential investors are enticed into the new issues aftermarket by the leptokurtotic return distribution. The survey literature and references in the popular press are in accord with our minimal assumptions. Continued participation in the market is warranted because the overconfidence of uniformed investors, in substituting for private information, implies expected returns which strictly dominate the market. Moreover, to match the historical return performance of the market, the rational and buy and hold trading strategies require average probabilities of receiving shares at the offer price of 30% and 62%, respectively.

Thesis Supervisor: Jerry A. Hausman
Title: Professor of Economics

Thesis Supervisor: Andrew W. Lo
Title: Professor of Finance
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To Natalie
Chapter 1

Introduction

The economist may attempt to ignore psychology, but it is sheer impossibility for him to ignore human nature . . . If the economist borrows his conception of man from the psychologist, his constructive work may have some chance of remaining purely economic in character. But if he does not, he will not thereby avoid psychology. Rather, he will force himself to make his own, and it will be bad psychology. (Clark, Pg. 4)

Ignoring psychology in economics, too often is synonymous with the attempt to simplify models and subsequent analyses. Certainly there are advantages to this. Transparency in our complex world is underrated. Without simplification, the complex web of linkages and interactions overwhelm economic analysis, rendering it mathematically intractable and humanly inconceivable. Yet, with the imposition of simplifying assumptions is the risk of confounding reality, or the very creation of artificial incongruities. In defense of economic theory, Milton Friedman (1953) claimed the validity of the underlying assumptions should not matter if the theory still makes good, refutable predictions. The question remains, however, what is to be done if the predictions are refuted? Is the theory bad or are the underlying assumptions invalid?

Numerous examples of this predicament abound, for example, the expected utility theory of Von Neumann-Morgenstern (1944), which provides insight into choice under uncertainty. In this theory, uncertain prospects are modeled as probability distributions over given outcomes. This theory requires the consumer preference relation to be asymmetric and negatively transitive, as well as requiring a ‘substitution’ and ‘independence’ assumption governing probability distributions (See Kreps, Chapter 3). And yet, the violations of expected utility theory are just as well-known—the Ellsberg (1961), Allais (1953), and Kahneman-Tversky (1979) paradoxes. However, do these paradoxes suggest financial markets reject expected utility theory? In looking at financial markets, we find that the examples of anomalies
abound: the equity premium puzzle; the closed-end fund puzzle; the IPO puzzle; calendar effects in the stock market—January, weekend, holiday, turn-of-the-month, and intra-day effects, etc. The task of the financial economist is to discern whether these anomalies, which are at odds with 'no arbitrage', 'perfect markets', and expected utility theory, are artificial creations of the imposed model assumptions, data and/or estimation issues; or real theoretical quandries?

Two generic approaches have been pursued in the literature. The first approach retains the original assumptions and tries to explain the resulting puzzles or anomalies jointly by an additional theory. The second approach abandons the prior assumptions and builds anew from the bottom up. Obviously, the challenge is to know which of the two approaches is most fruitful.

If we consider the first approach, a popular application currently in vogue, has been attempts at solving the equity premium puzzle. The standard utility optimization approach remains intact, and much work has focused on introducing more volatility into the Euler equation, via the stochastic discount factor, including the reassessment of the aggregation of consumption due to limited stock market participation (See Allen and Gale (1994), Basak and Cuoco (1997)), the introduction of habit persistence (See Campbell and Cochrane (1995)), the introduction of leisure (See Eichenbaum, Hansen and Singleton (1988)), durable goods (See Startz (1989)), etc. To date, whether these solutions have been fruitful in advancing the literature and our understanding of this particular anomaly remains at issue.

The second approach typically requires the loosening of assumptions which are too strict, such as, unlimited rationality, homogeneity, etc. Tantamount to the popularization of this approach has been 'behavioral economics' which retains the normative status of optimization, but in loosening unlimited rationality assumptions, endeavors to develop explicitly descriptive models of systematic errors and cognitive behaviors of market participants and organizations. No doubt this approach has been spurred by the findings of psychologists, most notably Daniel Kahneman and Amos Tversky, who have found again and again that the usual axioms of finance theory—expected utility theory; risk aversion; Bayesian updating; rational expectations—are descriptively false. Much of this work, however, relies on heavily criticized survey responses, interpretation of the popular press, and behavioral analysis.

This dissertation takes each of the two approaches in meeting the challenge of determining real equilibrium exchange rates in the emerging markets context and explaining the 'new issues' puzzle. However, common to both approaches is the recognition of the importance of investor sentiment in economic models. Chapters 2 and 3 of this dissertation investigate the foreign exchange market in emerging countries. We continue to adhere to full or unlimited rationality of individuals, but in integrating two previously separate strands of the literature, provide for a pivotal role for investor sentiment, the investor's expectations of depreciation, to influence general equilibrium conditions. Underlying the derivation of this model, is the belief that while psychology drives the market in the short run, fundamentals will drive it
in the long run. Chapter 3 applies the model to Mexico. We select Mexico because of the richness of its crisis history and currency arrangements. Chapter 4 takes the second approach to explain investor participation in a market characterized by long run underperformance. This chapter recasts the inquiry into the dimension of the investor to model investor behavior in the new issues market. Motivated by survey results and views expressed in the popular press, we loosen adherence to the assumption of rational expectations by allowing some segment of the market to adhere instead to 'rules of thumb' which substitute for information. Within this framework, overconfidence that the historical return performance will be repeated can explain investor participation in this market. The resulting short-run dynamics from profit-taking cast doubt on the appropriateness of the previous long-run performance studies in this context.

So, while this dissertation does not address which approach is best, better, more appealing, etc. it demonstrates that each can be equally valid and appealing depending on the context, but more notably is the insistence that regardless of which approach is followed, investor sentiment must not be simplified away. Investor sentiment can be a driving force in the market whether it is conditioned on market fundamentals, whims, or ad hoc 'rules of thumb.' The second and third chapters demonstrate there is much valuable information to be learned from strict and simplifying assumptions, while the fourth chapter demonstrates the power of the second approach to resolve financial anomalies. However, in regard to this second approach, we are not suggesting modeling attempts should allow any behavior at all or, in particular, that which solves the 'anomalies' of interest, because behavior that is allowed at the whim of the modeler loses all predictive power. Noise trader type models and the behavioral finance approach are making promising inroads, although sceptics remain. The existence of sceptics, though, is crucial for the improvement of the approach. To address the initial question raised, we suggest resolution boils down to the modeler's joint comfortableness with the assumptions' descriptive reality and the practical usefulness of the refutable implications of the theory.
Bibliography


Chapter 2

Equilibrium Exchange Rates in the Fragile Emerging Markets Context

2.1 Introduction

The notion of a country’s long run equilibrium exchange rate is crucial for long-term investment decisions, risk management and directional currency trades. The equilibrium exchange rate provides a measure by which the spot exchange rate can be assessed, i.e., as being over- or under-valued. For emerging market economies, where the experience is typically of wild swings in nominal and real rates, a long run view is indispensable, especially as investors look to the emerging markets for higher returns. These higher returns, however, are not without increased risk. Often, these risks are severe, demonstrated by crises that affect the stability of an entire country or group of countries, as we are seeing currently in Asia.

Modeling in the context of emerging markets requires attention to the defining macro features of the environment: political instability, dubious economic policies, distortive government regulations, market frictions, to name a few. These macro features have implications at the micro level. Portfolio and consumption profiles of domestic investors may be constrained by the policies of the national governments. For example, methods of payment may be prespecified or investors may be liquidity or credit constrained. Furthermore, currency arrangements in emerging markets, may be fragile. Semi-fixed currency arrangements, such as crawling pegs, gliding parities, currency boards, etc., have been in vogue as recommended policies in the transformation and stabilization phases of development. However, currencies may be misvalued at the initial peg, and hence, inconsistent with fiscal and monetary policies. Also, governments may have stronger political goals that override sound economic objectives. Consequently, emerging market currency arrangements are financially vulnerable to macroeconomic excesses. In such
an environment, an initially misaligned currency can be exacerbated, increasing the likelihood of a currency crisis occurring. Thus, possessing an accurate view on the long run equilibrium exchange rate for these countries becomes crucial as the optimal investment strategy desires exit before the crisis and capital loss. Hence, to appropriately capture the fragility in emerging markets requires the incorporation of a measure to capture the credibility of national authorities' commitment to and ability to sustain the exchange rate regime which will influence the portfolio and consumption profiles of economic agents.

This paper develops a general equilibrium exchange rate model for emerging market economies. A cash-in-advance constraint is combined with asymmetric financing constraints to capture the relevant liquidity and payments environment. A collapsing currency framework is embedded within this modified portfolio balance approach to asset stock equilibrium. Investor's unconditional expectation of future depreciation serves as the transmission mechanism by which changes in government policies and fundamentals alter the likelihood of a crisis, thereby influencing asset and consumption demands, and hence, the real equilibrium exchange rate. The real equilibrium exchange rate depends directly on the consumption allocation decision of investors through which changes in investor sentiment transmit; the rate of investor time preference; the covariance of consumption growth and asset returns; and the country's risk (default) premium. Within this framework, we analyze the comparative static effects of changes in monetary, fiscal and currency policies on consumption and asset demands and the real equilibrium exchange rate.

The next section discusses briefly the development of relevant exchange rate models. Section 2.3 presents the theoretical model. Comparative static results follow in Section 2.4. Section 2.5 concludes. All detailed derivations are presented in the Appendix. The application of the model to Mexico can be found in Chapter 3.

2.2 Relevant Literature

To understand exchange rates, economists have considered the behavior of exchange rates in relation to prices (Law of One Price, Purchasing Power Parity); interest rates (Uncovered and Covered Interest Parity Hypotheses); the balance of payments (flow, monetary, and portfolio balance models); and more recently, news and expectation processes (including speculative attack and noise trader models). The transition in 1973 from the Bretton Woods regime of fixed, but adjustable, exchange rates between major currencies, to floating rates provided a significant stimulus for exchange rate modeling. The sheer magnitude of the variation in exchange rates, however, during the first few years of floating rates, cast doubt upon single-period equilibrium models.

The extent of the failings of the early balance of payment models of exchange rate determination,
however, was not adequately acknowledged until much later with the emergence of two studies by Meese and Rogoff (1983, 1988). These studies find that models of systematic exchange rate behavior could not outperform a naive random walk model. The later Meese and Rogoff (1988) study extends the previous analysis to real exchange rates and extends the post-sample period through June 1984. In concentrating attention on the accounting relation between real exchange rates and real interest differentials, they characterize the post-sample forecasting results as 'slightly more favorable.'

The poor empirical performance of these balance of payments models has been interpreted as suggestive of a more complicated relationship between exchange rates and current account balances. In particular, the direction of the literature has been toward linking the effect of current account imbalances on exchange rates and aggregate supplies and demands in the markets for financial assets denominated in different currencies. Economists shifted attention to exchange rate models incorporating equilibrium conditions for stocks of assets. This 'portfolio-balance' approach focuses on the requirement that available stocks of national monies and other financial assets are a necessary element in equilibrium conditions. This asset approach (See Kouri (1976)) views the exchange rate as determined by the same forces determining the price of other assets in the market—the prices at which the market is prepared to hold the total outstanding stocks of the asset. Empirical studies of portfolio balance models have been reviewed by Rogoff (1985). Whereas particular asset approach specifications may be questionable, overall, Mussa (1992) argues, the gross correspondence of the exchange rate market and asset markets are sufficiently aligned to insist the behavior of asset markets is the relevant theory for understanding the foreign exchange market in the determination of exchange rates.

The currency crises¹ precipitated by speculators in the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS), for example France (March 1983) and Italy (January 1976); in Latin America, Brazil (October 1986), Chile (June 1982), Argentina (June 1981), and Mexico (February 1982, December 1984); and in Asia today (Thailand, Indonesia . . . ) demonstrate harshly the reality that long run effects of policy changes by governments can differ from short run effects, i.e., namely that policy changes do not necessarily induce uniform and once and for all changes in the exchange rate as there can be preceding expectational effects. This recognition and the continuing occurrence of crisis has spurred the development and urgency of speculative attack models of exchange rates.

The speculative attack and collapsing currency regimes literature evolved from the seminal paper by Salant and Henderson (1978) which models a speculative attack on a country's gold reserves. Krugman (1979) builds on this model and derives the timing of a speculative attack in a deterministic framework when domestic credit finances a budget deficit which is inconsistent with the exchange rate regime. The authorities announce they are prepared to peg the exchange rate until reserves reach a specified lower

¹For a historical survey of financial crises in developed countries, 1720-1975, see Kindleberger (1978).
bound, at which point they will shift to a floating currency regime. With the government pegging the exchange rate (the relative rate of return on domestic and foreign currency denominated assets) investors wish to hold domestic and foreign assets in fixed proportions. They rebalance their portfolios by exchanging some of the additional domestic assets for foreign exchange reserves of the central bank. Since they exchange only a portion of the incremental supply (constant portfolio allocations), the shadow exchange rate, which will prevail in the event that the pegging policy is abandoned, depreciates gradually over time. When it first equals the current exchange rate investors attack the peg, depleting the authorities' remaining reserves. However, within Krugman's nonlinear specification an explicit solution for the time of collapse cannot be derived.

Flood and Garber (1984a) extend Krugman's analysis to a linear model to derive the timing of a crisis. Permutations of the Krugman and the Flood and Garber models have added insight in various dimensions. Dornbusch (1987) considers the collapse of a fixed exchange rate regime to floating and the transition from a fixed to crawling peg regime. Flood and Garber (1984b) and Obstfeld (1986) were first to formalize the possibility of self-fulfilling speculative attacks. Willman (1987) introduces uncertainty regarding the credit policy rule and level of reserves; Bacchetta (1990) investigates the real effects of anticipated crises through capital controls, and Blackburn (1988) considers an environment of imperfect asset substitutability and sticky prices.

The evidence from the few empirical studies of speculative attacks support the modeling approach of the earlier models of Krugman (1979) and Flood and Garber (1984a). Therefore, we embed a Dornbusch (1987) currency warning system within a modified portfolio balance model, tailored for the emerging markets.

2.3 Model

The model describes a two country, small and large, world economy, where the small country represents the emerging market economy and the large country, the rest of the world (or the United States). The small country will be referred to as the domestic economy and the rest of the world as the foreign economy. The domestic investors face methods of payment constraints: exports and foreign investment are financed using the foreign currency, while domestic goods and investments are financed in the local currency. Foreign investors, however, only use the currency of the domestic economy to finance their purchases of the domestic economy's bonds. Because the domestic economy places priority on financing its deficit by domestic credit creation, the stability of the country's currency is a second priority. The sterilization of domestic credit creation entails the sale of foreign reserves which jeopardizes the ability

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2See Literature Review Section in the next chapter.
to support the currency arrangement. The country risk of the domestic economy is captured by a risk premium on domestic bonds and the existence of precautionary holdings of foreign currency by domestic residents.

The next sections set out the details of the model. In the following discussion, variables with an asterisk pertain to the foreign country. The domestic economy will be of primary focus, with consideration of the foreign economy allocated to Appendix B.

2.3.1 Domestic Investor's Optimization Program

The representative domestic investor optimizes over consumption and portfolio profiles in the world economy. The domestic investor is assumed infinitely lived. In each period, the investor consumes traded and non-traded goods and allocates wealth among four available financial assets.

The domestic investor can hold domestic and/or foreign currencies, denoted by $M_t$ and $N_t$, respectively. The explicit market return on the domestic and foreign currencies is zero, however, the currencies are imperfect substitutes. Each currency serves as a financing vehicle. In addition, the foreign currency, serves as a precautionary saving instrument for domestic investors in the presence of domestic currency risk. The spot nominal exchange rate, defined by the amount of domestic currency needed to purchase one unit of foreign currency at time $t$, is denoted by $S_t$. In addition, investors can hold domestic and foreign bonds, $B_t$ and $F_t$, respectively.

Domestic and foreign bonds are imperfect substitutes due to both foreign exchange risk and country default risk, i.e., uncovered interest parity does not hold. Instead, the expected returns on the domestic and foreign securities are equated, taking into account the expected change in the nominal exchange rate and a country (default) risk premium, $\rho$. We assume that no uncertainty surrounds the natural logarithm or continuously compounded foreign interest rate:\footnote{Hereafter, the natural logarithm of a given variable will be denoted by lowercase character, unless otherwise specified.}

$$E_t i^*_t = i^*_{t+1} = i^* \forall t$$

$E[\cdot]$ is the mathematical expectations operator. The relevant interest parity condition is given by:

$$E_t i_{t+1} \approx i^* + E_t \theta_{t+1} + E_t \rho_{t+1}$$

(2.1)

where we write depreciation as the expected change in the log nominal exchange rate:

$$\theta_t = E_t s_{t+1} - s_t = \frac{E_t S_{t+1} - S_t}{S_t}$$

$$E_t s_{t+1} = s_t + E_t \rho_{t+1}$$

$$i^*_{t+1} = i^* - \theta_t$$

$$i^* = E_t i^*$$
We will assume the interest differential follows a first-order autoregressive process, AR(1):

\[ i_t - i^* = \theta_t + \varphi x_t = x_t \]  \hspace{1cm} (2.2)

where

\[ x_{t+1} = a + \varphi x_t + \eta_{t+1} \]  \hspace{1cm} (2.3)

with \( \eta_{t+1} \), a conditionally homoskedastic gaussian martingale difference sequence, \( \eta_{t+1} \sim N(0, \sigma^2_{\eta}) \). In addition, we will assume that the unexpected log return:

\[ i_{t+1} - E_t i_{t+1} = u_{t+1} \]  \hspace{1cm} (2.4)

is also conditionally homoskedastic and correlated with innovations in the interest differential:

\[ Var_t(u_{t+1}) = \sigma^2_u \]  \hspace{1cm} (2.5)

\[ Cov_t(u_{t+1}, \eta_{t+1}) = \sigma_{u\eta} \]  \hspace{1cm} (2.6)

The domestic and foreign currencies are imperfect substitutes in exchange. This is made explicit by the imposition of asymmetric financing constraints which represent the ‘globalization (dollarization) of the world economy.’ Domestic investors must pay for imported goods (the excess of traded goods consumption over traded goods production), and foreign currency (dollar) denominated bonds with foreign currency (dollars) and pay for domestic currency denominated bonds and non-traded goods with domestic currency:

\[ \Delta B_t - R^*_t B_{t-1} + P_t^NC_t^N = M_t \]  \hspace{1cm} (2.7)

\[ (\Delta F_t - R^*_t F_{t-1})S_t + S_t P_t^T C_t^T \leq S_t N_t \]  \hspace{1cm} (2.8)

\( \Delta \) denotes the first difference, \( R^*_{t+1} = \exp(i^*_{t+1}) \) and \( R^* = \exp(i^*) \). The superscripts N and T, represent non-traded and traded goods, respectively. Notice, when domestic investors hold excess dollars, Equation 2.8 will be slack. In addition, the domestic investor is subject to a modified cash-in-advance constraint requiring adequate combined holdings of domestic and foreign currencies to finance the total value of their consumption and portfolio investments.\(^5\)

\(^{4}\)A martingale difference sequence is defined for \( X_t \) if the following properties hold: 1. \( \{X_t\}_{t=1}^{\infty} \) is a sequence of random scalars with \( E(X_t) = 0, \forall t \); 2. \( E(X_t | X_{t-1}, X_{t-2}, ..., X_1) = 0, t = 2, 3, ... \)

\(^{5}\)Cash in advance models are developed in Clower (1967) and Lucas (1984), among others.
\[ P_tC_t = P_t^N C_t^N + (S_t P_t^T) C_t^T \leq M_t + S_t N_t \]  

(2.9)

This modified cash-in-advance constraint allows for currency substitution. It captures both the transaction service demand for both currencies among domestic investors, as well as, the precautionary demand for foreign currency over the domestic in a world with uncertainty and country risk. In the case of domestic liquidity constraints, the cash-in-advance constraint will come under pressure, depending on the extent of currency substitution or diversification. In the case of extreme domestic currency risk, we would expect substitution out of the domestic currency into the foreign currency. In this instance, because the amount of money in circulation is determined by the respective Central Banks, holdings of foreign currency by domestic investors may not adequately finance the consumption demands, thereby, putting the payments chain under pressure.\(^6\)

Investors are risk averse with preferences described by a standard constant relative risk aversion (CRRA), time separable, power utility function\(^7\) of the form:

\[ U(C_t) = \frac{C_t^{1-\gamma}}{1-\gamma} \]  

(2.10)

\[ U_t > 0, U_{tt} < 0 \]

\[ \gamma \neq 1 \]

The representative domestic investor chooses traded and non-traded goods consumption, \(C^T\) and \(C^N\), respectively, and the portfolio weight, \(\omega\), which allocates wealth, net of currency holdings, between domestic and foreign bonds. We can write the investor's aggregate consumption as:

\[ C_t = (C_t^T)^{\rho} (C_t^N)^{1-\rho} \]

and the aggregate price level in terms of domestic currency is:

\[ P_t = (S_t P_t^T)^{\rho} (P_t^N)^{1-\rho} \]

where \(\rho\) represents the share of traded goods in consumption and \(P_t^T\) represents the world price of

\(^6\)In fact, the model restricts domestic holdings of foreign currency to the residual of the foreign money supply less foreign demand; i.e., the foreign country's inflation preference constrains domestic holdings of foreign currency.

\(^7\)The use of a power utility function is restrictive in the sense that it equates the elasticity of intertemporal substitution (the willingness of the investor to substitute consumption between time periods) and the reciprocal of the coefficient of risk aversion (the willingness of the investor to allocate consumption between different states of the world). We restrict the coefficient of relative risk aversion, \(\gamma\), from being equal to one, to avoid the myopic logarithmic utility function.
traded goods in terms of foreign currency units. We take $\rho$ (and similarly, the foreign preference $\rho^*$) as an exogenous preference parameter of the domestic (foreign) investors. Wealth in the future period is comprised of the total return on invested net wealth this period, where labor income$^8$ is given by domestic production,$^9$ $Y_t$, and government taxes, $T_t$, are treated as exogenous.

Domestic investors maximize the expected lifetime utility of consumption, subject to the expected evolution of their wealth, $W_t$, the modified cash-in-advance constraint (Equation 2.9), and asymmetric financing constraints (Equations 2.7 and 2.8), based on their assessment of the probability that the currency regime will be abandoned prior to the beginning of the following period. Their actions, in turn, will affect the probability of collapse. The investors' program (in terms of domestic currency) is described by:

$$\max_{C_t, C_t^T, \omega} E_t \sum_{t=0}^{\infty} \beta^t \frac{[(C_t^T)^{\rho}(C_t^N)^{1-\rho}]^{1-\gamma}}{1-\gamma}$$

subject to

$$W_{t+1} = (W_t - P_tC_t)R_{p,t+1}$$

$$(\Delta F_t - \sigma F_{t-1})S_t + S_t P_tC_t^T \leq S_t N_t$$

$$(\Delta B_t - R_t B_{t-1} + P_t^N C_t^N = M_t$$

where

$$W_t = P_t Y_t - T_t + (1 + R_t) B_{t-1} + (1 + R^*)S_t F_{t-1}$$

and

$$R_{p,t+1} = \omega_t (R_{t+1} - R^*) + R^*$$

$^8$ By Walras' Law, we ignore the labor market and concentrate solely on the bond, goods, and money markets.

$^9$ Production in this two country world economy is characterized by a standard Neoclassical framework. To simplify the discussion as much as possible we do not here consider the traded and non-traded goods sectors separately, only in aggregate. Aggregate production of traded and non-traded goods, $Y_t = Y_t^N + Y_t^F$, in the domestic economy is characterized by a Cobb-Douglas production function with exogenous technological progress, $A_t$:

$$Y_t = A_t K_t^\phi L_t^{1-\phi}$$

The growth rate of the domestic economy can be decomposed into the following components:

$$g_t = a_t + (1 - \phi) K_t^\phi + (1 - \phi) n_t$$

where $g$ represents the growth rate of $Y_t$ (GDP); $a_t$, the growth rate of domestic technological progress; $\Delta K = I$, domestic investment; and $n_t$, the growth rate of the domestic labor force.
denotes the return on the portfolio.

We can combine the financing constraints (2.7) and (2.8) with the cash-in-advance constraint, (2.9), into the following single constraint:

\[ M_t + S_t N_t \geq P^N_t C^N_t + S_t P^T_t C^T_t + \Delta B_t - R_t B_{t-1} + (\Delta F_t - R^*_t F_{t-1}) S_t \]  

(2.15)

Further note, a strictly binding cash-in-advance constraint, Equation 2.9, implies total net investments in foreign and domestic bonds must be positive:

\[ (\Delta F_t - R^*_t F_{t-1}) S_t + \Delta B_t - R_t B_{t-1} \geq 0 \]  

(2.16)

We can simplify the resource constraint (2.12) using equation (2.13) and by disaggregating output and consumption into private and public components, noting that the production and total consumption of non-traded goods by investors and the government must be equal in equilibrium:\(^{10}\)

\[ W_{t+1} = (S_t P^T_t (Y^T_t - C^T_t) + P^N_t G^N_t - T_t) R_{p,t+1} \]

When the cash-in-advance constraint is strictly binding, the dimensions of the agent's dynamic choice problem reduces to a standard portfolio choice problem with a Lagrangian multiplier on the constraint, Equation 2.15 (See Sargent, 1987). The resulting Euler equation\(^{11}\) is given by:

\[ 1 = E_t [\beta ((\frac{C_{t+1}}{C_t})^{-\gamma} \frac{P_t}{P_{t+1}} (1 + R_{t+1})] \]  

(2.17)

Note that for a logarithmic approximation:

\[ \log((1 + R_{t+1}) \frac{P_t}{P_{t+1}}) \approx i_{t+1} - \pi_{t+1} = r_{t+1} \]  

(2.18)

If we log-linearize the Euler equation 2.17 using a second-order Taylor approximation around the condi-

\(^{10}\)Equilibrium in the non-traded goods sector requires the price of non-traded goods in each country to equate the total domestic demand, public and private, with domestic production:

\[ C^N_t (P^N_t) = C^N_t (P^N_t) + G^N_t (P^N_t) = Y^N_t (P^N_t) \]

Equilibrium in the traded goods sector requires that total world demand (private and public, foreign and domestic) for traded goods equals total world production at the world price of traded goods, \(P^T_t\):

\[ C^T_t = C^T_t + G^T_t \text{ for } i = T, T^* \]

\[ C^T_t + C^T_t = Y^T_t + Y^T_t \]

\(^{11}\)See Appendix A.1 for derivation.
tional mean of \((r_{t+1}, \Delta c_{t+1})\):

\[
0 = \log \beta + E_t \log(1 + r_{t+1}) - \gamma E_t \log \Delta c_{t+1} + \frac{1}{2} \text{Var}_t[\gamma \Delta c_{t+1} - r_{t+1}]
\]

The real exchange rate, defined as the relative prices of aggregate consumption (allowing for deviations from purchasing power parity) in the foreign and domestic countries, \(Q_t = \frac{S_t P^*_t}{P_t}\), can be written in terms of the differential between the domestic and foreign real interest rates using the interest parity condition, Equation 2.1 above:

\[
Q_t E_t(1 + r_{t+1}) = E_t Q_{t+1}(1 + r^*_{t+1})(1 + \psi_{t+1})
\]  
(2.19)

Upon taking the natural logarithm of the above real return relationship, we can substitute for the expected real domestic interest rate and rearrange the Euler equation as follows to determine the equilibrium expected real exchange rate growth:

\[
E_t \Delta q_{t+1} = \psi + \gamma E_t \Delta c_{t+1} - E_t r^*_{t+1} - E_t \psi_{t+1}
\]  
(2.20)

where

\[
\psi = -\log \beta - \frac{1}{2} \text{Var}_t[\gamma \Delta c_{t+1} - r_{t+1}]
\]  
(2.21)

The expected change in the real exchange rate is positively related to the growth of consumption, and negatively related to the investor's time preference, the foreign real interest rate, the country risk premium, and the variance of consumption growth and returns. Our equilibrium exchange rate differs from the standard derivation by the incorporation of the country credit risk premium and by the allowance of consumption growth and returns to covary. The real exchange rate today exhibits persistence to the extent that in expectation it is determined by yesterday's real exchange rate. The hypothesis that real exchange rates exhibit no regressive tendencies has not been established convincingly.  

12

2.3.2 Government sector

The domestic government consumes traded, \(G^T_t\), and non-traded goods, \(G^N_t\), taxes households, \(T_t\), issues new bonds, and pays interest on outstanding bonds, \(\bar{B}_t = R_t \bar{B}_{t-1}\). (The underline represents the total supply held foreign and domestically.) Capital gains and losses on bonds are limited to those associated

\[\text{Boughton (1984) in extending comparisons of models of systematic and random behavior of exchange rates in the literature investigated the portfolio balance models of Artus (1981) and Boughton (1984). He finds that in tests of post-sample forecasting accuracy (January 1981 - December 1984) the portfolio balance models usually performed better than a random-walk model. The estimated reduced forms of those models specify the real exchange rate as the dependent variable with an imposed coefficient of 1 in the Artus specification, and with estimated coefficients ranging from 0.87 to 0.97 in both the Boughton specifications.}\]
with exchange rate movements if we assume that both B and F are one period bonds and that the stock of
government debt is refinanced at the beginning of each period. Ordinarily, the domestic government
can finance its deficit by printing money, issuing bonds, or by engaging in the market for foreign exchange
in some combination:

\[ D_t = G_t^N + G_t^T - T_t = \frac{\Delta M_t}{P_t} + \frac{\Delta B_t}{P_t} - R_t \frac{B_{t-1}}{P_t} \]  \hspace{1cm} (2.22)

The domestic monetary base, \( M \), is comprised of domestic credit and international reserves:

\[ M_t = DC_t + IR_t \]  \hspace{1cm} (2.23)

For the emerging market (domestic) economy, we assume that the government finances its deficit by
domestic credit creation: 13

\[ -D_t = \Delta DC_t \]  \hspace{1cm} (2.24)

This implies that deficit financing will be inflationary to the extent that domestic credit creation is not
offset by drawing down international reserves, i.e.,

\[ \Delta M_t = \Delta DC_t + \Delta IR_t \]

and

\[ \Delta M_t = 0 \iff \Delta DC_t = -\Delta IR_t \]

We assume the government puts priority on financing the deficit by domestic credit creation; whereas,
the exchange rate regime is a secondary priority. Hence, when the deficit and domestic credit creation
escalates, and international reserves are sold to sterilize the money supply, the currency regime eventually
must be abandoned as support of the currency becomes no longer possible without adequate reserves.
Implicit is the assumption that alternative methods of financing of the deficit are not considered, i.e., we
are not allowing for uncertainty in the method of deficit financing. The assumption that the fiscal deficit
and therefore the required rate of domestic credit expansion is not influenced by the exchange rate policy
is motivated by political constraints on fiscal policy. Obstfeld (1986) shows that if the process governing
domestic credit growth changes with the exchange rate regime, there may be multiple equilibria and

13 Rather than assuming domestic credit creation alone finances the deficit, we could have chosen a fixed mixed-policy
rule such as:

\[ D_t = \beta_1 \frac{\Delta M_t}{P_t} + \beta_2 \frac{\Delta B_t}{P_t} + (1 - \beta_1 - \beta_2) R_t \frac{B_{t-1}}{P_t} \]
rational, self-fulfilling balance of payments crises may arise. To maintain tractability, we do not allow the deficit financing condition to be endogenous.

The stocks of the four financial assets are determined by the interaction of the respective country's monetary policy, budgetary policy, and official interventions in the foreign exchange market:

\[
\frac{B_t}{P_t} = \int D_t dt - \frac{M_t}{P_t} - \int \frac{R_t B_{t-1}}{P_t} dt
\]

(2.25)

\[
\frac{F_t}{P_t^*} = \int D_t^* dt - \frac{N_t}{P_t^*} - \int \frac{R_t F_{t-1}}{P_t^*} dt
\]

(2.26)

The deficit financing condition of the domestic country reduces Equation 2.26 to:

\[
\frac{B_t}{P_t} = -DC_t (1 - \frac{1}{P_t}) - \frac{IR_t}{P_t} - \int \frac{R_t B_{t-1}}{P_t} dt
\]

(2.27)

The asset stock equilibrium conditions (2.25) and (2.26) determine the nominal exchange rate as the ratio of the relative real returns on the domestic and foreign assets, from the condition that intervention in the foreign exchange market satisfies:

\[
\int \frac{R_t B_{t-1}}{P_t} dt = S_t \int \frac{R_t F_{t-1}}{P_t^*} dt
\]

such that

\[
S_t = \frac{\int \frac{R_t B_{t-1}}{P_t} dt}{\int \frac{R_t F_{t-1}}{P_t^*} dt}
\]

(2.28)

Hence, the real exchange rate, as defined by the relative price of the real returns, is written:

\[
Q_t = \frac{S_t P_t^*}{P_t} = \frac{P_t^* \int \frac{R_t B_{t-1}}{P_t} dt}{P_t \int \frac{R_t F_{t-1}}{P_t^*} dt}
\]

(2.29)

2.3.3 Currency Regime

This setup builds on the work of Krugman (1979), Dornbusch (1987), and Flood, Garber, and Kramer (1996). The exchange rate policy of the emerging market is characterized by a managed or dirty floating regime.\textsuperscript{14} A band is set wherein the currency floats subject to intervention. Accordingly, the band chosen determines a ceiling or maximum allowable rate of depreciation, (we allow for variance in this

\textsuperscript{14}We take a general approach to modeling the currency regime where the minimum we require is that the regime mandated by the monetary authority specifies some upper bound or ceiling on the allowable rate of depreciation of the nominal exchange rate over the period or foreseeable future. The idea is to model the transition between managed crawls where the crawl takes on the spectrum of fixed to free float, inclusive.
rate over time) denoted by $\mu_t$, i.e., $S_{t+1} < S_t (1 + \mu_{t+1})$. Expected depreciation of the currency, then, for a given credible regime must be less than this maximum rate. For this to be a credible policy, in light of domestic credit growth to finance the deficit which runs down the reserves to the extent of acceptable inflation, a minimum reserve level (the 'trigger level' of reserves, $R$) is required to sustain the currency below the ceiling. Less than this trigger level of reserves releases the currency to depreciate beyond the ceiling. A realignment of the bands to accommodate the allowable rate of depreciation is a credible action of the Central Bank, provided it does not represent a departure from former credible policies and does not change the maximum allowable rate of depreciation. Loose fiscal and monetary policies unduly run down reserves, putting increased pressure on the exchange rate and undermines the government's commitment to its own policy. A currency crisis will in effect precede the loss of all reserves.

Provided investor expectations of depreciation are less than or equal to the current policy, the currency faces no threat of speculative attack. If, however, investor's expectation today of next period's depreciation exceeds that which is allowed under the current regime, for example, if they doubt the credibility of the national authorities to support the currency or suspect there to be less than the trigger level of reserves available due to fiscal negligence, there will be an attack on the currency today. In equilibrium, there can be no expectation today of either a capital gain or loss tomorrow (Krugman, 1979). The unconditional expectation of depreciation, as determined by the probability of crisis weighted rate of depreciation, enters the investor's asset demands and influences consumption and asset profiles.

### 2.3.4 The Probability of an Attack

The probability of an attack on the currency can be determined as the probability that investors' expected depreciation tomorrow exceeds the policy mandate. This probability is in fact, equivalent to both the probability that the expected level of reserves tomorrow will be less than the trigger level or that the nominal exchange rate expected tomorrow is outside the allowable ceiling.

Monetary equilibrium in the domestic economy requires the real supply of domestic currency to equal the combined foreign and domestic real demand for money balances. The demands for domestic currency are derived in Appendix A, as the utility maximizing solution to the investor's program. To focus the discussion on the impact of the depreciation expectations, we use a reduced form relationship, such that domestic currency demands are negatively related to expected depreciation:

\[
M_t^D = \alpha - \xi \theta_t
\]  
(2.30)

\[
M_t^{D*} = \alpha^* - \xi \theta_t^*
\]  
(2.31)

The total world demand for real domestic currency then is given by the sum of foreign and domestic
demands:

\[ \bar{M}_t^D = M_t^D + M_t^{D*} \]

\[ \frac{M_t^D}{P_t} = \bar{\alpha} - \bar{\xi} \theta_t \]  (2.32)

where we assume there is no information disadvantage between foreign and domestic investors\(^{15}\) such that \( \theta_t^* = \theta_t^{D*} \). We also write \( \bar{\alpha} = \alpha + \alpha^* \) and \( \bar{\xi} = \xi + \xi^* \). Equating (2.23) and (2.32) yields the monetary equilibrium condition:

\[ \frac{DC_t + IR_t}{P_t} = \bar{\alpha} - \bar{\xi} \theta_t \]  (2.33)

Therefore, the equilibrium depreciation expectation of investors, in the case of no crisis (referred to as the conditional depreciation expectation), must satisfy:

\[ \theta_t = \frac{\bar{\alpha} - \frac{DC_t + IR_t}{P_t}}{\bar{\xi}} < \mu_t \]  (2.34)

The critical level of reserves required to sustain the crawling peg at the trigger point, while still maintaining monetary equilibrium is determined by:

\[ \frac{DC_t + R_t}{P_t} = \bar{\alpha} - \bar{\xi} \mu_t \]  (2.35)

Notice that for \( IR_t \neq \mathcal{R}_t, \theta_t \) will not equal \( \mu_t \), and in fact, for \( IR_t > \mathcal{R}_t, \theta_t \) is strictly less than \( \mu_t \).

The probability of an attack on the currency at time \( t \), then, can be determined as:

\[ p_t = \text{Prob}(E_t \theta_{t+1} > \mu_t) \]  (2.36)

If we plug in for \( E_t \theta_{t+1} \) and \( \mu_t \), using (2.34) and (2.35), notice that:

\[ \text{Prob}(E_t \theta_{t+1} > \mu_t) \rightarrow \text{Prob}(E_t R_{t+1} < \mathcal{R}_{t+1}) \]

If we assume that investor's conditional expectation follows a martingale,\(^{16}\) then

\[ \text{Prob}(E_t \theta_{t+1} > \mu_t) = \text{Prob}(\theta_t > \mu_t) = \text{Prob}(E_t S_{t+1} > S_t(1 + \mu_t)) \]

\(^{15}\)This is for simplification purposes, i.e., to avoid having to specify two expectation formulation processes.

\(^{16}\)This does not imply investor's expectation of the nominal exchange rate follows a martingale.
Substituting for $\theta_t$ from Equation 2.34 above:

$$\text{Prob}(\theta_t > \mu_t) = \text{Prob}(\frac{\bar{\alpha} - \frac{DC_t + IR_t}{\bar{\xi}}}{\bar{\xi}} > \mu_t)$$ (2.37)

Domestic credit growth is determined from our deficit financing condition (Equation 2.24) and using Equation 2.23:

$$g_{DC_t} = \frac{-D_t}{M_{t-1} - IR_{t-1}}$$ (2.38)

We can solve for the probability of crisis by rewriting Equation 2.37 in terms of the growth rate of domestic credit (2.38):

$$p_t = \text{Prob}(g_{DC_t} < \frac{[-\mu_t \bar{\xi} + \bar{\alpha}]P_t - IR_t}{DC_{t-1}} - 1)$$ (2.39)

Renaming $\zeta_t = \frac{[-\mu_t \bar{\xi} + \bar{\alpha}]P_t - IR_t}{DC_{t-1}} - 1$,

$$p_t = F(\zeta_t)$$ (2.40)

where $F(\cdot)$ represents the cumulative distribution function for domestic credit growth. The probability of a crisis (Equation 2.40) is increasing in the loss of reserves, an expansion of domestic credit, and the lower maximum allowable rates of depreciation or tighter currency band:

$$\frac{\partial p_t}{\partial IR_t} < 0$$

$$\frac{\partial p_t}{\partial DC_t} > 0$$

$$\frac{\partial p_t}{\partial \mu_t} < 0$$

2.3.5 Unconditional Depreciation Expectation

Upon determination of $p_t$, we can use $p_t$ to formulate the unconditional depreciation expectation, $\theta^e_t$, as the probability weighted sum of the conditional expectations of depreciation in the event of no crisis and crisis, respectively:

$$\theta^e_t = (1 - p_t)\theta_t + p_t\mu_t$$ (2.41)

From (2.40) and (2.41), we see that the unconditional depreciation expectation is declining in the level of reserves:

$$\frac{\partial \theta^e_t}{\partial IR_t} = \frac{\partial p_t}{\partial IR_t}(\mu_t - \theta_t) - \frac{\partial \theta_t}{\partial IR_t}(p_t - 1) < 0$$

The unconditional expectation must be at or between the level of depreciation dictated by the policy
and the conditional expectation loci, \( \theta_t \), governed by the monetary equilibrium condition (2.34).

### 2.3.6 Domestic Asset and Consumption Demands

The domestic asset and consumption demands will be a function of the investor's unconditional depreciation expectation given by (2.41). We follow the method of Campbell and Viceira (1996) to solve for the optimal portfolio allocation and optimal consumption-wealth ratio of an approximate problem to the system of equations (2.11), (2.12), and (2.15). The derivations are left to Appendix A. The procedure relies on the method of undetermined coefficients to solve for the parameters of the optimal demands of a log-linear approximation. The optimal log consumption-wealth ratio is given by:

\[
\begin{align*}
\tilde{c}_t - w_t & = b_0 + b_1 (E_t \tilde{i}_{t+1} - i^*) + b_2 (E_t \tilde{i}_{t+1} - i^*)^2 \\
& = b_0 + b_1 (\theta_{t+1}^{e} + E_t \varphi_{t+1}) + b_2 (\theta_{t+1}^{e} + E_t \varphi_{t+1})^2
\end{align*}
\]

(2.42)

(2.43)

where \( \tilde{C}_t = P_tC_t \), so \( \tilde{c}_t = log(P_tC_t) \). The optimal portfolio allocation \( \omega_t \) is similarly determined as a function of the unconditional expectation of depreciation and the risk premium:

\[
\omega_t = a_0 + a_1 (E_t \tilde{i}_{t+1} - i^*) = a_0 + a_1 (\theta_{t+1}^{e} + E_t \varphi_{t+1})
\]

(2.44)

where the parameters \( \{a_0, a_1, a_2, b_0, b_1, b_2\} \) are given by the joint solutions to the system of equations (A.6)-(A.12) in Appendix A.

The domestic and foreign bond demands are determined from the optimal portfolio allocation and net wealth, \( NW_t = W_t - \tilde{C}_t \):

\[
B_t = \omega_t NW_t
\]

(2.45)

\[
F_t = (1 - \omega_t) NW_t
\]

(2.46)

We can solve for the representative domestic investor's demand for domestic and foreign currencies directly, using the financing constraints (2.7) and (2.8), the optimal consumption (2.42), the optimal domestic demands for bonds, domestic (2.45) and foreign (2.46), and the market clearing conditions for foreign and domestic monies:

\[
M_t = \Delta(\omega_t NW_t) - i_t \omega_{t-1} NW_{t-1} + P_t^N (Y_t^N - G_t^N)
\]

To avoid notational clutter, we consider domestic holdings of foreign currency in terms of the foreign currency rather than domestic:

\[
\Delta F_t - R_t^* F_{t-1} + C_t^T P_t^T \leq N_t
\]
Similarly, we can write this as:

$$[\Delta((1 - \omega_t)NW_t) - R^*(1 - \omega_{t-1})NW_{t-1}) - (Y_t^T - G_t^T)P_t^T \leq N_t]$$

Using the market clearing condition for the foreign currency:

$$N_t = \bar{N}_t - N_t^*$$

and the foreign financing constraints (See Appendix B), the domestic foreign currency demand is defined as:

$$N_t = \bar{N}_t - (\Delta F_t^* - R_t^*F_{t-1}^*) + P_t^*C_t^*$$

where the foreign demands for foreign bonds are given in Appendix B. The domestic currency demands are nonlinear functions of lagged net wealth, expected depreciation, the value of non-traded goods consumption, and the risk premium.

### 2.4 Comparative Statics

This model in a framework of risk and return, explicitly allows for portfolio diversification and general equilibrium effects, in contrast to the partial equilibrium framework of Dornbusch (1987). The incorporation of the unconditional depreciation expectation into investor asset and consumption demands places value on the investor's view regarding policy viability in the future, thereby, influencing future viability itself.

For changes in depreciation expectations, we can compute the comparative static results of the impact on the optimal consumption and asset demands:

$$\frac{\partial \tilde{c}_t}{\partial \theta_{t+1}} = b_1 + 2b_2(\theta_{t+1}^* + E_t \varphi_{t+1})$$

$$\frac{\partial B_t}{\partial \theta_{t+1}^*} = a_1 NW_t$$

$$\frac{\partial F_t^*}{\partial \theta_{t+1}^*} = -a_1 NW_t$$

$$\frac{\partial M_t}{\partial \theta_{t+1}} = \xi = a_1 NW_t + b_1 + 2b_2(\theta_{t+1}^* + E_t \varphi_{t+1})$$

The change in aggregate consumption is driven by the interest differential between the domestic and foreign economies. In terms of traded and non-traded consumption goods, with reference to the Euler
equation (2.17) governing the path of consumption, we see for a fixed share of traded goods in consumption, the ratio of aggregate consumption today to aggregate consumption tomorrow falls, for increases in the expectation of depreciation, i.e., investors substitute consumption today for tomorrow in the expectation of a depreciating currency, holding $\rho$ fixed. If we allow the share of traded goods in consumption to be endogenous, increases in the expectation of depreciation induces a shift toward non-traded goods from traded goods, i.e. $\rho$ falls. Holdings of foreign and domestic bonds move in opposite directions and domestic money holdings change to accommodate changes in bond holdings and consumption.

For a change in the probability of crisis, the effect on the asset and consumption demands, denoted by $A_t = \{c_t, B_t, F_t, M_t, N_t\}$, can be written

$$\frac{\partial A_t}{\partial p_t} = \frac{\partial A_t}{\partial \theta^t_{t+1}} \frac{\partial \theta^t_{t+1}}{\partial p_t}$$

where from (2.41):

$$\frac{\partial \theta^t_{t+1}}{\partial p_t} = \mu_t - \theta_t$$

Further, we can analyze changes in the exogenous policy parameters of the domestic government: $X = \{R$ or $i, D (G$ and $T), \mu \}$ on the asset and consumption profiles. Changes in a given policy parameter, $X$, affect investor consumption and asset profiles via the influence of the change in probability of crisis on their unconditional expectation of depreciation:

$$\frac{\partial A_t}{\partial X_t} = \frac{\partial A_t}{\partial \theta^t_{t+1}} \frac{\partial \theta^t_{t+1}}{\partial p_t} \frac{\partial p_t}{\partial X_t}$$

Changes in investor asset holdings are transmitted via the depreciation expectation. The policy change will effect the probability of crisis directly. This change in crisis probability influences the investor's unconditional expectation depreciation which then prompts the change in asset allocation. Changes in asset allocations must satisfy the cash-in-advance and financing constraints of the model:

$$\frac{\partial}{\partial \theta^t_{t+1}} (M_t + S_t N_t) \geq \frac{\partial}{\partial \theta^t_{t+1}} [P_t^N C_t^N + S_t P_t^T G_t^T + \Delta B_t - R_t B_{t-1} + (\Delta F_t - R^* F_{t-1}) S_t]$$

and the equilibrium conditions of the model governing the goods, bond, and money markets:

$$\frac{\partial}{\partial \theta^t_{t+1}} C_t(P_t) = \frac{\partial}{\partial \theta^t_{t+1}} Y_t(P_t)$$
\[
\frac{\partial}{\partial \theta_{t+1}^e} \bar{B}_t = \frac{\partial}{\partial \theta_{t+1}^e} B_t + \frac{\partial}{\partial \theta_{t+1}^e} B_t^* \\
\frac{\partial}{\partial \theta_{t+1}^e} \bar{F}_t = \frac{\partial}{\partial \theta_{t+1}^e} F_t + \frac{\partial}{\partial \theta_{t+1}^e} F_t^* \\
\frac{\partial}{\partial \theta_{t+1}^e} \bar{M}_t = \frac{\partial}{\partial \theta_{t+1}^e} M_t + \frac{\partial}{\partial \theta_{t+1}^e} M_t^* \\
\frac{\partial}{\partial \theta_{t+1}^e} \bar{N}_t = \frac{\partial}{\partial \theta_{t+1}^e} N_t + \frac{\partial}{\partial \theta_{t+1}^e} N_t^*
\]

How is the real exchange rate affected by changes in policy variables? Having explored the comparative statics for the optimal consumption and asset demands, we return to the equilibrium growth of the real exchange rate, Equations 2.20 and 2.21:

\[
E_t \Delta q_{t+1} = \psi + \gamma E_t \Delta c_{t+1} - E_t r_{t+1}^* - E_t \varphi_{t+1}
\]

\[
\psi = -\log \beta - \frac{1}{2} \text{Var}_t[\gamma \Delta c_{t+1} - r_{t+1}]
\]

where from (2.43):

\[
\Delta \tilde{c}_t = \Delta w_t + b_1 \Delta (\theta_{t+1}^e + E_t \varphi_{t+1}) + b_2 \Delta (\theta_{t+1}^e + E_t \varphi_{t+1})^2
\]

From the above, there will be indirect effects via the changes in consumption and asset demands, as well as direct effects, i.e., a change in the foreign interest rate, etc. For example, for a given change in generic policy variable, \( X_t \):

\[
\frac{dE_t \Delta q_{t+1}}{dX_t} = -\frac{1}{2} \frac{\partial}{\partial X_t} \text{Var}_t[\gamma \Delta c_{t+1} - r_{t+1}] + \gamma \frac{\partial E_t \Delta c_{t+1}}{\partial X_t} - \frac{\partial E_t r_{t+1}^*}{\partial X_t} - \frac{\partial E_t \varphi_{t+1}}{\partial X_t}
\]

where we see the change in the real equilibrium exchange rate can be broken down into four components: 1. changes due to the effect of the variance between the optimal consumption growth rate and the real interest rate; 2. changes in the optimal consumption growth; 3. the foreign rate of interest (or inflation rate); and 4. changes induced by changes in the risk premium.

Although we make allowance for portfolio diversification and general equilibrium interactions, our model is still limited by our assumption that the deficit is solely financed by domestic credit creation. Without specifying a time path for the financing of the deficit, it is not clear that an assumption of fixed proportions for financing instruments will be better than assuming strict domestic credit financing, as allowing for uncertainty introduces the possibility of multiple equilibria.
2.5 Conclusion

We construct a general equilibrium model to capture the financial fragility of emerging markets. The model embeds a partial equilibrium speculative attack framework to provide a currency warning feature for the portfolio balance approach. The standard portfolio balance approach is tailored by the imposition of both a cash-in-advance constraint and asymmetric financing constraints on the domestic and foreign countries. The solution for optimal consumption and portfolio profiles is obtained for an approximate problem utilizing a log-linear approximation. Comparative static results are derived in terms of the coefficients of the asset demand functions for given changes in the exogenous parameters of the model. The unconditional depreciation expectation serves as the transmission mechanism of changes in the probability of crisis from changes in policy parameters to induce changes in asset and consumption demands. We believe the model captures well the defining characteristics of the financially fragile environment of emerging market economies. The next chapter, Chapter 3, applies the model to Mexico.
Appendix A

The Domestic Investor’s Optimization Program

The Bellman equation for the domestic investor’s optimization program, Equations 2.11, 2.12 and 2.15, is:

\[
V_t(W_t) = \max_{C_t, C_t^T, \omega} \left\{ \frac{[C_t^T \rho(C_t^N)^{1-\gamma}]}{1-\gamma} + \beta E_t[V_{t+1}(W_{t+1})] + \lambda[M_t + S_t N_t - P_t^N C_t^N + S_t P_t^T C_t^T + \Delta B_t - R_t B_{t-1} + (\Delta F_t - R_t^P F_{t-1}) S_t] \right\}
\]

where

\[
W_{t+1} = (W_t - \tilde{C}_t) R_{p,t+1}
\]

for

\[
W_t = P_t Y_t - T_t + (1 + R_t) B_{t-1} + (1 + R_t^P) S_{t-1} F_{t-1}
\]

and

\[
P_t C_t = \tilde{C}_t
\]

The necessary first order conditions with respect to \( C_t \) and \( C_t^T \) are, respectively,\(^1\)

\[
0 = C_t^{-\gamma} - \beta E_t[V_{t+1}(W_{t+1}) P_t R_{p,t+1}] - \lambda P_t
\]

\[
0 = C_t^{-\gamma} \left( \frac{C_t^N}{C_t^T} \right)^{1-\rho} - \beta E_t[V_{t+1}(W_{t+1}) S_t P_t^T R_{p,t+1}] - \lambda S_t P_t^T
\]

\(^1\)The optimal locus of non-traded goods consumption is determined by the residual, \( C^N_t = C_t - C_t^T \), the market clearing condition, \( C_t^N (P_t^N) + C_t^T (P_t^N) = Y_t^N (P_t^N) \), and the exogenous preference parameter, \( \rho \).
The necessary first order condition with respect to the portfolio share, \( \omega_t \):

\[
0 = E_t[V_{t+1}/(W_{t+1})((W_t - \bar{C}_t)(i_{t+1} - i_{t+1}^*))]
\]

The complimentary slackness conditions are given by:

\[
\lambda(M_t + S_tN_t - P_t^N C_t^N + S_t P_t^{TN} C_t^T - \Delta B_t + R_t B_{t-1} - (\Delta F_t - R_t^* F_{t-1}) S_t) = 0
\]

\[
\lambda = 0 \rightarrow M_t + S_tN_t \geq P_t^N C_t^N + S_t P_t^{TN} C_t^T - \Delta B_t + R_t B_{t-1} - (\Delta F_t - R_t^* F_{t-1}) S_t
\]

\[
\lambda > 0 \rightarrow M_t + S_tN_t = P_t^N C_t^N + S_t P_t^{TN} C_t^T + \Delta B_t - R_t B_{t-1} + (\Delta F_t - R_t^* F_{t-1}) S_t
\]

The envelope condition is given by:

\[
V_t(W_t) = E_t[\beta V_{t+1}/(W_{t+1})R_{p,t+1}]
\]

Combining the envelope condition with the first order condition for aggregate consumption yields:

\[
\frac{C_t^{-\gamma}}{P_t} - \lambda = V_t(W_t)
\]

and similarly for tradeable goods consumption:

\[
\frac{C_t^{-\gamma} P_t^{CN}}{S_t P_t^{TN}}^{1-\rho} - \lambda = V_t(W_t)
\]

Focusing on the simpler aggregate consumption equation, we can advance the envelope condition forward one period:

\[
\frac{(C_{t+1})^{-\gamma}}{P_{t+1}} - \lambda = V_{t+1}(W_{t+1})
\]

Combining the advanced envelope condition with the first order condition for aggregate consumption yields:

\[
1 = E_t[\beta \frac{P_{t+1}}{C_t^{-\gamma}} - \lambda (1 + \omega_t i_{t+1} + (1 - \omega_t) R_{t+1}^*)]
\]

Using first order condition for the optimal portfolio share, \( \omega \), yields:

\[
1 = E_t[\beta \frac{P_{t+1}}{C_t^{-\gamma}} - \lambda (1 + R_{t+1})]
\]
Equation 2.17 displayed in the text is for the case \( \lambda = 0 \):

\[
1 = E_t[\beta((C_{t+1})/C_t)^{-\gamma} \frac{P_t}{P_{t+1}}(1 + R_{t+1})]
\]

### A.1 Consumption and Asset Demands

This section follows Campbell and Viceira (1996). The investor's optimal aggregate consumption must satisfy the portfolio Euler equation:

\[
1 = E_t[\beta((\frac{\tilde{C}_{t+1}}{C_t})^{-\gamma} R_{p,t+1})]
\]  \hspace{1cm} (A.1)

and the following budget constraint formed by combining the financing constraints (Equations 2.7 and 2.8), the strictly binding cash-in-advance constraint (Equation 2.9) and the evolution of wealth:

\[
\tilde{C}_t + \Delta B_t + \Delta F_t S_t = M_t + S_t N_t
\]

\[
P_t Y_t - T_t + (1 + R_t)B_{t-1} + (1 + R^*)F_{t-1}^* S_t = W_t
\]

\[
W_t - \tilde{C}_t = \Delta B_t + \Delta F_t S_t = \frac{W_{t+1}}{R_{p,t+1}}
\]  \hspace{1cm} (A.2)

To solve for the optimal portfolio shares and consumption profile, we will approximate the choice problem by log-linearizing the Euler equation (A.1) and the budget constraint (A.2). The derived analytical solutions will then be a solution to this approximate problem.

The optimal portfolio share, \( \omega \), can be determined using the Euler equation (A.1), the properties of mathematical expectations, and the interest parity condition (2.1). We begin by log-linearizing the Euler equation, using a second-order Taylor expansion around the conditional mean of \((R_{p,t+1}, \Delta \tilde{c}_{t+1})\):

\[
0 \approx \log \beta - \gamma E_t \Delta \tilde{c}_{t+1} + E_t R_{p,t+1} + \frac{1}{2} \text{Var}_t[\gamma \Delta \tilde{c}_{t+1} - R_{p,t+1}]
\]  \hspace{1cm} (A.3)

Only in cases where consumption growth and the return on net wealth are jointly lognormally distributed will this log-linearization hold exactly. However, we do not make this assumption here because both consumption and the return on wealth are endogenous.

The Euler equation must hold for both the domestic and foreign securities. We similarly log-linearize these equations and form the difference for the domestic security less the foreign:

\[
E_t R_{t+1} - R^* + \frac{1}{2} \text{Var}_t[R_{t+1}] = \gamma \text{Cov}_t[R_{t+1}, \Delta \tilde{c}_{t-1}]
\]
We log-linearize the budget constraint around the mean consumption-wealth ratio:

\[ \Delta w_{t+1} \approx R_{p,t+1} + (1 - \frac{1}{\delta})(\bar{c}_t - w_t) + k \]

where

\[ k = \log \delta + (1 - \delta) \frac{\log(1 - \delta)}{\delta} \]

and

\[ \delta = 1 - \exp(E(\bar{c}_t - w_t)) \]

We can further log-linearize the portfolio return (Equation 2.14) around \( R_{t+1} = R^* = 0 \) to obtain:

\[ r_{p,t+1} = \omega_t (i_{t+1} - i^*) + i^* \]

Combining this log-linearization of the portfolio return with the log-linearization of the budget constraint, yields the following approximation:

\[ \Delta w_{t+1} \approx \omega_t (i_{t+1} - i^*) + i^* + (1 - \frac{1}{\delta})(\bar{c}_t - w_t) + k \]

This constraint is now linear in portfolio weights and returns. The next step in solving for the optimal portfolio share is to characterize the optimal portfolio rule. We relate first the current optimal portfolio choice to future optimal portfolio choices. From this characterization, a guess for the functional form is made for the optimal portfolio policy. We, then, solve for the parameters by the method of undetermined coefficients. Using the triviality:

\[ \Delta \bar{c}_{t+1} = (\bar{c}_{t+1} - w_{t+1}) - (\bar{c}_t - w_t) + \Delta w_{t+1} \]

and the log-linearized budget constraint, we can rewrite:

\[
\begin{align*}
Cov_t[i_{t+1}, \Delta \bar{c}_{t+1}] &= Cov_t[i_{t+1}, \bar{c}_{t+1} - w_{t+1}] - Cov_t[i_{t+1}, \omega_t(i_{t+1} - i^*)] \\
&\quad + i^* + (1 - \frac{1}{\gamma})(\bar{c}_t - w_t) + k] \\
&= Cov_t[i_{t+1}, \bar{c}_{t+1} - w_{t+1}] + \omega_t Var_t[i_{t+1}] \\
&= \frac{1}{\gamma} \frac{Ei_{t+1} - i^* + \frac{1}{2} Var_t[i_{t+1}]}{Var_t[i_{t+1}]} - \frac{Cov_t[i_{t+1}, \bar{c}_{t+1} - w_{t+1}]}{Var_t[i_{t+1}]} \\
&\quad \text{(A.4)}
\end{align*}
\]

Substituting this into the Euler equation and solving in terms of the optimal portfolio share yields:

\[ \omega_t = \frac{1}{\gamma} \frac{Ei_{t+1} - i^* + \frac{1}{2} Var_t[i_{t+1}]}{Var_t[i_{t+1}]} - \frac{Cov_t[i_{t+1}, \bar{c}_{t+1} - w_{t+1}]}{Var_t[i_{t+1}]} \quad \text{(A.5)} \]
This optimal portfolio share equation is comprised of two terms: first, a ‘myopic’ term or the risk premium induced demand component; second, a ‘hedging demand’ à la Merton (1969, 1973), which hedges against future adverse changes in investment opportunities. This equation, however, cannot be a complete solution of the optimal portfolio share because the hedging component involves future consumption and portfolio decisions, endogenous variables, via the covariance term.

Following the manipulations of Campbell and Viceira (1996) we can rewrite this covariance term by combining the triviality and the budget constraint:

$$\bar{c}_{t+1} - w_{t+1} = \Delta \bar{c}_{t+1} - r_{p,t+1} + \frac{1}{\delta}(\bar{c}_{t} - w_{t}) - k$$

and solving this difference equation forward yields:

$$\bar{c}_{t+1} - w_{t+1} = E_{t+1} \sum_{i=1}^{\infty} \delta^i (r_{p,t+1+i} - \Delta \bar{c}_{t+1+i}) + \frac{\delta}{1-\delta} k$$

We can replace this expression in the (A.4), using the Euler equation (A.1) to substitute out for consumption growth:

$$Cov_t[i_{t+1}, \bar{c}_{t+1} - w_{t+1}] = Cov_t[i_{t+1}, (1 - \frac{1}{\gamma})E_{t+1} \sum_{i=1}^{\infty} \delta^i R_{p,t+1+i} - \frac{\delta}{1-\delta} k - \frac{1}{2\gamma} E_{t+1} \sum_{i=1}^{\infty} \delta^i Var_t(i \Delta \bar{c}_{t+1} - R_{p,t+1})$$

We can further write this as:

$$Cov_t[i_{t+1}, \bar{c}_{t+1} - w_{t+1}] = (1 - \frac{1}{\gamma})Cov_t[i_{t+1} - E_{t}i_{t+1}, (E_{t+1} - E_t) \sum_{i=1}^{\infty} \delta^i R_{p,t+1+i}] - \frac{1}{2\gamma} Cov_t[i_{t+1} - E_{t}i_{t+1}, (E_{t+1} - E_t) \sum_{i=1}^{\infty} \delta^i \nu_{p,t+i}]$$

where we have denoted $\frac{1}{2\gamma} Var_t(i \Delta \bar{c}_{t+1} - R_{p,t+1})$ by $\nu_{p,t+i}$. Inserting this expression into the portfolio share equation (A.5), now yields two components to the hedging demand:

$$\omega_t = \frac{1}{\gamma} \frac{E_{t}i_{t+1} - i^* + \frac{1}{2} Var_t[i_{t+1}]}{Var_t[i_{t+1}]} - \frac{(1 - \frac{1}{\gamma})Cov_t[i_{t+1} - E_{t}i_{t+1}, (E_{t+1} - E_t) \sum_{i=1}^{\infty} \delta^i R_{p,t+1+i}]}{Var_t[i_{t+1}]} + \frac{1}{2\gamma Var_t[i_{t+1}]} Cov_t[i_{t+1} - E_{t}i_{t+1}, (E_{t+1} - E_t) \sum_{i=1}^{\infty} \delta^i \nu_{p,t+i}]$$

Note the last term containing $\nu_{p,t+i}$ still involves the endogenous future portfolio and consumption
choices. We will solve for the optimal consumption-wealth ratio, the optimal portfolio share, and the term, \( \nu_{p,t+i} \), jointly by the method of undetermined coefficients, making the following guesses for the optimal portfolio allocation and consumption-wealth ratio:

\[
\omega_{t+i} = a_0 + a_1 x_t \\
\bar{c}_{t+i} - w_{t+i} = b_0 + b_1 x_t + b_2 x_t^2 \\
\nu_{p,t} = \nu_0 + \nu_1 x_t + \nu_2 x_t^2
\]

where, recall from the interest parity condition:

\[
x_t = i_{t+1} - i^* = \theta_{t+1} + \varphi_{t+1}
\]

The parameters \( \{a_0, a_1, b_0, b_1, b_2\} \) satisfy the following equations:

\[
a_0 = \left( \frac{1}{2\gamma} \right) - \frac{\sigma_{\mu u}}{\sigma_u^2} (b_1 + 2b_2a) \tag{A.6}
\]

\[
a_1 = \frac{1}{\gamma} \left[ \frac{1}{\gamma} - 2b_2 \phi \sigma_{\eta u} \right] \tag{A.7}
\]

\[
v_0 = \left( \frac{1}{2\gamma} - \frac{\sigma_{\mu u}}{\sigma_u^2} (b_1 + 2b_2a(1-\varphi)) \right)^2 \frac{2}{2} \left[ (1-\gamma)(\frac{1}{\gamma} - 1)\sigma_u^2 \right] + \frac{b_2^2}{2} \left[ \left( \frac{1}{\gamma} - 1 \right) \sigma_u^2 \right] + \\
b_2^2 \left[ \left( \frac{1}{\gamma} - 1 \right) (\sigma_u^2 + 2a^2) \sigma_u^2 + b_1 b_2 \left[ \left( \frac{1}{\gamma} - 1 \right) 2a \sigma_u^2 \right] - \left[ \frac{1}{2\gamma} - \frac{\sigma_{\mu u}}{\sigma_u^2} (b_1 + 2b_2a) \right] b_1 [(1-\gamma)\sigma_{\eta u}] - \\
\left[ \left( \frac{1}{2\gamma} \right) - \frac{\sigma_{\mu u}}{\sigma_u^2} (b_1 + 2b_2a) \right] b_2 [(1-\gamma)2a \sigma_{\eta u}] \right] \tag{A.8}
\]

and

\[
v_0 = k - \frac{1}{\gamma} \log \beta + (1 - \frac{1}{\gamma}) i^* + b_0 (1 - \frac{1}{\delta}) + ab_1 + b_2 (a^2 + \sigma_u^2) \tag{A.9}
\]

and

\[
v_1 = \left( \frac{1}{2\gamma} \right) - \frac{\sigma_{\mu u}}{\sigma_u^2} (b_1 + 2b_2a) (1 - \frac{1}{\gamma}) + b_1 (\varphi - \frac{1}{\delta}) + b_2 2a \varphi \tag{A.10}
\]

\[
v_2 = \left[ \frac{\sigma_u^2}{\gamma} \left( \frac{1}{\gamma} - 2b_2 \phi \sigma_{\eta u} \right)^2 \right]^{\frac{1}{2}} \left[ (1-\gamma)(1-\frac{1}{\gamma})\sigma_u^2 \right] + b_2^2 \left[ \left( \frac{1}{\gamma} - 1 \right) 2\varphi \sigma_u^2 \right] -
\]

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\[ \frac{1}{\sigma_u^2} \left[ \frac{1}{\gamma} - 2b_2 \phi \sigma_{\eta u} \right] b_2 \left[ (1 - \gamma) 2 \phi \sigma_{\eta u} \right] \]  \hspace{1cm} (A.11)

and

\[ v_2 = \frac{1}{\sigma_u^2} \left[ \frac{1}{\gamma} - 2b_2 \phi \sigma_{\eta u} \right] (1 - \frac{1}{\gamma}) + b_2 (\sqrt{\varphi^2} - \frac{1}{\delta}) \]  \hspace{1cm} (A.12)
Appendix B

The Foreign Investor’s Optimization Program

Infinitely-lived foreign investors transact for traded and non-traded goods consumption in foreign currency only, in contrast to the domestic investors. The foreign country cash-in-advance constraint does not involve the domestic country’s currency. The domestic country’s currency is held by foreign investors solely to finance the purchase of the domestic country’s bonds. We are not assuming the domestic and foreign investors have the same preferences over risk, traded goods, or time. The foreign investor’s program is described by:

$$\max_{C^*, C^T*, \omega^*} E_0^{\infty} \beta^t \sum_{t=0}^{\infty} \beta^t \frac{[(C^T*)^\rho^*(C^N*)^{1-\rho^*}]^{1-\gamma^*}}{1-\gamma^*}$$

subject to the resource, cash-in-advance, and financing constraints:

$$W_{t+1}^* = (W_t^* - P_t^* C_t^*) R_{t+1}^*$$

where

$$W_t^* = P_t^* Y_t^* - T_t^* + (1 + R_t^*) B^*_{t-1} + (1 + R^*) S_t F^*_{t-1}$$

and

$$R_{t+1}^* = \omega^* (R_{t+1}^* - R) + R$$

denotes the return on the foreign investor’s portfolio. The standard cash-in-advance for the foreign country is given by:

$$P_t^N C_t^N + (S_t P_t^T) C_t^T \leq S_t N_t^*$$  \hspace{1cm} (B.1)
and the financing constraints by:

\[ S_t N_t^* = (\Delta F_t^* - R_t^* F_{t-1}^*) S_t + S_t P_t^T C_t^{T*} + S_t P_t^{N*} C_t^{N*} \]  
(B.2)

\[ M_t^* = \Delta B_t^* - R_t B_{t-1}^* \]  
(B.3)

Notice, the cash-in-advance constraint is redundant for the foreign investors in the presence of the financing constraint for a positive net change in the foreigner's foreign bond position. To solve the foreign investors problem, we proceed in a similar fashion using dynamic programming methods with the only difference being that the currency demands are determined upon determination of the optimal consumption and portfolio share. The Bellman equation is:

\[ V_t(W_t^*) = \max_{C_t^*, C_{t+1}^{T*}, \omega_t} \frac{[(C_t^{T*})^\rho^* (C_t^{N*})^{1-\rho^*}]^{1-\gamma^*}}{1-\gamma^*} + \beta^* E_t[V_{t+1}(W_{t+1}^*)] \]

The Euler equation for the foreign economy is then:

\[ 1 = E_t[\beta^* (\frac{\tilde{C}_t^*}{\tilde{C}_t})^{1-\gamma^*} R_{p,t+1}^*] \]

**Foreign Government Sector**

The foreign government deficit is represented by the generalization:

\[ D_t^* = G_t^{N*} + G_t^{T*} - T_t^* = \frac{\Delta M_t^*}{P_t^*} + \frac{\Delta B_t^*}{P_t^*} - R_t B_{t-1}^* \]

**Foreign Production**

The foreign country production of traded and non-traded goods is similarly represented by a Neoclassical production function with exogenous technological progress, \( A_t^* \):

\[ Y_t^* = A_t^* (K_t^*)^{\phi^*} (L_t^*)^{1-\phi^*} \]

**Foreign Market Clearing Conditions**

The price of foreign non-traded goods equates the supply and demand of non-traded goods in the foreign country:

\[ \bar{C}_t^{N*}(P_t^{N*}) = C_t^{N*} + G_t^{N*}(P_t^{N*}) = Y_t^{N*}(P_t^{N*}) \]

The traded goods equilibrium condition is given in footnote 10. The foreign asset stock equilibrium condition is given by Equation 2.26.
B.1 Consumption and Asset Demands

The consumption and asset demands for the foreign country are similarly derived. However, the financing constraints and the cash in advance constraint (Equations (B.2), (B.3) and (B.1)), respectively, completely determine the currency holdings of foreign investors. The consumption demands and the asset allocations are determined by the method of undetermined coefficients. Foreign investor's demands for foreign and domestic bonds are determined from the optimal allocation of net wealth.

\[
\omega_{t+1}^* = a_0^* + a_1^* x_t
\]

\[
c_{t+1}^* - w_{t+1}^* = b_0^* + b_1^* x_t + b_2^* x_t^2
\]

\[
M_t^* = \Delta (\omega_t^* NW_t^*) - R_t^* \omega_{t-1}^* NW_{t-1}^*
\]

\[
S_t N_t^* = P_t^* C_t^* + S_t \Delta (\omega_t^* NW_t^*) - R_t^* S_t (1 - \omega_{t-1}^*) NW_{t-1}^*
\]

\[
B_t^* = \omega_t^* NW_t^*
\]

\[
F_t^* = (1 - \omega_t^*) NW_t^*
\]

\[
C_t = (C_t^T)\rho^* (C_t^N)^{1-\rho^*}
\]

where the parameters \(\{a_0^*, a_1^*, b_0^*, b_1^*, b_2^*\}\) satisfy similar symmetric equations to (A.6)-(A.11) for the domestic economy.
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Chapter 3

Mexico: Probability of Crisis, Depreciation Expectations and Equilibrium Exchange Rates

3.1 Introduction

As margins narrow in the United States and in developed countries, investors have left these safer havens in search of higher returns in the emerging markets. Investors, perhaps overconfident in their ability to predict crises or speculative attacks on currencies, invest abroad in unstable and fragile environments, soon forgetting the high risks they take on. Crises in Latin America and in the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) in the past decades, not to mention the current crises in southeast Asia, are brutal reminders of the financial, economic, and political fragility of countries and regions. These episodes reinforce the practical role for economic and financial models to provide forecasts of calamities to come.

This paper applies the equilibrium exchange rate model of the previous chapter to Mexico. The model of Chapter 2 is developed precisely with the view to providing critical insight into forecasting the probability of a crisis, the real equilibrium exchange rate, and a notion of investor sentiment—an unconditional expectation of depreciation. The model achieves this end by embedding a speculative attack, partial equilibrium model within a general equilibrium portfolio balance framework, without adherence to uncovered interest parity, purchasing power parity, or an imposed unresponsiveness of asset demands to substitution motives.
Although empirical applications of partial equilibrium speculative attack models are still few in number, those conducted focus primarily on the Mexican, Argentinian, or European experiences, no doubt, due to data availability and high reporting standards. Therefore, our application to Mexico will have a basis of comparison. Moreover, Mexico provides a rich environment for analysis as crises in the Mexican economy have occurred with regular frequency, prompting the adoption of various currency arrangements over the past two decades.

Upon estimation of the model, we find significant feedback effects between the probability of crisis, demand for real money balances, and the equilibrium real exchange rate. A standard probit approach to estimating the probability of crisis (one quarter ahead forecast) is not satisfactory; whereas, the model implied probabilities are useful as a currency warning measure. We note a distinct downward trend in Mexico's probability of crisis, beginning in the late 1980s. In fact, the crisis at the close of 1994 receives a probability slightly lower than 50%. We investigate the possibility that the deficit financing assumption of the model becomes inappropriate by the end of our sample period, thus biasing downward the estimated crisis probabilities. We find this not to be the case. Second, the real equilibrium exchange rate of the model is shown to deviate substantially from purchasing power parity, but mirrors to a smoother extent movements of the real interest differential. Lastly, and perhaps of most interest, we find the implied depreciation expectations of investors are increasing, even in light of the decreasing probability of crisis, suggesting investors expect to pay a higher price for continued stability.

In the next section, we discuss the relevant empirical implementations of speculative attack models. In Section 3.3 we present the main structural equations of the model. Section 3.4 discusses the empirical procedure. The test results follow in Section 3.5. Section 3.6 concludes. The source of data, preliminary data analysis, and all tests of the model assumptions can be found in the Appendix.

3.2 Relevant Literature

As the first noteworthy empirical application of a speculative attack model, Blanco and Garber (1986) use a variant of the Krugman (1979) and Flood and Garber (1984a, 1984b) models to predict the timing and magnitude of devaluations forced by speculative attacks on the Mexican peso between 1973 and 1982. They investigate the devaluations of 1976 and 1982 using a first-order autoregressive function for the rate of growth of domestic credit. They find international reserves decline to maintain monetary equilibrium until a critical level is reached at which the speculative attack occurs. They produce time-series estimates of one-step ahead probabilities of devaluation. They find that when predicted by the model, actual depreciations did occur. Moreover, the probability of devaluation reaches relatively high values prior to the actual devaluations, serving to predict future devaluations.
Cumby and van Wijnbergen (1989) take a similar approach to analyzing attacks on the Argentine crawling peg of the early 1980s. They estimate, in contrast to Blanco and Garber, different time series processes for the money demand disturbance, the foreign interest rate and domestic credit growth. The level of reserves at which the central bank abandons its currency peg is treated as a stochastic variable. They find the sharp increase in the growth of domestic credit to be the main factor triggering the attack on the Argentine peso. In a later study, van Wijnbergen (1991) demonstrates the sustainability of the move to less flexible exchange rate regimes, as undertaken in Brazil, Israel, and Argentina with the interest of controlling inflation, is severely undermined by the pursuit of inconsistent monetary and fiscal policy.

In the most comprehensive study to date, Eichengreen, Rose, and Wyplosz (1994) conduct an empirical analysis of speculative attack episodes on pegged exchange rates in 22 countries between 1967-1992. They split their data set into two categories: observations in the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) and non-ERM observations. For the latter observations, in looking at the univariate behavior of macroeconomic fundamentals, they find significant differences in the behavior of key macroeconomic variables—budget deficits, inflation rates, rates of credit growth, and trade balances—for crisis and non-crisis periods. For the ERM observations, they detect only significant differences for reserves, interest rates, and the rate of growth of money and prices, where the rates of growth of these latter two variables are in the direction opposite that predicted by the Krugman, and Flood and Garber models.

Goldberg (1994) applies a discrete time model of a collapsing exchange rate regime (an extension of the Flood and Garber (1994) model) to Mexico. She predicts the ex ante probabilities of currency crises and sizes of expected devaluations month by month, 1980-1986. Fiscal, domestic, and relative price shocks are determined as the forces contributing to the speculative attacks on the Mexican peso. Hence, a reduced probability of speculative attack on the Mexican peso, she suggests, can be achieved by: 1. reducing domestic credit growth; 2. increasing the uncertainty surrounding domestic credit growth; 3. reducing the size of currency realignments; and 4. increasing the frequency of currency realignments.

In more recent examinations of Mexico, Ötker and Pazarbaşioglu (1996) similarly investigate the performance of a partial equilibrium attack model. They carry out a simple probit analysis to generate one-step ahead probabilities of a regime change. Their probit results, however, are fairly weak and with limited functionality to serve as their intended ‘currency warning framework,’ particularly in light of the insignificance of their ‘shadow exchange rate’ which underlies their analysis. Melick (1996) finds disappointing results for the application of an amalgamation of speculative attack models to Mexico over the past two decades. The disappointment results from the divergence of the actual experience and the model assumptions, namely, that the standard speculative attack model relies on domestic credit

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growth as the primary deficit financing vehicle, which is becoming further from the truth for Mexico.

This paper estimates the structural system of equations of the model presented in Chapter 2. The analysis goes beyond the singular partial equilibrium analysis to involve estimation of the real exchange rate and the generation of unconditional depreciation expectations. We will generate one-step ahead forecasts for the probability of crisis, comparing these to the probability forecasts from the historical series obtained from direct integration of the probability density function of the model. We will compare the forecast of real equilibrium rates to that dictated by purchasing power parity and the real interest differential. Lastly, we generate the conditional and unconditional depreciation expectations suggested by the model to compare with the actual depreciation experience of Mexico.

3.3 Empirical Application of Model to Mexico

In the model of Chapter 2, we derived the expected growth rate of the real equilibrium exchange rate from the log-linearization of the Euler equation, which we arrived at by solving the domestic investor's optimization problem. Recall, the domestic investor chooses the allocation of their initial wealth, \( W_0 \), between consumption and available investments to maximize the lifetime expected utility of consumption. The assets available to the domestic investor include domestic and foreign monies, both having a rate of zero return, and domestic and foreign bonds with rates of return, \( i \) and \( i^* \), respectively. Because investors require the different currencies to purchase traded and non-traded goods, as well as to make investments in national securities, represented by our two financing constraints (Equations 3.4 and 3.5 below) and the imposition of a cash-in-advance constraint (Equation 3.3), currencies are held in equilibrium. In fact, excess foreign currency may be held due to precautionary saving motives of investors fearing default in an environment of currency risk. Hence, the domestic and foreign currencies are imperfect substitutes. We present the domestic investor's optimization program from the previous chapter below:

\[
\max_{C_t, C^{T_t}, \omega} \quad E_0 \sum_{t=0}^{\infty} \beta^t \frac{[(C_T)^{\rho} (C^N)_{t+1}^{1-\gamma}]}{1 - \gamma} \\

\text{subject to} \\
W_{t+1} = (W_t - P_tC_t)R_{p,t+1} \\
P_tC_t = P^NC_t + (S_tP^T_t)C^T_t \leq M_t + S_tN_t \\
(\Delta F_t - R^*_tF_{t-1})S_t + S_tP^T_tC^T_t \leq S_tN_t \\
\Delta B_t - R_tB_{t-1} + P^NC_t \leq M_t
\]

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where
\[ W_t = P_t Y_t - T_t + (1 + R_t)B_{t-1} + (1 + R^*)S_t F_{t-1} \]  
(3.6)

and the portfolio return is given by:
\[ R_{p,t+1} = \omega_t (R_{t+1} - R^*) + R^* \]  
(3.7)

The Euler equation resulting from the optimization is given by:
\[ 1 = E_t[\beta(\frac{C_{t+1}}{C_t})^{-\gamma} \frac{P_t}{P_{t+1}} (1 + R_{t+1})] \]  
(3.8)

The log-linear approximation of the Euler equation yields an equation for the expected growth in the real equilibrium exchange rate:¹
\[ E_t \Delta q_{t+1} = \psi + \gamma E_t \Delta c_{t+1} - E_t r^*_{t+1} - E_t p_{t+1} \]  
(3.9)

where
\[ \psi = -\log \beta - \frac{1}{2} \text{Var}_t[\gamma \Delta c_{t+1} - r_{t+1}] \]  
(3.10)

Using the total demand for domestic real balances and the available supply of real domestic money, the condition for monetary equilibrium is represented by:
\[ \frac{DC_t + IR_t}{P_t} = \frac{M_t}{P_t} = \bar{\alpha} - \bar{\beta}_t \]  
(3.11)

where the right-hand side of (3.11) is written in reduced form to emphasize the negative influence of unconditional expectations of depreciation on real money demand.

The probability of a crisis for the domestic economy is determined as the probability that the expectation of depreciation tomorrow exceeds that allowed under the prevailing currency arrangement, while maintaining the condition for monetary equilibrium:
\[ \text{Prob}(\theta_t > \mu_t) = \text{Prob}(\frac{\bar{\alpha} - \frac{DC_t + IR_t}{P_t}}{\xi} > \mu_t) \]  
(3.12)

where \( \mu_t \) represents the maximum allowable rate of depreciation under the prevailing currency arrange-

¹Solving the above recursively, we can write the expected logarithm of the real exchange rate in terms of a time trend, constant, and fundamental variables:
\[ E_t q_{t+1} = q_0 + (1 - t)\psi - E_t \log(\prod_{j=0}^{t} r_{t+1-j}) - E_t \log(\prod_{j=0}^{t} p_{t+1-j}) + \gamma E_t (\prod_{j=0}^{t} c_{t+1-j}) \]
ment. The first priority of national authorities—the financing of the deficit via domestic credit creation—undermines the government's ability to support the currency, the government's second priority. The deficit financing condition of the model is represented by:

$$-D_t = \Delta DC_t$$  \hspace{1cm} (3.13)

Replacing domestic credit, using this deficit financing condition, we solved for the probability of crisis in terms of the growth rate of domestic credit:

$$p_t = \text{Prob}(g_{DCt} < \frac{[-\mu_t \bar{\xi} + \bar{\alpha}]P_t - IR_t}{DC_{t-1}} - 1)$$  \hspace{1cm} (3.14)

$$p_t = F\left(\frac{[-\mu_t \bar{\xi} + \bar{\alpha}]P_t - IR_t}{DC_{t-1}} - 1\right)$$  \hspace{1cm} (3.15)

To estimate the model, we will estimate the probability of crisis, (3.15); the demand for real money balances, (3.11), and the expected growth rate of the real equilibrium exchange rate, (3.9):

$$p_t = F\left(\frac{[-\mu_t \bar{\xi} + \bar{\alpha}]P_t - IR_t}{DC_{t-1}} - 1\right)$$

$$\frac{\overline{M}_t}{P_t} = \bar{\alpha} - \bar{\xi} \theta_t$$

$$E_t \Delta q_{t+1} = -\log \beta - \frac{1}{2} \text{Var}_t[\gamma \Delta c_{t+1} - r_{t+1}] + \gamma E_t \Delta c_{t+1} - E_t r_{t+1}^e - E_t \psi_{t+1}$$

### 3.4 Estimation Procedure

To estimate the probability of crisis, we assume a normal distribution for the conditional distribution of the growth rate of domestic credit. The probability of crisis, provided by Equation 3.15, then is modeled as a probit equation of the form:

$$\Pr(Crisis_t = 1) = \Phi(\beta'X)$$  \hspace{1cm} (3.16)

$$\Pr(Crisis_t = 0) = 1 - \Phi(\beta'X)$$
where $\beta = \{\beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}\}^{-1}$ and $X = \{\mu_t, P_t, IR_t, DC_{t-1}\}^{-1}$ The dependent 'Crisis,' variable is assigned the value of one for the following quarters in agreement with the Ötker and Pazarbaşioğlu (1996) study:


Note that in Equation 3.16, the domestic price level is endogenous. Indeed, all domestic prices, including asset prices (interest rates) are endogenous. We instrument for the domestic price level $P$, by $P^*$, the exogenous foreign price level taken to be that of the U.S.\footnote{The supply of foreign and domestic money is exogenous. Because we require equilibrium in the money market, prices adjust such that for a given supply of money and the satisfaction of the financing constraints, the supply of non-traded goods equals the demand and the supply of domestic bonds equals the demand. The government deficit and hence, creation of domestic credit is exogenous, which implies the change in reserves will be dictated by the equilibrium conditions of the model and the deficit financing condition.}

The equilibrium demand for domestic money, Equation 3.11, is a reduced form that we relied on to simplify the exposition of the model in the previous chapter. Here we estimate explicitly the demand for real balances as a function of the domestic interest rate, domestic GDP, and expected unconditional depreciation:

$$\frac{M_t}{P_t} = \beta_{22} + \beta_{23}Y_t + \beta_{24}\theta^*_t + \epsilon_{2t} \tag{3.17}$$

The unconditional expectation of depreciation, recall, is the probability weighted sum of expected depreciation in the event of a crisis, $\mu_t$, and in the event of no crisis, $\theta_t$:

$$\theta^*_t = p_t\mu_t + (1 - p_t)\theta_t \tag{3.18}$$

We instrument for the endogenous conditional depreciation expectation, $\theta_t$, by the growth rate of the trade balance.\footnote{We depict the actual $P$ series and the instrument series $P^*$ in Figure A.12 in the Appendix.} We use this as our instrument because our financing constraints on the domestic investors require domestic investors to purchase traded goods with foreign currency and non-traded goods with domestic currency such that, ceteris paribus, a trade deficit suggests the demand for foreign currency to exchange for goods exceeds the domestic demand such that the domestic currency depreciates relative to the foreign. We must also instrument for the endogenous domestic rate of interest, the return on the domestic security. We use the domestic bond issuance to instrument for changes in the interest rate. The asset stock equilibrium condition of the model:

$$\frac{B}{P_t} = \int D_t dt - \frac{M_t}{P_t} - \int \frac{R_t B_{t-1}}{P_t} dt$$

\footnote{Another instrument used to instrument for depreciation, i.e., the nominal (and expected nominal) exchange rate, is the futures price in the foreign exchange market (See Blanco and Garber (1986)).}
implies that changes in bond issuance, holding the deficit constant, will shift the supply of money which allows us to trace out the demand curve for real money balances.\(^5\)

To estimate the Euler equation (3.9), we can write the expected logarithmic change in the real exchange rate, replacing for the endogenous risk premium using the interest parity condition (Equation 2.1):

\[
E_t p_{t+1} = i_t - i_t^* - E_t \theta_{t+1}
\]

and the unconditional depreciation expectation (3.18):

\[
\Delta q_t = \beta_{31} + \beta_{32} r_t^* + \beta_{33} \Delta p_t^* + \beta_{34} i_t + \beta_{35} \theta_{t+1}^2 + \beta_{36} \Delta c_t + \varepsilon_{3t} \tag{3.19}
\]

where \(\Delta p_t^*\) represents the foreign (U.S.) rate of inflation. Here again, we must instrument for the conditional depreciation expectation and the domestic interest rate.

The system of three equations we will estimate are provided below:

\[
\begin{align*}
Pr(Crisis_t = 1) &= \Phi(\beta'X) \\
Pr(Crisis_t = 0) &= 1 - \Phi(\beta'X)
\end{align*}
\tag{3.20}
\]

\[
\frac{\bar{M}_t}{P_t} = \beta_{21} + \beta_{22} i_t + \beta_{23} Y_t + \beta_{24} \theta_t^2 + \epsilon_{2t} \tag{3.21}
\]

\[
\Delta q_t = \beta_{31} + \beta_{32} r_t^* + \beta_{33} \Delta p_t^* + \beta_{34} i_t + \beta_{35} \theta_{t+1}^2 + \beta_{36} \Delta c_t + \varepsilon_{3t} \tag{3.22}
\]

We write the likelihood of observing the realized random variables over the entire sample period \(t=1\) to \(T\) as:

\[
L = \prod_{t=1}^{T} \left\{ f_{\varepsilon_2 \varepsilon_3} [\varepsilon_2 t \varepsilon_3 t] \cdot [\Phi(\beta_{11} \mu_t + \beta_{12} P_t + \beta_{13} IR_t + \beta_{14} DC_{t-1})]^{\text{Crisis}_t} \cdot [1 - \Phi(\beta_{11} \mu_t + \beta_{12} P_t + \beta_{13} IR_t + \beta_{14} DC_{t-1})]^{1-\text{Crisis}_t} \right\} \tag{3.23}
\]

where \(f_x[x]\) is the density function for random variable \(x\). For \(\varepsilon_2\) and \(\varepsilon_3\) independent, the natural

\(^5\)See Figures A.13 and A.14 in the Appendix for graphical representations of realized variables and instruments.
The logarithm of the likelihood function is given by:

\[
\ln L = \sum_{t=1}^{T} \left( \ln f_{\varepsilon_2}(\varepsilon_{2t}) + \ln f_{\varepsilon_3}(\varepsilon_{3t}) + \text{Crisis}_t [\ln \Phi(\beta_{11}\mu_t + \beta_{12}P_t + \beta_{13}IR_t + \beta_{14}DC_t^{-1})] + (1 - \text{Crisis}_t)[1 - \Phi(\beta_{11}\mu_t + \beta_{12}P_t + \beta_{13}IR_t + \beta_{14}DC_t^{-1})] \right)
\]

(3.24)

making use of the standard normal probability density function \(\phi\):

\[
\ln L = \sum_{t=1}^{T} \left( \ln \left( \frac{1}{\sigma_{\varepsilon_2}} \right) + \ln \phi\left( \frac{\varepsilon_{2t}}{\sigma_{\varepsilon_2}} \right) + \ln \left( \frac{1}{\sigma_{\varepsilon_3}} \right) + \ln \phi\left( \frac{\varepsilon_{3t}}{\sigma_{\varepsilon_3}} \right) + \ln \Phi[(\beta_{11}\mu_t + \beta_{12}P_t + \beta_{13}IR_t + \beta_{14}DC_t^{-1})(1 - 2\text{Crisis}_t)] \right)
\]

(3.25)

using Equations 3.21 and 3.22 to replace for \(\varepsilon_2\) and \(\varepsilon_3\):

\[
\ln L = \sum_{t=1}^{T} \left( \ln \left( \frac{1}{\sigma_{\varepsilon_2}} \right) + \ln \phi\left( \frac{1}{\sigma_{\varepsilon_2}} \left( \frac{M_t}{P_t} - \beta_{21} - \beta_{22}i_t - \beta_{23}Y_t - \beta_{24}\theta_t^e \right) \right) + \ln \left( \frac{1}{\sigma_{\varepsilon_3}} \right) + \ln \phi\left( \frac{1}{\sigma_{\varepsilon_3}} \left( \Delta q_t - \beta_{31} - \beta_{32}r_t^e - \beta_{33}\Delta p_t^e - \beta_{34}i_t - \beta_{35}\theta_t^e - \beta_{36}\Delta q_t \right) \right) + \ln \Phi[(\beta_{11}\mu_t + \beta_{12}P_t + \beta_{13}IR_t + \beta_{14}DC_t^{-1})(1 - 2\text{Crisis}_t)] \right)
\]

(3.26)

We will estimate this system of equations simultaneously using full information maximum likelihood. If, however, there is no feedback between the real equilibrium exchange rate, the probability of crisis, and asset demands, or if causality runs in one direction, then estimation of the system will reduce to equation by equation estimation. To test for no feedback or no contemporaneous correlation, we will estimate the system as a triangular system, beginning with the probability of crisis equation. Using the one-step ahead forecasted probabilities, \(\hat{p}\), we then estimate, separately, the remaining two equations by two stages least squares. To test the model specification, we perform a Hausman (1978) test.

The empirical analysis for Mexico is performed for the time interval, 1931Q1-1996Q1, using quarterly data from the International Monetary Fund's *International Financial Statistics*. For a detailed description of the variables and sources see Tables A.1 and A.2 in the Appendix. During the period of consideration, the Mexican peso was devalued three times: July 25, 1985, December 14, 1987, December 20, 1994; the national authorities switched to a more flexible regime on four occasions: December 20, 1982, August 5, 1985, November 18, 1987, January 1989; and twice simultaneously devalued and switched to a more flexible regime: February 1982 and February 1988.
Before estimation, we perform preliminary analysis on the relevant data series, testing for unit roots to insure our dealings with stationary time series. We use the Dickey-Fuller (1979) approach to test for unit roots. The details of the testing procedure and equation specifications for the variables are provided in the Appendix. The results for our unit root tests (See Tables A.3 and A.4 in the Appendix) suggest in estimating the equations, for the variables \{Y, P^*, DC, IR, B, r^*, CU, \frac{M}{M}, \frac{RB}{p}\}, we cannot reject the null of a unit root. Consequently, for these variables, we first difference the data prior to the estimation.

3.5 Results

We estimate these three structural equations sequentially by two stages least squares, and then secondly, by full information maximum likelihood.\(^6\) The results for the two procedures are presented in Table 3.1. The estimated asymptotic standard errors are presented in the parentheses. All asterisked entries indicate significance at the 95% confidence level.

In examining the probit results, we find that the maximum rate of depreciation, the lagged level of domestic credit, and international reserves are significant influences on the probability of crisis, while the domestic price level does not influence the crisis probability. Our probit specification and interval of analysis differs somewhat from Ötker and Pazarbaşıoğlu (1996). They investigate the shorter time period, 1982.10-1994.12, and use monthly data. However, we similarly find the probability of crisis to be increasing in domestic credit, domestic prices, and the loss of non-gold reserves. In contrast to the Ötker and Pazarbaşıoğlu (1996) study, we find our maximum allowable depreciation rate profile, \(\mu\), to be significant, while their shadow exchange rate, the predicted post-crisis rate, is insignificant.

In the money demand equation estimated by 2SLS, the sign for depreciation is wrong—positive. By neither estimation method is the depreciation expectation significant, although under FIML the sign is correct—negative. Goldberg (1994) finds money demand to be positively related to depreciation and Melick (1996) similarly finds the interest rate semi-elasticities have signs opposite to that assumed by his model. Notice, however, for our system estimation, the sign is correct under FIML estimation, but hardly significant. Regarding the real exchange rate equation, we are disappointed by the insignificance of our depreciation variable, and not too surprised that the foreign rate of inflation is not significant, as this is surely represented by inclusion of the foreign real interest rate.

We use a Hausman test to test the assumption of no contemporaneous correlation or no feedback

---

\(^6\)The full information maximum likelihood estimates of all the reduced form parameters, not solely those corresponding to the endogenous variables included in a particular equation, are derived by maximizing the likelihood function (given by Equation 3.26) of the reduced form disturbances (assumed distributed multivariate normal) subject to the zero restrictions on all the structural parameters of the system. With normally distributed disturbances, FIML is efficient among all estimators. Hausman (1975, 1983) provides a useful interpretation of the FIML estimator as an IV estimator. We use GAUSSX to implement the FIML estimation.
Table 3.1: 2SLS and FIML Estimation Results

<table>
<thead>
<tr>
<th>Equation</th>
<th>Variable</th>
<th>2SLS (A.S.E)</th>
<th>FIML (A.S.E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>probit</td>
<td>constant</td>
<td>0.010 (0.098)</td>
<td>0.012 (0.036)</td>
</tr>
<tr>
<td></td>
<td>$\mu$</td>
<td>-0.054* (0.010)</td>
<td>-0.047* (0.015)</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.074 (0.538)</td>
<td>0.075 (0.339)</td>
</tr>
<tr>
<td></td>
<td>IR</td>
<td>-0.886* (0.112)</td>
<td>-0.889* (0.116)</td>
</tr>
<tr>
<td></td>
<td>DC$_{-1}$</td>
<td>1.259* (0.366)</td>
<td>1.241* (0.089)</td>
</tr>
<tr>
<td>Pseudo $R^2$</td>
<td></td>
<td>0.678</td>
<td></td>
</tr>
<tr>
<td>Log Likelihood</td>
<td></td>
<td>-7.079</td>
<td></td>
</tr>
<tr>
<td>$M_p$</td>
<td>constant</td>
<td>12.381* (0.376)</td>
<td>12.277* (0.156)</td>
</tr>
<tr>
<td></td>
<td>i</td>
<td>-1.040 (0.076)</td>
<td>-1.043 (0.035)</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>3.887* (0.303)</td>
<td>3.891* (0.211)</td>
</tr>
<tr>
<td></td>
<td>$\theta^c$</td>
<td>0.001 (0.002)</td>
<td>-0.002 (0.018)</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td></td>
<td>0.763</td>
<td></td>
</tr>
<tr>
<td>$\Delta q$</td>
<td>constant</td>
<td>-0.600* (0.184)</td>
<td>-0.711* (0.177)</td>
</tr>
<tr>
<td></td>
<td>r$^*$</td>
<td>-0.928* (0.281)</td>
<td>-1.120* (0.288)</td>
</tr>
<tr>
<td></td>
<td>$\Delta p^*$</td>
<td>-0.120 (0.525)</td>
<td>-0.079 (0.432)</td>
</tr>
<tr>
<td></td>
<td>i</td>
<td>0.003* (0.001)</td>
<td>0.003* (0.001)</td>
</tr>
<tr>
<td></td>
<td>$\theta^e$</td>
<td>0.399 (0.403)</td>
<td>0.432 (0.436)</td>
</tr>
<tr>
<td></td>
<td>$\Delta c$</td>
<td>1.283* (0.189)</td>
<td>1.280* (0.112)</td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td>0.8187</td>
<td></td>
</tr>
<tr>
<td>Log Likelihood</td>
<td></td>
<td>46.887</td>
<td></td>
</tr>
</tbody>
</table>
between the equations. Under the null hypothesis of no feedback, both the 2SLS and the FIML estimates are consistent. However, under the alternative hypothesis of feedback, 2SLS is no longer consistent, but FIML is efficient and consistent:

<table>
<thead>
<tr>
<th></th>
<th>H₀: No feedback</th>
<th>Hₐ: Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>2SLS</td>
<td>consistent</td>
<td>not consistent</td>
</tr>
<tr>
<td>FIML</td>
<td>consistent</td>
<td>consistent/efficient</td>
</tr>
</tbody>
</table>

The test statistic is as follows:

\[ W = x_{19}^2 = [\hat{\beta}_{FIML} - \hat{\beta}_{2SLS}] \Sigma^{-1} [\hat{\beta}_{FIML} - \hat{\beta}_{2SLS}]' = 87.98 \]

where

\[ \Sigma = \text{Var}[\hat{\beta}_{FIML}] - \text{Var}[\hat{\beta}_{2SLS}] \]

We reject at the 95% level of confidence the null hypothesis of no feedback. Hence, in the remainder of the discussion, i.e., in the generation of one-step ahead forecasts, etc., we rely on the FIML estimation results.

The only coefficient restrictions the theoretical model imposes are in the real exchange rate equation: \( \beta_{32} = \beta_{34} = \beta_{35} = -1 \). We test this joint restriction for the FIML estimation by an F test:

\[
H_0 : \quad \beta_{32} = \beta_{34} = \beta_{35} = -1 \\
F(3, 66) = 92.37
\]

We can reject the joint hypothesis at the 95% level of confidence. In addition, the model implies \( \beta_{36} = \gamma \), the coefficient of relative risk aversion. Therefore, our estimated coefficient of relative risk aversion then proves to be approximately 1.28 for Mexico.

### 3.5.1 Probability of Crisis

We generate one-step ahead probabilities from our probit model. In Figure 3.0, we depict the one-step ahead probabilities to see how closely they match with the actual quarters of 'crisis' or 'regime change' shown as vertical lines. Note the near zero inter-crisis probabilities, with the exceptions of peculiarities in the second quarter of 1986 and the first quarter of 1990. This 'spiky' appearance is similar to the forecasts of Goldberg (1994) and Ötker and Pazarbaşıoğlu (1996).
Figure 3.0: One-Step Ahead Probit Probability of Crisis

Similar to Blanco and Garber (1986), we form the historical time series of probabilities for Mexico by directly integrating Equation 3.15, under the assumption of a normal distribution for domestic credit growth:

$$
\Phi(\zeta) = \frac{1}{\sqrt{2\pi}\sigma} \int_{-\infty}^{\infty} \exp\left(-\frac{(\zeta - \bar{\zeta})^2}{2\sigma^2}\right) d\zeta
$$

(3.27)

where $\bar{\zeta} = \bar{\beta}_{24}$, and $\bar{\alpha} = \frac{1}{N} \sum_{i=1}^{N} [\bar{M}_{t} - (\bar{\beta}_{21} + \bar{\beta}_{22}t_{i} + \bar{\beta}_{23}Y_{i})]$. The series of probabilities is depicted in Figure 3.1. A third order polynomial is used for the trendline. In contrast to the probit probabilities, the inter-crisis periods have significant non-zero probabilities. Note also, the distinct trend in declining probabilities from the late 1980s onward. In particular, the 1994 year end crisis does not even receive a fifty percent probability.

To compare the probit generated probabilities with the model defined probabilities we present them together in Figure 3.2. Notice the model generated probability series captures well the periods of actual crisis used in the probit analysis. The model probabilities, however, provide additional transitional probabilities which are significantly above that provided by the probit analysis similar to the Flood and Garber (1986) study. We are optimistic that these inter-crisis probabilities can be useful for implementation in risk management assessments and active portfolio management.

How to interpret the declining probability of crisis? The model is either losing predictive capacity due
Figure 3-1: Model Probability of Crisis

Figure 3-2: Probabilities of Crisis
Table 3.2: Test of Deficit Financing Condition

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Estimate (Test Statistic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>-1003.987 (-1.135)</td>
</tr>
<tr>
<td>$\frac{\Delta B_t}{P_t}$</td>
<td>253.455 (0.730)</td>
</tr>
<tr>
<td>$\frac{\Delta DC_t}{P_t}$</td>
<td>-10.685* (-3.062)</td>
</tr>
<tr>
<td>$\frac{\Delta I_t}{P_t}$</td>
<td>78.146 (0.363)</td>
</tr>
<tr>
<td>$\frac{R_tB_{t-1}}{P_t}$</td>
<td>5.502* (1.992)</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.738</td>
</tr>
</tbody>
</table>

to the invalidity of the financing assumption, i.e., the national authorities do not limit themselves solely to domestic credit creation as a means of financing the deficit (See Figure A.9 in the Appendix). Or, indeed, the reforms put in place in the previous decade, the major domestic financial sector reforms and capital account liberalization Mexico undertook in 1989,\(^7\) warrant this decline in probability. Melick (1996) notes, “a better case can be made that fiscal profligacy lay behind the collapses in the 1970s and 1980s than that of December 1994 (pg. 18).” This suggests our financing condition (3.13) may potentially be inappropriate.

If we estimate a more general financing condition for Mexico:

$$D_t = \beta_1 + \beta_2 \frac{\Delta DC_t}{P_t} + \beta_3 \frac{\Delta I_t}{P_t} + \beta_4 \frac{\Delta B_t}{P_t} + \beta_5 \frac{R_t B_{t-1}}{P_t} + \epsilon_t$$  \hspace{1cm} (3.28)

our strict domestic credit financing condition suggests:

$$H_0 : \beta_1 = \beta_3 = \beta_4 = \beta_5 = 0$$

The results of our estimation are provided in Table 3.2:

We use an F-test to test the above zero restrictions:

$$F_{[4,66]} = 45.786$$

\(^7\)This cannot be substantiated directly in our estimation procedure, however. Similar to Ötker and Pazarbasioglu (1996), in our preceding probit analysis we test for a structural break corresponding to the financial sector reforms and capital account liberalization in 1989, but find no evidence of a significant break in the data.
Figure 3-3: Adjusted Probability of Crisis

We can reject at the 95% confidence level that our deficit financing condition holds in the strict form. However, it is interesting to note that only the real change in domestic credit creation and the interest payment on the previous period bond issuance are significant. The estimation does suggest that domestic credit is used to bring down the deficit, while reserves are used in sterilization. In Figure 3.3, we depict how this alteration of the deficit financing condition alters only minorly the probability of crisis, especially in 1994, suggesting the deficit financing assumption is not responsible for the declining probability as the modification causes the probability to further decline.

3.5.2 Euler Equation

Using an initial value of the real exchange rate for 1980Q4 provided by purchasing power parity, we generate the predicted value of the real exchange rate from the predicted values of the changes, $\Delta q$. In Figure 3.4, we compare these predicted values to the log real exchange rate under the assumption of purchasing power parity\(^8\) and to the real interest differential. The real exchange rate deviates significantly from the PPP assumption and movements are positively correlated with the real interest differential, although much smoother.

\(^8\)Under PPP, $Q=1$, as $S_t = \frac{P_t}{P_t}$ for all $t$, hence $q=0$. 

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3.5.3 Unconditional Depreciation Expectations

A distinguishing feature of our modeling approach is the incorporation of depreciation expectations underlying the speculative attack framework into the optimal portfolio and consumption profiles of investors. To understand the workings of the model, we generate the depreciation expectations of the model. The equations for the conditional and unconditional expectations of depreciation in the model are provided below, respectively:

\[ \theta_t = \frac{\hat{\alpha} - DC_t + IR_t}{\xi} < \mu_t \]  

(3.29)

\[ \theta^*_t = (1 - \hat{p}_t)\theta_t + \hat{p}_t \mu_t \]  

(3.30)

Using these equations and our estimation results above, we generate the historical sequence of conditional and unconditional expectations of depreciation dictated by the model:  

65
In Figure 3.5, we include the actual depreciation experience of Mexico. The model generated expectations capture well the regime shifts to floating arrangements in the second quarter of 1982, and the fourth quarters of 1987 and 1994. The largest deviation of the model expectations and the actual experience arise post-1987. Whereas, the actual depreciation is stable during the fixed and pre-announced crawling peg experience during 1988-1994, the model expectations are increasing during this time, suggesting that investor expectations of depreciation can warn or anticipate the future devaluations. The contrast between the actual devaluation experience and the expectations of investors in the model indicates the unsustainable nature of the currency arrangement, leading up to the 1994 crisis. Most interesting is the continued expectation of even higher depreciation beyond the crisis, reaching upwards of 50%.

It is useful to examine these expectations in relation to the probability of crisis. Notice in Figure 3.6, although the probability of crisis is decreasing in time after the peak in the late 1980s, expected depreciation is still high and on the rise. To explain this, investors may be more willing to accept a weaker future currency on the road to recovery. But why anticipate a weaker currency in an environment less prone to crisis? Clearly to address this question requires consideration of the equilibrium interactions of the model, i.e., this behavior may be arising due to concern over rising interest rate fears in the U.S. to quell U.S. inflation fears in the early 1990s. This action by foreigners may be prompting weaker currency views in the emerging market economies.
3.6 Conclusion

We apply the model for the determination of equilibrium exchange rates in the fragile emerging markets context to Mexico. We find that overall the model assumptions cannot be rejected for the Mexican environment. The structural equations of the model are estimated consistently and efficiently by FIML in the presence of contemporaneous correlation. The probability of crisis generated by the model provides a currency warning framework; whereas, a standard probit specification is insufficient to capture the inter-crisis probabilities in one-step ahead forecasts. The real exchange rate is determined to deviate significantly from purchasing power parity, and reflects smoother movements in the interest rate differential. In comparing the actual depreciation experience with the investor’s expectation of depreciation in the model, the relative smoothness of the latter can account for the smoother movements in the real equilibrium exchange rate. These model expectations match the collapse of the currency regime as the actual depreciation releases upon devaluation. The interesting feature of the expectations is that they continue to rise after periods of crisis and in an environment characterized by a declining likelihood of future crisis.
Appendix A

Data

The data is taken from the International Financial Statistics (IFS) of the International Monetary Fund (IMF) quarterly files, 1981Q1 - 1996Q1. Missing data and data for domestic and foreign holdings of money and bonds is supplied by the IBAMEX Database of Banco de México. All variables, with the exception of the 'Crisis' dummy are in terms of Millions of New Pesos.

A.1 Exchange Rate Arrangement

Information on the currency policy in Mexico for the years 1980-1997 is provided by the Exchange Arrangement announcements for Mexico in the International Monetary Fund's "Exchange Arrangements & Exchange Restrictions Annual Report" for each year. We chronicle below the major changes in the exchange rate arrangements which governed the determination of $\mu_t$, the maximum allowable rate of depreciation. Dates used in the 'Crisis' indicator variable by Ötker and Pazarbaşioglu (1996) are denoted by an asterisk.

A.2 Unit Root Tests

For the variables used in the analysis, we first test for stationarity of the data series using Dickey-Fuller (1979) tests for unit roots. The graphical presentations of the data series follow this discussion. We conduct unit root tests only for the variables which appear potentially non-stationary based upon the graphical representation. The model specification for the unit root tests, i.e., whether or not to include a constant and/or time trend, is dictated by economic theory, when it applies. As it happens, for all variables, we estimate either of two cases for the model specification: Case 1 includes a constant; Case 2 includes both a constant and time trend. We present the null and alternative hypotheses for these
Table A.1: Data Description

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Period Average Nominal Exchange Rate</td>
<td>IFS (line rf)</td>
</tr>
<tr>
<td>IR</td>
<td>Central Bank Total Nongold Reserves</td>
<td>(line 11.d)</td>
</tr>
<tr>
<td>DC</td>
<td>Domestic Credit</td>
<td>(line 32)</td>
</tr>
<tr>
<td>M</td>
<td>Mcney</td>
<td>(line 34)</td>
</tr>
<tr>
<td>B</td>
<td>Bonds</td>
<td>(line 46ab)</td>
</tr>
<tr>
<td>R, R*</td>
<td>Treasury Bill Rates (Mexico &amp; U.S.)</td>
<td>(line 60c)</td>
</tr>
<tr>
<td>P, P*</td>
<td>Consumer Price Indexes (Mexico &amp; U.S.)</td>
<td>(line 64)</td>
</tr>
<tr>
<td>IM</td>
<td>Imports</td>
<td>(line 71)</td>
</tr>
<tr>
<td>EX</td>
<td>Exports</td>
<td>(line 70)</td>
</tr>
<tr>
<td>D</td>
<td>Government Deficit</td>
<td>(line 80)</td>
</tr>
<tr>
<td>T</td>
<td>Government Revenues</td>
<td>(line 81)</td>
</tr>
<tr>
<td>G</td>
<td>Government Expenditures</td>
<td>(line 82)</td>
</tr>
<tr>
<td>C</td>
<td>Private Consumption Expenditure</td>
<td>(line 96f)</td>
</tr>
<tr>
<td>G_C</td>
<td>Government Consumption Expenditure</td>
<td>(line 91f)</td>
</tr>
<tr>
<td>K</td>
<td>Gross Fixed Capital Formation</td>
<td>(line 95e)</td>
</tr>
<tr>
<td>Y</td>
<td>Gross Domestic Product</td>
<td>(line 99b)</td>
</tr>
<tr>
<td>Crisis</td>
<td>Regime Change Dates</td>
<td>Ötker and Pazarbasioglu (1996)</td>
</tr>
</tbody>
</table>

specifications:

Case 1.

\[ H_0 : \rho = 1 \]
\[ y_t = \alpha + y_{t-1} + u_t \]

\[ H_A : |\rho| < 1 \]
\[ y_t = \alpha + \rho y_{t-1} + u_t \]

Case 2.

\[ H_0 : \rho = 1 \]
\[ y_t = \alpha + y_{t-1} + u_t \]

\[ H_A : |\rho| < 1 \]
\[ y_t = \alpha + \delta t + \rho y_{t-1} + u_t \]
<table>
<thead>
<tr>
<th>Date</th>
<th>Currency Arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 February 1982*</td>
<td>Floating</td>
</tr>
<tr>
<td>5 June 1982</td>
<td>Crawling peg established with daily crawl rate set at 0.04 pesos</td>
</tr>
<tr>
<td>5 August 1982*</td>
<td>Dual exchange rate introduced; fixed rate in controlled market; floating rate in commercial market</td>
</tr>
<tr>
<td>20 December 1982</td>
<td>47% devaluation of peso; crawling peg introduced with daily crawl rate of 0.13 pesos</td>
</tr>
<tr>
<td>6 December 1984</td>
<td>Daily crawl rate increased to 0.17 pesos</td>
</tr>
<tr>
<td>6 March 1985</td>
<td>Daily crawl rate increased to 0.21 pesos</td>
</tr>
<tr>
<td>25 July 1985</td>
<td>Peso devalued 17%</td>
</tr>
<tr>
<td>5 August 1985*</td>
<td>Abandonment of crawling peg, switch to managed float in controlled market</td>
</tr>
<tr>
<td>18 November 1987*</td>
<td>Floating</td>
</tr>
<tr>
<td>15 December 1987</td>
<td>Peso fixed at 2,209.7/$US</td>
</tr>
<tr>
<td>31 January 1998</td>
<td>Peso fixed at 2,221</td>
</tr>
<tr>
<td>February 1998*</td>
<td>Abandonment of preannounced fixed peg for preannounced crawling peg, daily crawl rate of 2 pesos</td>
</tr>
<tr>
<td>1 March 1988</td>
<td>Peso fixed at 2,281 in controlled market</td>
</tr>
<tr>
<td>January 1989*</td>
<td>Preannounced crawling peg, daily crawl rate of 1 peso</td>
</tr>
<tr>
<td>27 May 1990</td>
<td>Reduction in the daily crawl rate to 80 cents</td>
</tr>
<tr>
<td>12 November 1990</td>
<td>Reduction in the daily crawl rate to 40 cents</td>
</tr>
<tr>
<td>28 May 1991</td>
<td>Increase in the daily crawl rate to 80 cents</td>
</tr>
<tr>
<td>11 November 1991</td>
<td>Abolition of dual exchange rate system; introduction of exchange rate bands</td>
</tr>
<tr>
<td>21 October 1992</td>
<td>Band ceiling daily crawl rate of 40 cents</td>
</tr>
<tr>
<td>1 January 1993</td>
<td>(Introduction of new peso = 1,000 of former pesos)</td>
</tr>
<tr>
<td>20 December 1994</td>
<td>15% devaluation of intervention band ceiling</td>
</tr>
<tr>
<td>22 December 1994*</td>
<td>Abolition of bands; free floating</td>
</tr>
</tbody>
</table>
The test statistics for $\rho$ in Case 1. are distributed standard normal. For the test statistics in Case 2, we rely on the relevant Dickey-Fuller critical values. An asterisk following the estimates in Tables A.3 and A.4 below indicates acceptance of the null hypothesis of a unit root at the 95% level of confidence.

**Graphical representation for model variables**

![Graph](image1)

**Figure A.1 Change in Natural Logarithm of Real Exchange Rate**

![Graph](image2)

**Figure A.2 Natural Logarithm of Foreign Real Interest Rate**
Figure A.3 Foreign Price Level

Figure A.4 Foreign Rate of Inflation
Figure A.5 Consumption Growth

Figure A.6 Gross Domestic Product (1990)
Figure A.7 Real Money Supply

Figure A.8 Bonds
Figure A.9 Domestic Credit

Figure A.10 Non-Gold Reserves
Table A.3: Dickey-Fuller Unit Root Tests for Structural Model

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Dependent Variable</th>
<th>Coefficient (test statistic)</th>
<th>Independent Variable</th>
<th>Dependent Variable</th>
<th>Coefficient (test statistic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B$</td>
<td>constant</td>
<td>-1.118</td>
<td>$P^*$</td>
<td>constant</td>
<td>1.355</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-0.405)</td>
<td></td>
<td></td>
<td>(4.371)</td>
</tr>
<tr>
<td>$B_{-1}$</td>
<td></td>
<td>1.077*</td>
<td>$P_{-1}$</td>
<td></td>
<td>0.995*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(16.337)</td>
<td></td>
<td></td>
<td>(9.468)</td>
</tr>
<tr>
<td>$\frac{M}{P}$</td>
<td>constant</td>
<td>15.556</td>
<td>$r^*$</td>
<td>constant</td>
<td>0.050</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.943)</td>
<td></td>
<td></td>
<td>(0.824)</td>
</tr>
<tr>
<td>$\frac{M}{P}_{-1}$</td>
<td></td>
<td>0.967*</td>
<td>$r_{-1}$</td>
<td></td>
<td>0.969*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.769)</td>
<td></td>
<td></td>
<td>(13.380)</td>
</tr>
<tr>
<td>DC</td>
<td>constant</td>
<td>5644.839</td>
<td>$Y$</td>
<td>constant</td>
<td>295.738</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.781)</td>
<td></td>
<td></td>
<td>(4.784)</td>
</tr>
<tr>
<td>DC_{-1}</td>
<td></td>
<td>1.016*</td>
<td>$Y_{-1}$</td>
<td></td>
<td>0.479*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(18.317)</td>
<td></td>
<td></td>
<td>(4.351)</td>
</tr>
<tr>
<td>IR</td>
<td>constant</td>
<td>988.260</td>
<td>$Y$</td>
<td>trend</td>
<td>1.678</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.679)</td>
<td></td>
<td></td>
<td>(4.074)</td>
</tr>
<tr>
<td>IR_{-1}</td>
<td></td>
<td>1.040*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.038)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure A.11 Trade Balance Growth

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Graphical representations for endogenous variables of model and instruments

Figure A.12 Foreign and Domestic Price Levels

Figure A.13 Trade Balance Growth and Depreciation Experience
Figure A.14 Interest Rates and Bonds

Graphical representations for variables used in tests of model assumptions

Figure A.15 Government Deficit
Figure A.16 Currency Holdings and Gross Private Expenditures

Figure A.17 Real Change in Money Supply
Figure A.18 Real Change in Bonds

Figure A.19 Real Gross Interest on Outstanding Bonds
Table A.4: Dickey-Fuller Unit Root Tests for Tests of Model Assumptions

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Dependent Variable</th>
<th>Coefficient (Test Statistic)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>constant</td>
<td>-1717.623 (-1.071)</td>
</tr>
<tr>
<td></td>
<td>CU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CU(_{-1})</td>
<td>0.964* (17.163)</td>
</tr>
<tr>
<td></td>
<td>trend</td>
<td>156.510 (2.254)</td>
</tr>
<tr>
<td>EXP</td>
<td>constant</td>
<td>-61211.708 (-2.013)</td>
</tr>
<tr>
<td></td>
<td>EXP(_{-1})</td>
<td>0.355 (-3.564)</td>
</tr>
<tr>
<td></td>
<td>trend</td>
<td>3566.164 (3.154)</td>
</tr>
<tr>
<td>(\frac{R_t B_{t-1}}{P_t})</td>
<td>constant</td>
<td>6.853 (0.527)</td>
</tr>
<tr>
<td></td>
<td>(\frac{R_t B_{t-1}}{P_t})(_{-1})</td>
<td>0.948* (13.147)</td>
</tr>
</tbody>
</table>

Figure A.20 Real Change in Reserves
Appendix B

Test of Model Assumptions

B.1 Test of Cash-In-Advance and Financing Constraints

Following Calvo and Mendoza (1995), we test for the validity of the imposition of the cash-in-advance and financing constraints by way of Granger Causality tests. Combining the cash-in-advance constraint (3.3):

\[ P_tC_t = P_t^N C_t^N + (S_t P_t^T) C_t^T \leq M_t + S_t N_t \]

with the financing constraints (3.4) and (3.5):

\[ \Delta B_t - R_t B_{t-1} + P_t^N C_t^N = M_t \]

\[ (\Delta F_t - R_t^* F_{t-1}) S_t + S_t P_t^T C_t^T \leq S_t N_t \]

yields:

\[ M_t + S_t N_t \geq P_t^N C_t^N + S_t P_t^T C_t^T + \Delta B_t - R_t B_{t-1} + (\Delta F_t - R_t^* F_{t-1}) S_t \quad (A.1) \]

The cash-in-advance constraint suggests that the total demand for currency holdings (we denote the left-hand side of (A.1) by CU) are dictated by expenditures (denote the right-hand side of (A.1) as EXP); whereas, the financing constraints suggest that expenditures are limited by methods of payment and currency holdings. To test this causality we employ a Granger (1969) causality test, where, in the case of expenditures, EXP, given by the right hand side of the above equation, and currencies, CU, the left hand side, we regress each of the two variables on past values of both variables:

\[ CU_t = \sum_{i=1}^l \alpha_i CU_{t-i} + \sum_{i=1}^l \beta_i EXP_{t-i} + \epsilon_{1t} \quad (A.2) \]
Table B.1: AIC Results

<table>
<thead>
<tr>
<th>Lag length</th>
<th>Equation A.2</th>
<th>Equation A.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>104.531</td>
<td>132.483</td>
</tr>
<tr>
<td>2</td>
<td>100.777*</td>
<td>127.648*</td>
</tr>
<tr>
<td>3</td>
<td>108.952</td>
<td>131.477</td>
</tr>
<tr>
<td>4</td>
<td>112.609</td>
<td>139.723</td>
</tr>
<tr>
<td>5</td>
<td>113.737</td>
<td>140.006</td>
</tr>
<tr>
<td>6</td>
<td>115.649</td>
<td>140.918</td>
</tr>
<tr>
<td>8</td>
<td>115.732</td>
<td>142.715</td>
</tr>
</tbody>
</table>

\[
EXP_t = \sum_{i=1}^{l} \gamma_i CU_{t-i} + \sum_{i=1}^{l} \delta_i EXP_{t-i} + \epsilon_{2t}
\]  

(A.3)

where the summations are for lag length, \( l \), for which the disturbances, \( \epsilon_{it} \) are white noise. We test, using a standard F-test of zero restrictions, whether the \( \beta_i \) and \( \gamma_i \) are zero, \( i=1, \ldots, l \). If the \( \beta_i \) are zero in Equation A.2, then past values of expenditures do not help to predict currency holdings. In this case, expenditures do not Granger-cause currency holdings, i.e., the cash-in-advance constraint would not be an appropriate characterization. Similarly, if the \( \gamma_i \) are zero in Equation A.3, then past values of currency holdings do not help predict expenditures, currency holdings do not Granger-cause expenditures, invalidating the imposition of financing constraints. Because CU is integrated of order one, i.e. in the previous section, we accepted the null of a unit root, the first differences are stationary and used in the estimation:

\[
\Delta CU_t = \sum_{i=1}^{l} \alpha_i \Delta CU_{t-i} + \sum_{i=1}^{l} \beta_i EXP_{t-i} + \epsilon_{1t}
\]  

(A.4)

\[
EXP_t = \sum_{i=1}^{l} \gamma_i \Delta CU_{t-i} + \sum_{i=1}^{l} \delta_i EXP_{t-i} + \epsilon_{2t}
\]  

(A.5)

To determine the appropriate lag length, we use the Akaike Information Criterion (AIC)\(^1\) which entails the minimization of the non-linear trade-off between residual variance, \( s^2 \), and the number of parameters, \( k \), estimated:

\[
AIC = n \log(s^2) + k \log(n)
\]  

(A.6)

where \( n \) is the number of observations. Table B.1 shows the AIC for each choice of \( l \) for each equation. We choose \( l = 2 \). The results of the estimation are provided in Table B.2. We conduct \( F \) tests that the

Table B.2: Granger-Causality Regression Results

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Coefficient (Test Statistic)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equation A.4</td>
</tr>
<tr>
<td>$\Delta CU_{t-1}$</td>
<td>1.389 (2.850)</td>
</tr>
<tr>
<td>$\Delta CU_{t-2}$</td>
<td>0.843 (1.566)</td>
</tr>
<tr>
<td>$\Delta EXP_{t-1}$</td>
<td>-0.507 (3.77)</td>
</tr>
<tr>
<td>$\Delta EXP_{t-2}$</td>
<td>0.788 (1.97)</td>
</tr>
</tbody>
</table>

$\beta_i$ and the $\gamma_i$ are zero. For $\beta_i$:

$$H_0 : \beta_1 = \beta_2 = 0$$

$$H_1 : \beta_1 , \beta_2 \neq 0$$

$$F_{[2, 56]} = 3.479$$

We cannot reject at the 95% level of confidence that expenditures Granger-cause currency holdings. Similarly, for $\gamma_i$:

$$H_0 : \gamma_1 = \gamma_2 = 0$$

$$H_A : \gamma_1 , \gamma_2 \neq 0$$

$$F_{[2, 56]} = 3.966$$

We cannot reject at the 95% level of confidence that currency holdings Granger-cause expenditures. These results support the Calvo and Mendoza (1995) findings:

The link between $\frac{MV}{P}$ and consumption displays mutual causality under the 2-quarter lag structure ... The causality links found in the data are supportive of a cash-in-advance (CIA) framework as a first approximation to modelling money demand behavior ... Causality from money to expenditure is also in line with a view of liquidity- or credit-constrained agents. (Pg. 28, emphasis mine.)

Interesting to note, the sign of $\text{EXP}_{-1}$ in (A.4) and $\text{CU}_{-1}$ in (A.5) is negative, suggestive of some stickiness in the response of currencies and expenditures to adjust to changes in expenditures and currency holdings, respectively.
B.2 Test of $\psi$ Time-Invariance

In the estimation stage, we simplified the analysis by assuming in Equation 3.10, $\psi = -\log \beta - \frac{1}{2} \text{Var}_t[\gamma c_{t+1} - r_{t+1}]$ is time invariant, i.e., that the variance of consumption growth and investment returns is invariant. To test the validity of this assumption, we conduct a Goldfeld-Quandt test.\(^2\) We compare $\text{Var}_1[\gamma c_{t+1} - r_{t+1}]$ for the first 25 observations of our data (1981.1-1987.1) and $\text{Var}_2[\gamma c_{t+1} - r_{t+1}]$ for the remaining 25 observations (1990.1-1996.1). We perform an F-test on the equality of the subsample variances:

$$H_0 : \sigma_1^2 = \sigma_2^2$$

$$H_A : \sigma_1^2 \neq \sigma_2^2$$

where

$$F_{[n_1-1, n_2-1]} = \frac{\sigma_1^2}{\sigma_2^2}$$

For the lower tail:

$$F_{[24,24]} = 0.31$$

the upper tail:

$$F_{[24,24]} = 3.21$$

and for a two-sided test:

$$(Pr < F1) + (Pr > F2) = 0.0059$$

At the 95% level of confidence, we cannot reject the null of equal variance.

B.3 Test of AR(1) Assumption

We test the AR(1) specification assumed for the expected log interest differential, $x_t = E_t i_{t+1} - i^*$. Using an assumption of rational expectations, such that $E_t i_{t+1} = i_{t+1}$, we estimate the AR(1) specification (Equation 2.3):

$$x_{t+1} = a + \varphi x_t + \eta_{t+1}$$  \hspace{1cm} (A.7)

Our regression results are as follows: To test the AR(1) model we test for white noise residuals. We take

Table B.3: AR(1) Estimation Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate (Standard Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$</td>
<td>0.140 (0.115)</td>
</tr>
<tr>
<td>$\varphi$</td>
<td>0.915* (0.061)</td>
</tr>
</tbody>
</table>

Table B.4: Test of AR(1) Residuals

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate (Standard Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.004 (0.0035)</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.142* (0.046)</td>
</tr>
</tbody>
</table>

the residuals from the AR(1) model above and estimate the following autoregression:

$$\eta_{t+1} = \alpha + \beta \eta_t + \epsilon_{t+1} \quad (A.8)$$

We find we can reject the AR(1) specification at the 95% level of confidence.
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Chapter 4

Piecing Together the ‘New Issues’ Puzzle

People who believe history repeats itself gamble on IPOs, they are willing to run the risk of losing a small amount in return for the hope of a much larger gain.

-The Wall Street Journal

4.1 The Puzzle

The initial public offering (IPO) or ‘new issues’ market, has been characterized by three stylizations, well documented in the corporate finance literature: 1. Short run underpricing;¹ 2. ‘Hot’ and ‘cold’ cycles in issuance;² and, 3. Long run underperformance.³ Tim Loughran and Jay Ritter in their 1995 Journal of Finance article “The New Issues Puzzle” proclaim:

Investing in firms issuing stock is hazardous to your wealth. Firms [IPOs] issuing stock during 1970-1990 . . . have been poor long-run investments for investors. The average annual return during the five years after issuing is only 5 percent for firms conducting IPOs . . . Investing an equal amount at the same time in a nonissuing firm with approximately the same market capitalization, and holding it for an identical period, would have produced an

average compound return of 12 percent per year ... The magnitude of . . . the underperformance is large: it implies that 44 percent more money would need to be invested in the issuers than in the nonissuers to be left with the same wealth five years later.(Emphasis mine, pg. 46)

And yet, IPO shares continue to be highly sought after investments. IPOs regularly make the headlines in the popular press. In fact, recently, the allocation of IPO shares by underwriters has been under investigation amidst allegations that shares are used as potential payoffs, violating standards of 'fair business practices.' "Investment banks silently allocate chunks of hot new stocks to the personal brokerage accounts they hold for corporate executives and venture capitalists . . . spinning or flipping the shares on the day of the IPO for quick profits in an apparent bid for business from the executives' firms."  
Moreover, companies, in increasing numbers are launching 'do-it-yourself' offerings on the Internet and such financial intermediaries as Fidelity Investments and Merrill Lynch now provide shares at non-market offer prices to non-institutional investors. The year 1996 set the record for the most number of IPOs in a given year, 887 deals, raising over $50 billion. Further, 1996 witnessed the largest single deal ever—the spin-off of AT&T Corporation's telecommunications equipment unit, Lucent Technologies Inc., raising $3,035 million globally. The year 1997 rates second with 692 deals, raising $39.25 billion. To provide a flavor of the potential upside and downside in this market, the percentage change in price, calculated from offer price to the last December price, for the 'best' performing IPOs follow (month of offer in parentheses), for 1996: Cymer (September), 406.6%; Outdoor Systems (April), 321.9%; Sipex (April), 239.5%; and for 1997: Rambus (May), 281.2%; LHS Group (May), 273.4%; and Complete Business Solutions (March), 262.5%. However, the percentage change in price for the 'worst' performing IPOs hardly compare in magnitude, for 1996: Cable & Co. Worldwide (June), -85.4%; N-Vision (May), -83.8%; Kaye Kotts Associates (February), -81.3%; and for 1997: DTM Corp (May), -82.8%; DSI Toys (May), -76.5%; and Axiom (July), -66.7%.  

How can we reconcile continued investment today in the IPO market with the long run underperformance? If an informed investor, i.e., one who has read the Loughran and Ritter (1995) paper, is presented with the choice between investing in an IPO or a 'size matched' firm, and is constrained to hold the stock for five years, it would be puzzling indeed if the investor picked the IPO in light of the empirical findings. This empirical result, however, may be blurring more primitive considerations of investors. If investors are not informed, or if they do not rely on a buy and hold investment strategy

---

6 Source: CommScan Inc., New York.
for their IPO investment, or if a size matched firm is not the relevant alternative at the margin for the investor, then one cannot legitimately make any normative statement about the investor's behavior with reference to the findings of Ritter and Loughran (1995). The Ritter and Loughran study is empirical rather than behavioral. Further, there is a fundamental inconsistency underlying the Loughran and Ritter conclusion about investing in IPOs. Their conclusion is predicated on an imposed strategy which is counter to that which the empirical evidence suggests.

This paper reconciles the behavioral reality of continued investment in the IPO market with the 'underperformance' results. We dispel the notion that investment in this market is puzzling by recasting the inquiry into the dimension of the investor. In particular, we pay special attention to the speculative nature of IPOs as an asset class arising from asymmetric information, the relevant investment horizon, and rational trading strategies for investors in this market. With these features in mind, we model investor behavior in the new issues market using rational and positive feedback traders, where the respective trading strategies of investors are motivated by stylized facts of the market, survey evidence, and 'word on the street.'

The minimal assumption of the model is that higher moments of the historical return distribution for new issues, beyond the mean and variance, matter for some segment of the market, in contrast to standard portfolio optimization models. In considering the appropriate investment horizon, we demonstrate the assumption of a five-year buy and hold strategy is too restrictive; thereby, biasing downward the performance results. By allowing investors the opportunity to rebalance, significant short run dynamics arise which are ignored by performance studies imposing buy and hold strategies. In addition, we find that we can explain participation by investors having the least amount of information and without access to shares at the offer price due to overconfidence, their 'expected' returns are shown to strictly dominate their expected return on the market. We are not claiming to ascertain the actual investment horizon nor whether the market is the appropriate benchmark, instead, we suggest that the long run performance studies to date are misguided in their application to the new issues market because they make no provision for the peculiar features of this market and are in conflict with the nature of the investment class—only conditionally viewed as a long run investment vehicle.

In the next section, we discuss the potential bias' and limitations of the standard performance study. We then discuss in Section 4.3 the unique features of the new issues market which provide further caveats for the application of the standard performance methodology. These features govern our modeling choice in Section 4.4. In Section 4.5, we use historical data to understand the expected return implications of the trading strategies of our investors. Section 4.6 concludes.

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8See Markowitz, 1991.
4.2 Performance Studies

Performance studies, in particular, long horizon event studies are rife with caveats. Typically these studies construct abnormal or excess returns using either a pre- or post-event level of return as the ‘normal’ return or a benchmark index or firm is selected. The seminal long run performance study for the new issues market, conducted by Loughran and Ritter (1995), employs the ‘matching firm’ approach. Each IPO is matched with an American or New York Stock Exchange-listed firm, to some extent according to industry and market capitalization. If for any reason the ‘match’ firm drops out of the sample, i.e. delists, the second-, third-, . . . best match is used as necessary. It is well known that long horizon returns are skewed right from the compounding of single period returns. The degree of this skewness is monotonic in the return variability. Hence the abnormal or excess returns calculated as the sample firm return less the return on a benchmark or a matched firm will be skewed right as well.

The statistical inferences for these compound returns is conducted using traditional testing methods (t-tests, etc.) without regard to potential violations of the necessary statistical assumptions, particularly, i.i.d. sampling and normality. Generally, i.i.d. sampling and normality fail to hold even approximately as the measured horizon is extended. Samples of long horizon returns are rarely drawn independently from the underlying population distribution which introduces sample selection bias, as well as survivorship bias for the firms selected as ‘matches’ or individual firm benchmarks. Moreover, returns in calendar time overlap introducing significant cross correlations. Sefcik & Thomson (1986) and Chandra & Balachandran (1990) conclude that inference which disregards cross-sectional correlations may be biased. Unfortunately, the remedies suggested by these authors hinge on either the availability of enough time-series data to estimate correlations among the sample firm returns or the possibility of aggregating the sample firms into portfolios. These methods are of little help in the long run horizon context for several reasons. First, the number of sample firms usually exceeds the available time series observations, precluding the estimation of large covariance matrices. Second, for portfolios, it is infeasible to obtain a sufficient number of realizations of long horizon returns in order to conduct statistical inferences.

Of particular interest and consequence for IPO studies, Barber and Lyon (1996) document that the application of the traditional t-test approach is misspecified when applied to samples of firms not ‘pre-event’ matched. Oftentimes, ‘pre-event’ matches are either not possible or difficult to determine, as is the case with the class of initial public offerings with limited prior performance data. In response, there have been alternative approaches suggested in the literature. The first, by Ikenberry, Lakonishok, and Vermaelen (1995), is a non-parametric bootstrap approach. With this approach, the researcher generates an empirical distribution of long horizon abnormal returns and then infers if the observed performance is consistent with this distribution. The difficulty, of course, is how to generate an empirical distribution when all that we observe is one realization of abnormal returns. Brav (1996) suggests the use of a
parametric bootstrap approach to take non-normality and lack of independence of abnormal returns into account. He applies his method to a sample of initial public offerings and finds that neither the Capital Asset Pricing Model (CAPM) nor the Fama and French (1993) 3-Factor Model are consistent with the long run underperformance of this class of firms. Third, Barber, Lyon, and Tsai (1996) advocate the use of carefully constructed benchmarks (portfolios) which are free of new listing and rebalancing biases, joint with the use of a skewness adjusted t-statistics to account for the skewness in the distribution of long horizon average abnormal returns. However, these methods have flaws—the bootstrap approach relies on the unlikely assumption that the sample and matched firms are similar on every dimension; the benchmark portfolio approach implies the method is applicable to ‘random events’ studies. To assess firm performance following a ‘non-random’ IPO event, the caveats discussed above apply, in addition, peculiar features of the IPO market prove to be complicating factors as well.

4.3 The ‘New Issues’ Market

To compound the pitfalls of standard performance analysis, the initial public offering ‘event’ is characterized by three additional features. First, there is limited pre-event experience or information asymmetry. For a firm going public, typically there is no prior public performance record, other than that contained in the prospectus. Second, the initial offer price is an artificial non-market price set by underwriters in conjunction with the firm which may or may not reveal all information. Third, the post-IPO return distribution for the population is heavily skewed with the potential gains capable of swamping several times the losses. All these features of the market contribute to the regard of IPOs as extremely risky and speculative. To provide support for this view, there have been both references in the academic literature, as well as, the popular press, likening IPOs to lottery tickets or gambles. Alon Brav and Paul Gompers (1996) suggest as an explanation of underperformance: “individuals might derive utility from buying shares . . . because they value them like a lottery ticket (pg. 27).” In the Wall Street Journal:

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9Because of the nascent nature of a large proportion of firms in the IPO sample, estimation of such models using IPO returns requires the allowance for time-varying parameters, as one would expect unstable estimators in the early post-IPO years.

10There are exceptions, however, where substantial firm information is publicly available prior to the prospectus release or IPO. For example, significant past performance information is oftentimes available for reverse leveraged buy-outs (LBOs). Similarly, under the Securities Act (1933) and Exchange Act (1934), firms are obliged to report to the Securities and Exchange Commission (SEC). Once a company's registration statement is effective, the 34 Act requires the company to file reports with the SEC. The obligation to file reports continues at least through the end of the fiscal year in which the registration (of securities) statement becomes effective. Beyond that date, the company is required to continue reporting unless it satisfies the following 'thresholds,' in which case the filing obligations are suspended: the company has fewer than 300 shareholders of the class of securities offered; or the company has fewer than 500 shareholders of the class of securities offered and less than $10 million in total assets for each of its last three fiscal years. Even if the company has not registered a securities offering, i.e., it has not had an IPO or current inten. on, it must file an Exchange Act registration statement if: it has more than $10 million total assets and a class of equity securities with 500 or more shareholders; or it lists its securities on an exchange or on Nasdaq. The firm essentially becomes de facto public.
Many people would agree that buying a lottery ticket is almost a waste of money, given the astronomical chances against hitting the jackpot. Many fewer would admit the same thing about initial public offerings or other high-risk investments. But the payoff with these issues is just as chancy.\textsuperscript{11}

Similarly, Loughran and Ritter (1995) suggest:

A possible reason for why these patterns persist is that investors are betting on longshots . . . In other words, investors seem to be systematically misestimating the probability of finding a big winner. It is the triumph of hope over experience. (Pg. 47)

Under such circumstances, we suggest the historical experience or 'odds at beating the market' may be the basis of investment decisions in the IPO market. Higher moments of the actual empirical return distribution, skewness and kurtosis, matter to investors in the new issues market; namely, the existence of a nontrivial probability of a huge return. This is in contrast to the standard portfolio optimization theory of Harry Markowitz (1991) where optimal portfolio selection relies only on the first two moments, the mean and variance of the return distribution. In terms of direct evidence that the historical return distribution matters, Shiller (1988) finds, in survey results, references to historically high returns on IPOs were made by 8% and 10% of respondents in IPO investor groups:\textsuperscript{12}

While the historically high returns on IPOs were mentioned by only 8 to 10 percent of the respondents . . . the evidence suggests that these high returns are very much on the investors' minds . . . The survey participants were asked to answer "Can you state, in a few words, the theory that led you to invest in (or consider investing in) the company's stock? Put the theory as you would have put it to convince a trusted friend to buy the stock." Because the question asks for a specific 'theory' this may have prevented 'high historical return' responses as this might not have been viewed as a 'theory' by the investor such that the 'theory' responses might depart from the actual motivation for the stock purchase. (Emphasis mine.)

In Table 4.0, we present the historical record for new issues by year of issue. We consider the average 12, 24, 36, and 60 month return performance for issues 1975 -1990.\textsuperscript{13} We find, when the first month return calculation includes the offer price (columns 2-5), the annualized returns calculated out to one-

\textsuperscript{12}The two groups representing IPO investors, IPO-1 and IPO-2, additionally targeted high-income active investors and IPO-2 targeted subscribers to the publication 'New Issues Alert'.
\textsuperscript{13}See Appendix A.1. for data source and descriptive statistics for data.
two-, three-, and five-year horizons dominate the same horizon return from investing in the market\textsuperscript{14} (columns 10-13). The one exception is the five-year return for the 1985 issues. In contrast, when the first aftermarket price is used to calculate the first month return (columns 6-9), only seven of the one- and two-year return horizons dominate the market. As we extend the horizon, in accord with the ‘long-run underperformance’ literature, the number of issue years outperforming the market declines. Only three issue years at the three-year horizon and four at the five-year horizon outperform the market. Interestingly, only the issues during 1977 and 1978 have average returns which dominate the market at the one-, two-, three-, and five-year horizons.

<table>
<thead>
<tr>
<th>Year</th>
<th>Offer Return</th>
<th>Non-Offer Return</th>
<th>Market Return</th>
<th>% due to Offer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12-24-36-60</td>
<td>12-24-36-60</td>
<td>12-24-36-60</td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>2.202</td>
<td>3.077</td>
<td>1.101</td>
<td>1.741</td>
</tr>
<tr>
<td>1976</td>
<td>2.207</td>
<td>3.945</td>
<td>1.127</td>
<td>2.032</td>
</tr>
<tr>
<td>1977</td>
<td>2.647</td>
<td>3.491</td>
<td>1.313</td>
<td>1.735</td>
</tr>
<tr>
<td>1978</td>
<td>2.411</td>
<td>3.919</td>
<td>1.191</td>
<td>1.929</td>
</tr>
<tr>
<td>1979</td>
<td>3.576</td>
<td>3.749</td>
<td>1.751</td>
<td>1.876</td>
</tr>
<tr>
<td>1980</td>
<td>2.561</td>
<td>1.744</td>
<td>1.281</td>
<td>0.871</td>
</tr>
<tr>
<td>1981</td>
<td>1.654</td>
<td>2.880</td>
<td>0.824</td>
<td>1.436</td>
</tr>
<tr>
<td>1982</td>
<td>3.702</td>
<td>2.286</td>
<td>1.816</td>
<td>1.126</td>
</tr>
<tr>
<td>1983</td>
<td>1.693</td>
<td>1.917</td>
<td>0.837</td>
<td>0.950</td>
</tr>
<tr>
<td>1984</td>
<td>2.398</td>
<td>2.954</td>
<td>1.189</td>
<td>1.473</td>
</tr>
<tr>
<td>1985</td>
<td>2.340</td>
<td>2.256</td>
<td>1.169</td>
<td>1.125</td>
</tr>
<tr>
<td>1986</td>
<td>2.214</td>
<td>1.983</td>
<td>1.105</td>
<td>0.992</td>
</tr>
<tr>
<td>1987</td>
<td>1.670</td>
<td>1.971</td>
<td>0.848</td>
<td>0.997</td>
</tr>
<tr>
<td>1988</td>
<td>2.594</td>
<td>2.268</td>
<td>1.291</td>
<td>1.125</td>
</tr>
<tr>
<td>1989</td>
<td>1.912</td>
<td>2.437</td>
<td>0.953</td>
<td>1.218</td>
</tr>
<tr>
<td>1990</td>
<td>2.383</td>
<td>2.518</td>
<td>1.211</td>
<td>1.280</td>
</tr>
</tbody>
</table>

Table 4.0: Annualized Monthly IPO Returns By Issue Year

The data indicates that investors able to purchase shares at the offer price, based purely on average historical performance, should according to an average return argument. They can expect on average to receive positive excess returns over the market at horizons up to five years and beyond. Roughly fifty percent of the money made by the end of the first year accrues to the ‘preferential’ investor who receives shares at the offer price in the first month (See last column). In fact, 80% of investors’ profit is generated the first time the IPOs trade. A review by Birinyi Associates Inc. of last year’s record $59.5 billion in initial public offerings showed that the stocks generated $7.99 billion of profit for investors, with $6.43 billion coming from the first trade.\textsuperscript{15} For non-preferential investors, i.e., those unable to buy shares at the offer price, however, the historical odds have proven less favorable. Yet, the chance of non-negative excess returns increases as the horizon shortens and the odds are less favorable this

\textsuperscript{14}The market return is the annualized monthly market index from the University of Chicago's CRSP tapes.

\textsuperscript{15}Duncan Martell, “Initial Sales Generate 80% Profit on First Trade,” The Boston Globe, February 23,1997, D5.
decade than in the past. With such odds, the 'new issues puzzle' at this point reduces to 'How can we explain non-preferential investors entering the aftermarket for new issues?' To this point, the average returns shown above do not provide much insight. We consider the possibility that a small probability of huge return, even in light of lower average returns, i.e., mass at the right tail of the empirical return distribution may entice this segment of investors into the market.

Figure A.1 in the Appendix presents the one, two, three and five year annual return distribution for the 1975-90 issues (omitting the offer price), Figures A.2-17 break down this distribution by issue year. For each issue year and horizon, we determine the third and fourth moments, the skewness and the kurtosis, respectively. These moments are depicted in Figures 4.1 and 4.2 below.

![Figure 4.1: Skewness in the New Issues Market](image_url)
Figure 4.2: Kurtosis in the New Issues Market

For comparison, recall the skewness (and all odd moments) for a normal distribution is zero and the kurtosis is equal to three, which we also indicate in the figures. From the figures displayed here and in the Appendix, we observe the tails of the IPO distributions are fat and asymmetric. The empirical return distribution is characterized by leptokurtosis. In addition, it appears the distribution is becoming less peaked, but not necessarily becoming more normal as the return horizon lengthens as discussed by the compounding of returns criticism of the performance methodology earlier.

Whereas, receiving shares at the offer price is enticement enough for preferential investors, the leptokurtosis in the returns, we suggest, is motivating the entry of non-preferential investors in the new issues market. Shiller claims:

Investors in IPOs do not diversify away the risk of their IPO investments, investing in only a small number themselves, the shape of this distribution is likely to matter to their sense of satisfaction in their investment ... (pg. 14).

Morgan Stanley Dean Witter & Co. in their Technology IPO Yearbook, Second Edition (1996), also suggest this attraction to a small probability of a huge gain is very much on the minds of investors:

If past is prologue, then some big ... money-making opportunities are being created that should far outweigh the losses. For example, in the last 16 years, shareholder value created from new public technology companies [alone] totals more than $415 billion, while the total amount lost by the public in the IPOs of new technology companies is around $19 billion. .
But some tech stocks are big winners, and the wealth they have created far outweighs the combined losses of the losers . . . (pgs.1-3, emphasis mine.)

Investor’s expected returns which give credence to the entire return distribution may provide more insight, as investors may be overweighting the upside and downweighting the downside as in Kahneman & Tversky’s (1991) ‘Prospect Theory.’

If offer prices and the small chance at a huge gain, with incommensurate downside potential, motivate or can explain entry into the new issues market by investors, how should we describe the behavior of investors in the market following entry. The notion that IPOs, as an investment class, are not necessarily long term investments is supported by the prevalence of ‘penalty bids’ and survey evidence. Penalty bids are levied against brokers who give shares to ‘flippers,’ individuals who turn around and sell their shares, ‘flip’; 16

...while penalty bids have been standard procedure for years, underwriters and analysts say firms impose them with much more frequency during tough IPO environments.

This notion of IPOs as initially perceived short term investments is further substantiated by survey evidence of Shiller (1988). The two respondent groups holding IPOs, responded 78% and 45% that excluding their IPO holdings “most other holdings are safe and unexciting,” leaving their IPO holdings as 22% and 55% as “risky and speculative.” 17 The trading history among Shiller’s survey respondents indicates most IPO investors are repeat purchasers of IPO’s. They do not flip, that is buy and sell promptly in the aftermarket. Instead investment tends to be made for something on the order of a year. In response to “What is the shortest period for which you held an initial public offering, from the date of purchase to the date of sale?” The mean responses and standard errors (weeks in parentheses) were 38.4 weeks (10.9) and 21.3 weeks (3.3) for respondent groups IPO-1 and IPO-2, respectively. In response to “What is the average or typical period for which you held an initial public offering, from the date of purchase to the date of sale?” The responses about doubled: 68.4 weeks (10.8) and 48.5 weeks (4.9), for IPO-1 and IPO-2, respectively. In yet another survey question: “Prior to purchasing (or considering purchasing) stock in the company, did you feel it was important to purchase the company stock right away, due to some short-lived profit opportunity?” 52% of the IPO-1 group and 66.7% of the IPO-2 group responded ‘yes’; whereas, only 33.3% of the control group (those responding in reference to investment in non-IPO stocks) responded ‘yes.’

17 IPO-2 may be comprised of investors investing on their own behalf, trying to ‘play the market,’ who may suffer from ‘overconfidence’ in investing, etc. which may explain the larger percentage of ‘risky and speculative’ asset holdings.
New issues, as a speculative and short term investment, are likely to be periodically reassessed and rebalanced, where past experience may be the overriding determinant as to whether the stock remains in the portfolio.\textsuperscript{18} We ask, can early performance forecast future returns in the new issues market? Does a rebalancing strategy, conditional on prior performance, outperform a buy and hold strategy in this market? Jain & Kini (1994) find no relation between post-IPO performance and the level of initial underpricing. Several previous studies have concluded that for individual securities, longer run performance, ranging from one year to five, in the aftermarket is not inversely related to the first month performance (See McDonald and Fisher (1972)). However, what about say, expected second year performance conditional on first year performance? Figures A.26-41 in the Appendix depict the second year return distribution for each issue year, conditional on the first year performance. A stock is categorized as \{L\} or \{H\} in the second year if they under- or over-perform the market in the first year, respectively. These conditional return distributions suggest that a trading strategy where rebalancing relies on the conditional distribution may be to an active trader’s advantage. Brav and Gompers (1996) calculate five full year returns with arbitrary monthly rebalancing. They find that although the absolute level of returns change, qualitative results are unchanged at the long horizon. However, their conclusion relies on average returns.

The defining features of the new issues market discussed in this section will serve as the basis of our model assumptions of the next section. The entry of uninformed, non-preferential investors is motivated by the leptokurtosis in the historical return distribution. In addition, we allow investors the opportunity to rebalance their portfolios. We will focus on expected returns to understand the model implications for investor participation in the new issues market.

\subsection{The Model}

We will follow the standard noise trader approach of De Long, Shleifer, Summers, and Waldmann (1990, hereafter DSSW). This modeling approach to financial markets relaxes the stringency of the efficient markets assumption. Instead, these models rely on two assumptions. First, some proportion of investors (‘noise,’ ‘chartists’, ‘positive feedback’ or ‘momentum’ traders, etc.) are not fully rational—their demands for risky assets are based on sentiments or beliefs rather than on fundamentals. Second, there is some proportion of investors who are fully rational, but for whom rational trading is risky, such that arbitrage is incomplete. Together, these two assumptions imply that changes in investor sentiment are not arbitrated completely away, affecting security prices.

\textsuperscript{18}The performance history of a stock is the principal variable that determines the inclusion or exclusion of the firm in the choice of mutual fund investors, i.e., "the respondents to a 1990 Consumer Reports survey of readers who invest in mutual funds, ranked past performance as the most important variable in their investment choice."
Noise trader models are appealing because they allow for a more realistic depiction of investor behavior. As particularly relevant for our purposes, when some investors follow positive feedback strategies, i.e., they chase trends or buy when prices rise and sell when prices fall, it need no longer be optimal for rational traders to counter shifts in their demand. Instead, they may optimally buy stocks that positive feedback investors buy when their price rises, i.e. rational traders 'jump on the bandwagon' prior to noise trades. Trading between rational arbitrageurs and positive feedback traders then leads to positive autocorrelations of returns at short horizons; whereas, the eventual return of prices to fundamentals accelerated also by arbitrage, leads to negative autocorrelation of returns at longer horizons. These dynamics agree with the short run underpricing and long run underperformance results for new issues. These predictions for stocks have been substantiated by Cutler, Poterba, and Summers (1989). Evidence of the overreaction of stock prices to fundamentals is presented for individual securities by DeBondt and Thaler (1987) and for the aggregate market by Campbell and Kyle (1988). The finding of positive serial correlation at short horizons implies a substantial number of positive feedback traders must be present in the market, and further that arbitrage is limited.

In modeling the new issues market, Rajan and Servaes (1993) include positive feedback traders to explain the existence of 'hot' issue markets. They assume some investors follow positive feedback strategies. These investors are willing to bid up the price of an issue once it starts trading, if other recent issues have risen in price. If enough investors follow such a strategy, they may induce the positive autocorrelation of initial returns which they assume. For our purposes, we are interested in the implications of a noise trader model for the relevant investment horizon and expected returns. Although, we will show in a later extension of our model (to generate cycles in issuance) generates the Rajan and Servaes result. We set out the model below.

Timing

---

19 The major claim against noise trader models dates back to Milton Friedman (1953). Friedman argued that investors trading on noise might lose their money to arbitrageurs, leading to their withdrawal from the market and the diminution of their effect on demand. The argument is countered by the noise trader models. Although noise traders are worse off than they would be if their expectations were rational, noise traders may be on average more willing to take aggressive positions, based on overconfidence or overoptimism. In so doing, the noise traders bear more risk. But if the market rewards risk-taking, then noise traders can earn higher expected returns, despite buying high and selling low. The risk borne may not even be fundamental. As in DSSW (1990), the risk is resale price risk arising from the unpredictability of future noise trader viewpoints. Hence, contrary to Friedman's claim, noise traders may not be arbitraged out of the market.
All investors are endowed with initial investable wealth, $W_0$. Investment can take place in the beginning of Period A and Period 1, by all investors. There are two available risky investments in periods A and 1: the market and a new issue. We refer to Period A as the new issues aftermarket where informed investors act to satisfy Period 0 demands. In Period 1, the portfolio rebalancing period, all investors, including pre-IPO shareholders or ‘insiders,’ have the opportunity at no cost to rebalance their portfolios. In the last period, Period 2, firms are liquidated, positions are ‘cashed in’ and investors consume their wealth. We assume for simplicity there is no discounting of returns by investors and the cost of rebalancing is zero. Investors in the market are either informed, rational traders, referenced by ‘I,’ or uninformed, positive feedback traders, referenced by ‘U,’ where we assume there are quantities $U$ and $I$ of each type of investor.

At the beginning of Period 0, the offer price, agreed to by underwriters and the firm, is announced. We take this offer price as exogenously specified. Practically, the offer price, $p_0$, is determined by the underwriter’s expected demand, conditioned on ‘road show’ interest by investors, and either fixed share or fixed revenue constraints imposed by the firm. (All subscripts refer to time periods and superscripts refer to ‘types’, i.e. investor type, I or U; and later, H and L to denote IPO type.) All investors determine optimal zero period allocations of initial wealth between the available risky assets. Investors submit their bid for IPO shares to the underwriter. The underwriter, using an exogenous allocation rule, allocates a fixed number, $q_0$, of shares to investors. We assume that no pre-existing shares held by insiders are traded until the lock-up restriction imposed by the underwriter is lifted, corresponding to after Period A trades.\footnote{Think of period A as representing the immediate aftermarket; whereas, Periods 1 and 2, can be thought of as one and two year horizons. This choice is made with reference to the existing capital gains tax horizon and the survey evidence of Shiller (1988). The current tax law sets 18 months for the delineation between short and long term investments.} The total number of pre-existing shares is represented by $s_0$, held by $s_0$ number of informed shareholders. The total investor population is of unit measure, $U + I + s_0 = 1$. A change in
the composition of investors changes the risk bearing capacity of the market.\footnote{\footnote{In this simple model, investor types are endogenously given, i.e., we do not make allowances for 'learning' where 'uninformed' types become informed.' Although a criticism of this model, we counter, to the uninformative positive feedback traders every new issue presents a new opportunity that with small probability there may be a huge reward. The same analogy can be made to lottery tickets. Why do people continue to play the lottery? Every jackpot has different odds and payoffs, but each time offers another chance to win. In particular, Richard Thaler and Eric Johnson (1991, pg. 49.) find: current choices are often evaluated with the knowledge of the outcomes which have preceded them. For example, under certain circumstances a prior gain can increase subjects' willingness to accept gambles [termed the house money effect]. The difference in the new issues case is that the assumption extends to a prior gain not necessarily experienced by the particular investor in question, i.e., similar to the influence a winner of the lottery may have on another individual's decision to enter into subsequent lotteries. Secondly, the positive feedback trading strategy substitutes for real learning, i.e., the positive feedback traders put too much weight on the last period performance in period 1 which obstructs any rational learning possible via interpretation of the signal. It is because the positive feedback traders are operating with an information deficit that they adhere to this trading strategy.}}

The shares on offer at price $p_0$ are assumed to fall short of the combined demands of both informed and uninformed investors:

$$D_U^0(p_0) + D_I^0(p_0) > q_0(p_0) \quad (4.1)$$

where $D_U^0(p_0) = Ud_0^U(p_0) = U\omega_0^U W_0$ represents the aggregate uninformed demand and $\omega_0^U$ represents the uninformed allocation of initial wealth in the IPO. Similarly, $D_I^0(p_0) = Id_0^I(p_0) = I\omega_0^I W_0$. Hence, the IPO shares must be rationed. Investors receiving shares at the offer price, hereafter, are referred to as 'preferential' (superscript 'P') and those not, as 'non-preferential' ('NP'). We allow underwriters to allocate shares with discretion.\footnote{Hanley and Wilhelm (1995) find: . . . approximately 70\% of the shares in underpriced offerings [sample of 38 managed IPOs] are allocated to institutional investors. Balancing their apparent preferential treatment in underpriced offerings, however, . . . institutional investors take similarly large positions in overpriced offerings. Moreover, . . . institutional investors are allocated large proportions of issues for which pre-offer interest is weak and . . . strong. . . the data support the conclusion that institutional investors capture the lion's share of profits associated with underpriced offerings, but only at the cost of active participation in less attractive offerings. Interestingly, Business Week estimates (April 4, 1994) that institutional investors purchase 80\% of the shares in 'hot' deals but only 60\% of the shares in 'normal' deals. . . our findings suggest that their estimates overstate the variation in institutional participation across offers.}}

The rationing condition is given by:

$$D_U^{0,P}(p_0) + D_I^{0,P}(p_0) = q_0(p_0) \quad (4.2)$$

Consequently, the aftermarket price of the new issues exceeds the offer price, consistent with the stylized fact of short-run underpricing.\footnote{There are compelling arguments in the literature, in some combination, justifying our imposition of rationing, rendering the underpricing phenomenon. These underpricing stories include: the winner's curse hypothesis expounded by Rock (1986) and further developed by Ritter and Beatty (1986); the costly information acquisition hypothesis developed by Breznik and Spirid (1989); the cascades hypothesis presented by Welch (1992); the signalling hypothesis of Allen and Faulhaber (1989), Welch (1989), Grinblatt and Hwang (1989).}
Information Structure

The Period 0 information set, $\mathcal{V}_0$, is comprised of public, $\Omega_0$, and private information, $\vartheta_0$:

$$
\mathcal{V}_0 = \Omega_0 \cup \vartheta_0
$$

Uninformed investors, by definition, have access only to public information. Their demands for new issues at the offer price, with no prior listed performance record, are conditioned on last year's historical average. Further portfolio allocation decisions are conditioned on past aftermarket performance of the stock. Uninformed traders rely on a positive feedback trading strategy.

In contrast, in Period 0, informed investors have access to private information, $\vartheta_0$, which is indicative of the performance of the firm through Period 1.\(^{24}\) This private information influences informed investors' buy or sell decision in the aftermarket. Additionally, between the aftermarket trades and rebalancing in Period 1, a noiseless signal, $\eta \in \vartheta_1$, is released in the marketplace. This signal, an earnings report or the like, is utilized only by informed investors. The signal provides information which influences the informed investors' rebalancing decision. The second year excess return of the IPO return over the market is written as the sum of the signal and a stochastic disturbance term:

$$
r_{12}^{IPO} - r_{12}^M = \eta + \mu
$$

$$
E(\mu) = 0
$$

$$
E(\mu^2) = \sigma^2
$$

The double subscript on the return indicates the interval over which the return applies. $E[\cdot]$ represents the mathematical expectation, where

$$
E[r_{12}^{IPO} - r_{12}^M] = E[\eta]
$$

and the informed investor's Period 1 expected excess return, conditioned on the signal information, is

---

\(^{24}\)This private information can be thought of access to privileged 'cheat sheets.' As mentioned in The Wall Street Journal:

Named for their similarity to the notes students sometimes sneak in to exams, Wall Street's version of cheat sheets contain one or more pages of information not found in the prospectus, such as earnings projections or comparisons with competitors . . . investors and IPO watchers say many Wall Street firms give out cheat sheets to their best clients, no questions asked . . . without projections and industry comparisons, it's difficult for investors to judge whether an IPO is being priced appropriately . . . individual investors do buy hot IPOs after they have already begun trading. And after big investors have already headed for the exits, individual investors are often left with the initial impression, partly sparked by cheat sheets . . . ("Cheat Sheets' On IPOs Raise Fairness Issue" Wall Street Journal, Wednesday, December 31, 1997, C1-2.)

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merely the signal itself:

\[ E_I^r \left[ r_{12}^{IPO} - r_{12}^{M} \right] = \eta \]

such that in expectation, knowing \( \eta \) provides informed investors with certainty as to the subsequent performance of the firm.\(^{25}\)

**Informed investor’s demand functions**

Informed, risk averse investors choose the proportion \( \alpha \), of initial wealth, \( W_0 \), to allocate to the new issue to maximize the expected utility of second period wealth:

\[
\max_{\alpha} E_0^r [U(\widetilde{W}_2)]
\]

(4.5)

for an increasing, concave utility function \( U \): \( U' > 0, \ U'' < 0 \); and where the end of period wealth is defined by the random variable:

\[ \widetilde{W}_2 = W_0 (1 + \tilde{r}_{IPO} + \alpha (\tilde{r}_{IPO} - \tilde{r}_m)) \]

We allow investors the opportunity to rebalance their portfolio in Period 1, which leads to the following proposition:

**Proposition 1** Rebalancing by informed traders is optimal given the information structure of the model.

**Proof:** By the definition of a noiseless signal. Given the information structure and ignoring for the moment the possibility of altering demands in the immediate aftermarket (Period A), the informed investor’s end of Period 2 wealth is maximized by a two stage optimization, rather than a two-period optimization in Period 0 which does not make use of the signal. The definition of a noiseless signal implies:

\[
\max E_I^r [U(\widetilde{W}_2)|\mathcal{O}_0, \eta] - \max E_0^r [U(\widetilde{W}_2)|\mathcal{O}_0] > 0
\]

Adding the first period optimand, \( \max E_0^r [U(\widetilde{W}_1)|\mathcal{O}_0] \), twice:

\[
\max E_I^r [U(\widetilde{W}_2)|\mathcal{O}_0, \eta] + \max E_0^r [U(\widetilde{W}_1)|\mathcal{O}_0] - \max E_I^r [U(\widetilde{W}_2)|\mathcal{O}_0] + \max E_0^r [U(\widetilde{W}_1)|\mathcal{O}_0] > 0
\]

and combining the third and fourth term yields:

\[
\max E_0^r [U(\widetilde{W}_1)|\mathcal{O}_0] + \max E_I^r [U(\widetilde{W}_2)|\mathcal{O}_0, \eta] > \max E_0^r [U(\widetilde{W}_2)|\mathcal{O}_0]
\]

\(^{25}\)We could have assumed that the signal is only received by the informed investors with it becoming public knowledge in the second period. Here, however, we just assume a positive feedback strategy by uninformed investors which does not involve the signal as a conditioning argument.
Although we are simplifying the analysis considerably by requiring our signal to be noiseless, there is some noisy signal, \( \tilde{\eta} \), for which the investor will be indifferent between rebalancing and a two period optimization or buy and hold strategy:

\[
\exists \tilde{\eta} : E'[r_2^{IPO} - r_2^{M}|\tilde{\eta}] = E'[\eta|\tilde{\eta}] \neq \eta
\]

\[
\Rightarrow \max E'[\mathcal{U}(\tilde{\mathcal{W}}_2)|\mathcal{S}_0, \tilde{\eta}] - \max E'[\mathcal{U}(\tilde{\mathcal{W}}_2)|\mathcal{S}_0] = 0
\]

\[
\Rightarrow \max E'[\mathcal{U}(\tilde{\mathcal{W}}_1)|\mathcal{S}_0] + \max E'[\mathcal{U}(\tilde{\mathcal{W}}_2)|\mathcal{S}_0, \tilde{\eta}] = \max E'[\mathcal{U}(\tilde{\mathcal{W}}_2)|\mathcal{S}_0]
\]

Similarly, we can think of a cost of rebalancing to serve the same purpose:

**Proposition 2** \( \exists C^* > 0 \), a non-negative cost of rebalancing, such that informed investors are indifferent between rebalancing and not, i.e., where the cost of rebalancing equals the value to the investor of the acquired information from the signal.

**Proof**:

\[
\exists C^* > 0 : \max E'[\mathcal{U}(\tilde{\mathcal{W}}_1)|\mathcal{S}_0] + \max E'[\mathcal{U}(\tilde{\mathcal{W}}_2)|\mathcal{S}_0, \eta] - C^* = \max E'[\mathcal{U}(\tilde{\mathcal{W}}_2)|\mathcal{S}_0]
\]

\[
\Rightarrow C^* = \max E'[\mathcal{U}(\tilde{\mathcal{W}}_1)|\mathcal{S}_0] + \max E'[\mathcal{U}(\tilde{\mathcal{W}}_2)|\mathcal{S}_0, \eta] - \max E'[\mathcal{U}(\tilde{\mathcal{W}}_2)|\mathcal{S}_0]
\]

Hence, we replace, the single two-period optimization with two single-period optimizations. The informed choice of portfolio weights at Period 0 and 1 are determined as:

\[
\alpha_0^I \in \arg \max E'[\mathcal{U}(\tilde{\mathcal{W}}_1)|\mathcal{S}_0] \quad (4.6)
\]

\[
\alpha_1^I \in \arg \max E'[\mathcal{U}(\tilde{\mathcal{W}}_2)|\mathcal{S}_0, \eta] \quad (4.7)
\]

and the expected utility of first period wealth can be written as the investor's probability (of preferential status) weighted expected utility:

\[
E_0'[\mathcal{U}(\tilde{\mathcal{W}}_1)] = P(P) E_0'[\mathcal{U}(\tilde{\mathcal{W}}_1(P))|\mathcal{S}_0] + (1 - P(P)) E_0'[\mathcal{U}(\tilde{\mathcal{W}}_1(NP))|\mathcal{S}_0] \quad (4.8)
\]
where the expected wealth, conditional on being preferential, i.e., receiving offer shares is explicitly the return on the preferential shares and the shares bought up in the aftermarket to satisfy Period A demands, plus the return on the market:

\[
\tilde{W}_1(P) = W_0 \left(1 + \tilde{\tau}_{01} \right) \frac{q_0}{W_0} + \left(1 + \tilde{\tau}_{A1}^M \right) \left(1 - \alpha_A^I - \frac{q_I}{W_0} \right) + \left( \alpha_A^I - \frac{q_I}{W_0} \right) \left( \tilde{\tau}_{A1}^{IPO} - \tilde{\tau}_{A1}^M \right) + \frac{q_I}{W_0} \tilde{\tau}_{01}^{IPO} \quad (4.9)
\]

and conditional on non-preferential status:

\[
\tilde{W}_1(NP) = W_0 \left[1 + \tilde{\tau}_{01}^M + \alpha_0^I \left( \tilde{\tau}_{A1}^{IPO} - \tilde{\tau}_{01}^M \right) \right] \quad (4.10)
\]

Terminal wealth is determined as:

\[
\tilde{W}_2 = \tilde{W}_1 \left[1 + \tilde{\tau}_{12}^M + \alpha_1^I \left( \tilde{\tau}_{12}^{IPO} - \tilde{\tau}_{12}^M \right) \right] \quad (4.11)
\]

**Proposition 3** Informed investors do not modify their Period 0 demands in the aftermarket.

**Proof.** By virtue of the informed investor’s expectations \((E_0'[U(\tilde{W}_1)])\) of first period wealth which incorporates the investor’s assessed likelihood of receiving offer shares and by their rational expectations of price movements which anticipate the momentum trader’s strategy, informed investors can ‘jump on the bandwagon’ to ride out the price gains from subsequent feedback trades. Because

\[
E_0'[\tilde{\tau}_A^I | \mathcal{F}_0] = \frac{P_A}{P_0}
\]

such that

\[
\max E_0'[U(\tilde{W}_A)^I | \mathcal{F}_0] + \max E_A'[U(\tilde{W}_1) | \mathcal{F}_0, \frac{P_0}{P_0}] = \max E_0'[U(\tilde{W}_1) | \mathcal{F}_0]
\]

Informed investors rationally anticipate the movement in aftermarket prices given their private information; thereby, rendering no difference between Period 0 and Period A demands for new issues. Yet, those informed investors, not allocated their optimal desired quantity of shares, will enter the aftermarket to satisfy this Period 0 optimal demand at the anticipated aftermarket prices. This implies that in Equation (4.9), \(\alpha_A^I = \alpha_0^I\), such that \((\alpha_A^I - \frac{q_I}{W_0}) = (\alpha_0^I - \frac{q_I}{W_0})\), the shares bought up by the informed trader in the aftermarket. The Period 0 demands of informed, rational investors anticipate the immediate aftermarket.

**Proposition 4** No rational trader follows a positive feedback strategy.
Proof. By the above optimization:

\[
\max E_0[\mathcal{U}(\tilde{\alpha}_0)] \mid \mathcal{F}_0] + \max E_1[\mathcal{U}(\tilde{\alpha}_0)] \mid \mathcal{F}_0, \eta] > \max E_0[\mathcal{U}(\tilde{\alpha}_0)] \mid \mathcal{F}_0] + \max E_1[\mathcal{U}(\tilde{\alpha}_0)] \mid \mathcal{F}_0]
\]

Uninformed investors

Uninformed investors have at their disposal only information which is publicly available, i.e., past return histories, newspaper and magazine articles, and institutional publications, none of which perfectly substitute for the private information held by underwriters and informed investors. Based on the attractiveness of the historical return distribution, uninformed investors enter the new issues market with a fixed initial request for shares, \(d_0^U = \alpha_0^U W_0\).

The uninformed investors are assumed to follow a positive feedback trading strategy, i.e. they buy if the price rises and sell if the price declines. We capture this sensitivity to price movements by the parameter \(\beta > 0\). Uninformed investors enter the aftermarket to satisfy their Period 0 demand, updated by their sensitivity to the immediate aftermarket-offer price differential, \(p_A - p_0\). Similarly, they rebalance their portfolios in Period 1 according to their sensitivity to the price differential, \(p_1 - p_A\). Uninformed feedback traders are quasi-rational, in the sense of Thaler (1991). Although their decision making hinges on an improvised rule-of-thumb trading strategy, the strategy is not inconsistent with the axioms of rational choice, just limited by the information available and relied on. The uninformed investors are rational in the sense that the rule engenders systematic and consistent choices.

The table below summarizes the investor demand functions by type: informed and uninformed; preferential and non-preferential, and for existing informed 'insider' shareholders:

<table>
<thead>
<tr>
<th>Period</th>
<th>Preferential</th>
<th>Non-Preferential</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(d_0^I = \alpha_0^I W_0)</td>
<td>(d_0^I)</td>
</tr>
<tr>
<td>A</td>
<td>(d_0^I - q_0^I + \beta(p_a - p_0))</td>
<td>(d_A^I = d_0^I + \beta(p_a - p_0))</td>
</tr>
<tr>
<td>1</td>
<td>(d_1^I = \alpha_1^I W_1)</td>
<td>(d_1^I)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>Preferential</th>
<th>Non-Preferential</th>
<th>Insider</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(d_0^I = \alpha_0^I W_0)</td>
<td>(d_0^I)</td>
<td>-</td>
</tr>
<tr>
<td>A</td>
<td>(d_0^I - q_0^I)</td>
<td>(d_A^I)</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>(d_1^I = \alpha_1^I W_1)</td>
<td>(d_1^I)</td>
<td>(d_1^I^T)</td>
</tr>
</tbody>
</table>

Market Clearing Conditions

In Period A, the immediate aftermarket price adjusts to equate the supply of and demand for shares, where informed investors act to satisfy Period 0 demands and uninformed investors act to satisfy Period
A demands:

\[ q_0 = U^P((d_0^U - q_0^U) + \beta(p_A - p_0)) + U^{NP}(d_0^U + \beta(p_A - p_0)) + I^P(d_0^I - q_0^I) + I^{NP}d_0^I \]  

(4.12)

such that

\[ p_A = p_0 + \frac{2q_0 - Id_0^I - Ud_0^U}{U\beta} \]  

(4.13)

In Period 1, the price similarly adjusts to equate the supply of and demand for shares, where now insiders can sell or buy shares:

\[ q_0 + s_0 = U(d_A^U + \beta(p_1 - p_A)) + Id_1^I + d_1^{SI} \]  

(4.14)

where

\[ p_1 = p_A + \frac{q_0 + s_0 - Id_1^I - Ud_1^U - d_1^{SI}}{U\beta} \]  

(4.15)

**Discretization of IPO state space**

We discretize the state space of possible IPO types to focus on two states: over- or underperformance vis-à-vis the market benchmark return. We consider IPO performance for two time intervals, [A,1] and [1,2]. There are four types of new issues.\(^{26}\) A new issue at the end of periods 1 and 2 can be of either two types: \{L\}, an ‘Underperformer’ or issue with lower return than the market; or, \{H\}, an ‘Overperformer’ or issue with higher return than the market, where:

\[ IPO\epsilon\{L\} \Leftrightarrow r^{IPO} < r^M \]

and

\[ IPO\epsilon\{H\} \Leftrightarrow r^{IPO} \geq r^M \]

The complete set of IPO types, defined by their two period performance record, then is given by:

\(^{26}\)Because we are focusing on investor behavior in the IPO market, the model assumes the firm type is exogenous. More importantly, implicit is the assumption that the actual act of ‘going public’ does not influence the subsequent performance of the firm. This assumption is empirically supported by the empirical finding of no ‘IPO’ effect in the long run performance study conducted by Brav and Gompers (1996). However, consideration of all the possible scenarios of consecutive types in the extension of the model (Section “Generating Cycles in Issuance”), does provide implications for the ‘timing’ of an IPO as second issues face greater likelihood of withdrawal or undersubscription following certain first issue types.
$S = \{LL, LH, HL, HH\}$

with the first variable indicating first period performance and the second indicating second period performance. Given the information structure of the model, informed investors and underwriters can distinguish IPOs based on first period expected performance: as either $\{L\}$ or $\{H\}$. Interpretation of the signal reveals the second period expected performance to informed investors; whereas, uninformed investors can only distinguish the first period type at Period 1 and the second period type at Period 2.

The price dynamics are exogenously determined by the IPO types as follows:

Table 4.2: Price Dynamics By IPO Type

<table>
<thead>
<tr>
<th>Period</th>
<th>IPO Type</th>
<th>LL</th>
<th>LH</th>
<th>HH</th>
<th>HL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$p_a &gt; p_0$</td>
<td>$p_a &gt; p_0$</td>
<td>$p_a &gt; p_0$</td>
<td>$p_a &gt; p_0$</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>$p_1 &lt; p_a$</td>
<td>$p_1 &lt; p_a$</td>
<td>$p_1 &gt; p_0$</td>
<td>$p_1 &gt; p_a$</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>$p_2 &lt; p_1$</td>
<td>$p_2 &gt; p_1$</td>
<td>$p_2 &gt; p_1$</td>
<td>$p_2 &lt; p_1$</td>
<td></td>
</tr>
</tbody>
</table>

These exogenous price dynamics impose the following constraints on the above equilibrium conditions:

1. To ensure short run underpricing, the rationing requirement:

   $$q_0 < Id_0^U + Ud_0^U < 2q_0$$

2. To ensure first period overperformance requires:

   $$\frac{q_0 + s_0 - Ud_A^U - Id_1^U - d_1^{SI}}{U\beta} > 0$$

3. To ensure first period underperformance requires:

   $$\frac{q_0 + s_0 - Ud_A^U - Id_1^U - d_1^{SI}}{U\beta} < 0$$

Predictions of the Model

Informed and uninformed investors queue for all issues; the uninformed because every issue looks the same; the informed because they either know the issue will outperform in Period 1 or they realize they can flip the shares in the aftermarket, taking advantage of the short run underpricing (figuratively
speaking, they ‘jump on the bandwagon’). Essentially, we are abstracting from the consequences to informed investors of flipping (i.e., the possibility that they may put at risk their future preferential status) and allowing the bandwagon effect to dominate any reputation considerations.\textsuperscript{27} We consider the aftermarket and rebalancing periods for each IPO type individually, making the appropriate demand adjustments to the general Equations 4.12 and 4.14 above:

1. {LL}

In Period A, non-preferential uninformed investors enter the aftermarket to satisfy price adjusted demands and informed investors toss their preferential shares:

\[ q_0 = U^P((d_0^U - q_0^U) + \beta(p_A - p_0)) + U^{NP}(d_0^U + \beta(p_A - p_0)) - I^Pq_0^I \]

\[ p_A = p_0 + \frac{2q_0 - Ud_0^U}{U\beta} \]

In Period 1, uninformed and all inside investors try to sell unwanted underperforming shares. However, there is a liquidity problem as there are no buyers entering the market.

\[ q_0 + s_0 = U(d_A^U + \beta(p_1 - p_A)) - s_0 \]

where

\[ p_1 = p_A + \frac{q_0 + 2s_0 - Ud_A^U}{U\beta} \]

This is the ‘winner’s curse’ case. (See Rock (1986)). Uninformed investors face liquidity problems when they attempt to rebalance their portfolio as no investors enter the market to buy shares following the poor first period performance. The uninformed traders wind up holding for the long term against their desired investment strategy; whereas, preferential informed investors are able to flip in and out of Period A.

2. {LH}

In Period A, non-preferential uninformed investors enter the aftermarket to satisfy price adjusted demands, buying up shares sold by informed investors:

\[ q_0 = U^P((d_0^U - q_0^U) + \beta(p_A - p_0)) + U^{NP}(d_0^U + \beta(p_A - p_0)) - I^Pq_0^I \]

\textsuperscript{27}This can be easily tempered by restricting the Period 0 demands of informed investors which governs the aftermarket trades to essentially alter the risk bearing capacity of the market similar to a change in the relative proportions of informed to uninformed investors.

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such that

\[ p_A = p_0 + \frac{2q_0 - Ud_A^U}{U\beta} \]

In Period 1, following the poor first period IPO performance, the uninformed feedback traders sell IPO shares to informed investors who anticipate, correctly, the subsequent overperformance:

\[ q_0 + s_0 = U(d_A^U + \beta(p_1 - p_A)) + Id_1^I + d_1^{SI} \]

where

\[ p_1 = p_A + \frac{q_0 + s_0 - Id_1^I - Ud_A^U - d_1^{SI}}{U\beta} \]

3. \{HH\}

In Period A, investors of both types enter the immediate aftermarket to satisfy initial period demands and find no sellers:

\[ q_0 = U^P((d_0^U - q_0^U) + \beta(p_A - p_0)) + U^{NP}(d_0^U + \beta(p_A - p_0)) + I^P(d_0^I - q_0^I) + I^{NP}(d_0^I) \]

such that

\[ p_A = p_0 + \frac{2q_0 - Ud_A^I - Ud_0^U}{U\beta} \]

In Period 1, again all investors desire to buy shares. Because the buyers outnumber the sellers, there is ‘accumulation’ or upward pressure on prices:

\[ q_0 + s_0 = U(d_A^U + \beta(p_1 - p_A)) + Id_1^I + d_1^{SI} \]

where

\[ p_1 = p_A + \frac{q_0 + s_0 - Id_1^I - Ud_A^U - d_1^{SI}}{U\beta} \]

4. \{HL\}

In Period A, informed investors attempt to satisfy Period 0 demands and informed, Period A demands. The immediate aftermarket price adjusts upward to equate the supply of and demand for shares:

\[ q_0 = U^P((d_0^U - q_0^U) + \beta(p_A - p_0)) + U^{NP}(d_0^U + \beta(p_A - p_0)) + I^P(d_0^I - q_0^I) + I^{NP}(d_0^I) \]

such that
\[ p_A = p_0 + \frac{2q_0 - Id_0^U - Ud_0^U}{U \beta} \]

In Period 1, the informed investors sell their shares to the uninformed:

\[ q_0 + s_0 = U(d_A^U + \beta(p_1 - p_A)) - Id_0^l - s_0^l \]

where

\[ p_1 = p_A + \frac{q_0 + s_0 - Id_0^l - Ud_0^U - s_0^l}{U \beta} \]

The most important implication of the model is the existence of strategic profit-taking by informed investors. Informed investors, using their private information and reliance on the noiseless signal, time the market, anticipating feedback trades by buying shares when they are cheap to hold, or resell to positive feedback traders. Positive feedback traders attempt to cut their losses after poor first period performances and ride out their first period gains. They lose on the IPOs which do not perform consistently. Both attempts at strategic profit-taking result in short term dynamics which the imposition of a buy and hold strategy ignores. A buy and hold strategy is only relevant for informed investors in only one case, for \{HH\} type issues. For the uninformed investor, the buy and hold scenario surfaces in three cases: 1. when it is optimal, for issue types \{HH\}; 2. when there are liquidity problems in the market, for issue types \{LL\}; 3. and mistakenly when the uninformed trading strategy fails, for issue types \{HL\}.

Generating Cycles in Issuance

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Introducing a second consecutive issue in Period 0, just prior to Period 1 such that the aftermarket trading (termed Period A') of the second issue coincides with Period 1, as a third investment alternative further enriches the dynamics to include implications for the ‘timing’ of issues. This extension introduces the possibility of reduced liquidity in the new issues market. Consequently, the second issue could be withdrawn. These liquidity concerns can explain the ‘hot’ and ‘cold’ cycles in issuance studied in the literature. Under this extension, there are eight states of nature over the two issue types:

\[ S' = \{LL, L\}, \{LL, H\}, \{LH, L\}, \{LH, H\}, \{HH, L\}, \{HH, H\}, \{HL, L\}, \{HL, H\}\]

The second IPO is characterized by exactly the same asymmetric information situation as the first, except that the investment maturity is only one period which rules out the value of any second issue signal release (hence it is ignored). Non-preferential investors now in Period 1 can opt to include the second new issue in their portfolio of investments. Specifically, positive feedback traders view the second issue as a second chance for glory, such that if their first IPO performs poorly, they will dump it and attempt to purchase the next issue.

Whereas, previously, investors faced liquidity problems—not being able to find buyers for poor performers and sellers for the truly good performers, in this two issue scenario, the first issue liquidity problems will be compounded for the second issue.\(^28\) Uninformed investors will similarly face liquidity problems when they try to dump poor first period performers which informed investors will anticipate

\(^{28}\) This extension is somewhat simplified as we have assumed there is no additional income arriving at Period 1, other than from the previous profit taking, i.e., the investor’s endowment is assumed concentrated in Period 0.
to fail in the second period, such that the uninformed investors will not be able to fully invest in the second issue. Further, anticipating this, informed traders may not purchase shares of the bad second issue if they believe they will not be able to flip out of these shares in the aftermarket. The implication here is that liquidity in the market may be significantly tight as to cause issues to be withdrawn, i.e., there will be particular IPO types which it will not be profitable for IPOs of other types to follow in issue. This will generate cycles in issues, the so called ‘hot’ and ‘cold’ periods:

1. Following a poor first period performing IPO, \{LH\}, uninformed investors will dump the first issue shares to informed investors and queue for second issue shares. Informed investors will queue for the second issue unconditionally if the second issue is type \{H\}, and only for the \{L\} type if they believe they will be able to flip these shares in the immediate aftermarket.

2. In contrast, following a \{LL\} first issue, uninformed investors will not be able to flip their shares in the first period. Anticipating this liquidity restriction on the uninformed investors, informed investors will queue only for \{H\} second issue types.

3. Following an overperforming first issue, uninformed investors will want to split available liquidity between the new second issue and the second period performance of the first issue. However, if the first issue type is \{HH\}, they will not be able to purchase any more of the first issue shares, only the second if they have expendable wealth.

4. For the \{HL\} first issue type, uninformed investors can buy up the informed shares that are sold in Period 1, as well as, queueing for the second issue which the informed queue for unconditionally, if the second issue is of \{H\} type, and conditional on the anticipated liquidity of the uninformed traders, if the second issue is instead type \{L\}.

In summary, the second issue may be withdrawn: uninformed traders may be liquidity constrained; while, informed traders may not queue for the second issue if they perceive the uninformed trader's liquidity constraints to hinder their ability to flip shares in the second issue aftermarket. The appropriate question to ask at this point is, 'Is liquidity a pressing issue in the new issues market?' Recent evidence suggests, liquidity is important:

The least appealing deals to investors right now are small deals without lengthy histories. Investors say they want to be able to get in or out of stocks without excessively altering prices, but such liquidity is especially bad now. "The first thing investors are asking is 'is there a back door?' and then, 'is it a good idea?' . . . saying no to a lot of the [IPOs] that are right around $100 million [in total expected market value], because in this environment you don't want to own something that illiquid."29 (Emphasis mine.)

---

Liquidity in the IPO market has implications for the timing of issues. According to the model extension, following certain types of first period performers an issuer faces potential difficulty at the IPO, such that, depending on the quality of the second IPO, it may be to a firm's advantage to time the issue. If liquidity is indeed problematic, then what we should see in the IPO market is firms and underwriters timing their issuance of initial shares. So in fact, cycles in issue can be due to the anticipated liquidity problems or tightness in the market. To investigate the timing of issues, we use a regression framework to determine whether measures of investor sentiment and historical IPO performance records have historically influenced the frequency of new issue withdrawals.

We regress the number of monthly withdrawals on lagged proportions of underperforming previous issues, \( \frac{L}{L_{\text{Total}}} \), lagged levels of the S&P500 index, and the lagged, weighted closed-end fund index,\(^{30}\) CEFD\(_{-1,-2} \), to capture potential liquidity concerns following sustained high levels of the market. The closed-end fund discount proxies for investor sentiment. When investor sentiment is high investors enter the market such that we expect withdrawals to vary inversely with both the investor sentiment measure and with upward movements in the level of the S&P500 Composite Index.

\[
WDL_t = \alpha + \beta_1 \left( \frac{L}{L_{\text{Total}}} \right)_{t-1} + \beta_2 \left( \frac{L}{L_{\text{Total}}} \right)_{t-2} + \beta_3 CEFD_{t-1} + \beta_4 CEFD_{t-2} + \\
\beta_5 (\Delta S&P)_{t-1} + \beta_6 (\Delta S&P)_{t-2} + \varepsilon_t
\]

(4.16)

For the restricted interval, March 1978-December 1985,\(^{31}\) we regress the number of withdrawn issues per month on the lagged independent variables. Because the timing may be imprecise as IPOs can be in registration for months, in the second regression we included contemporaneous influences. Table 4.3 presents the results, where an asterisk denotes significance at the 95% confidence level. Interestingly, the change in the S&P 500 Composite Index does not prove influential in the frequency of withdrawn issues at any lag. However, the closed end fund discount measure and the past history of the proportion of poor performing issues do influence withdrawals and in the inverse relation we predicted. Also note how poorly the model explains the variation in withdrawals, obviously due to our omission of firm characteristics. We present in Figure 4.3, the frequency of successful and withdrawn IPOs with the average S&P500 Composite Index for each year.


\(^{31}\)The sample is dictated by the availability of the closed end fund discount data.
Table 4.3: Withdrawn Issues

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Coefficient (Standard Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>-1.579 (2.330)</td>
</tr>
<tr>
<td>( \frac{L}{L+H} )</td>
<td>-3.636 (1.866)</td>
</tr>
<tr>
<td>( \frac{L}{L+H}_{-1} )</td>
<td>-3.803* (1.846)</td>
</tr>
<tr>
<td>( \frac{L}{L+H}_{-2} )</td>
<td>-5.017* (1.714)</td>
</tr>
<tr>
<td>CEFD</td>
<td>-0.612* (0.262)</td>
</tr>
<tr>
<td>( CEFD_{-1} )</td>
<td>-0.703* (0.267)</td>
</tr>
<tr>
<td>( CEFD_{-2} )</td>
<td>-0.186 (0.268)</td>
</tr>
<tr>
<td>( \Delta S&amp;P )</td>
<td>-0.029 (0.118)</td>
</tr>
<tr>
<td>( \Delta S&amp;P_{-1} )</td>
<td>-0.009 (0.156)</td>
</tr>
<tr>
<td>( \Delta S&amp;P_{-2} )</td>
<td>-0.020 (0.121)</td>
</tr>
<tr>
<td>( \overline{R^2} )</td>
<td>0.386 0.315</td>
</tr>
</tbody>
</table>

Figure 4.3: Successful and Withdrawn Issues By Year
4.5 Expected Return on the IPO Investment

Upon modeling the behavior of investors in the new issues market, the puzzle at this point no longer persists if it can be shown that non-preferential uninformed investors expect to make positive returns in excess of the market. Expected returns to investors are a function of the beliefs held as to the likelihood of their receiving or not receiving shares at the offer price and the likely performance of the IPOs. While we do not require positive feedback traders to outperform rational traders, the minimum we require is that they are not consistently losing money.

Obviously, attempting to back out the actual return expectations of investors is a futile endeavor; however, we can determine the returns expected by the investors in our model, using their respective trading strategy and relevant information set. Informed investors fully anticipate taking advantage of the positive feedback traders, i.e., scooping preferential shares and flipping first period underperformers in the aftermarket; buying up poor first period underperformers which outperform in the second period; and selling to the uninformed investors issues that initially outperform only to underperform by the second period. The informed ‘expected’ average return relies on the informed investor’s expected transition matrix governing IPO performance and their probability of preferential status:

\[ ER^I\{IPO\} = \Pr(P)ER^I(P) + \Pr(NP)ER^I(NP) \]  \hspace{1cm} (4.17)

where the expected preferential return is calculated using the offer price for all shares received; the \{HH\} type issue is held to Period 2, the \{HL\} type is held until Period 1, the \{LL\} type is flipped in Period A, and the \{LH\} type is also flipped in Period A, but then subsequently purchased back cheaper in Period 1 (we suppress the IPO superscript on the return):

\[ ER^I(P) = \int\left[\Pr(HH)\tilde{r}_{02}(HH) + \Pr(HL)\tilde{r}_{01}(HL) + \Pr(LH)\tilde{r}_{0A}(LH)\right] + \Pr(LL)\tilde{r}_{0A}(LL) + \Pr(LH)\tilde{r}_{12}(LH)dr \]  \hspace{1cm} (4.18)

\[ ER^I(NP) = \int\left[\Pr(HH)\tilde{r}_{A2}(HH) + \Pr(HL)\tilde{r}_{A1}(HL) + \Pr(LH)\tilde{r}_{12}(LH)dr \right] \]  \hspace{1cm} (4.19)

The non-preferential expected return includes the expected returns from holding shares of \{HH\} bought in the aftermarket until Period 2, shares of \{HL\} bought in the aftermarket and sold in Period 1, and shares in \{LH\} bought at Period 1 and held to Period 2.

The uninformed expected average return relies on the historical transition matrixes over IPO types (i.e., last period’s probability matrix) and last issue year’s realized returns:

\[ ER^U\{IPO\} = \Pr(P)ER^U(P) + \Pr(NP)ER^U(NP) \]  \hspace{1cm} (4.20)
where the expected preferential returns arise from holding \{HH\} and \{HL\} shares from Period 0 to Period 1, \{LH\} shares held until Period 1, and \{LL\} shares held until Period 2:

\[ ER^U(P) = P_{r(L)}(L-1)r_{01}(L-1) + P_{r(H)}(H-1)r_{01}(H-1)) + P_{r(L|H)}(H-1)r_{12}(HL-1) + \\
+ P_{r(H|H)}(H-1)r_{12}(HH-1) + P_{r(L|L)}(L-1)r_{12}(LL-1) \]  

(4.21)

The non-preferential expected return arise from holding shares purchased in the immediate aftermarket is represented as:

\[ ER^U(NP) = U_{r(L)}(L-1)r_{A1}(L-1) + U_{r(H)}(H-1)r_{A1}(H-1) + U_{r(L|H)}(H-1)r_{12}(HL-1) + \\
+ U_{r(H|H)}(HH-1)r_{12}(HH-1) + U_{r(L|L)}(L-1)r_{12}(LL-1) \]  

(4.22)

For uninformed positive feedback traders to participate in this market, at a minimum we require only that they expect to make on average non-negative excess returns over the market:

\[ ER^U\{IPO\} - ER^U\{M\} \geq 0 \]

We are interested in backing out these 'expected' return implications of our model from the historical data. We use data on IPOs issued during the years 1975-1990, inclusively (See Appendix A for description and source of data.) For the purpose of exploring the above model implications, we choose the interval [A,1] to be the first year aftermarket and [1, 2] to be the second year. Using monthly returns, we calculate annual compound returns for each issue, by issue year. Next we discretize the state space for new issues, by year of issue. The transition probabilities are determined by considering the probability that the first year and second year annual return exceeds or falls short of the relevant market annual return. We do this twice, first using the offer price in the first month return calculation and then secondly, omitting the offer price, using instead the first available aftermarket price in the calculation of the first month return. The probability of underperformance increases dramatically as we omit the offer price from the first month return calculation, See Figures 4.4 and 4.5. Second, the probability of underperformance increases in the second year, excluding the offer price, see Figure 4.5.
Having discretized the state space, we back out the Markov transition matrix for each issue year. See Appendix A.4 for year by year matrices. The average of the transition matrixes is presented in Table 4.4.
Table 4.4: Average Transition Matrix

<table>
<thead>
<tr>
<th></th>
<th>L</th>
<th>H</th>
<th></th>
<th>L</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period 1</td>
<td>L</td>
<td>0.169</td>
<td>0.054</td>
<td>Period 2</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>0.477</td>
<td>0.316</td>
<td></td>
<td>H</td>
</tr>
</tbody>
</table>

Figures A.18-25 in Appendix A.2 depict the first, second, and two year annual return performance of issues relative to the issue year average and the market average. It is interesting to notice the difference in type likelihood, conditional on preferential status, i.e., preferential offer types, in order of greatest likelihood, we find on average are \([\{HL\}, \{HH\}, \{LL\}, \{LH\}\] and for non-preferential offer types, the likelihoods change to \([\{LL\}, \{HL\}, \{LH\}, \{HH\}\] in agreement with the underperformance results.

**Empirical Return Performance by Trading Strategy**

Using the historical return performance and transition matrixes, we calculate the expected preferential and non-preferential returns for informed and uninformed traders. For informed rational investors we use the actual realized returns and the true transition probabilities; whereas, for the uninformed positive feedback traders we use the prior period historical returns and the previous period’s historical transition matrix. Furthermore, recall that the uninformed traders in comparing their expected return to the expected return on the market, use simply last year’s market return.

We find the positive feedback traders to be excessively overoptimistic. Figure 4.6 shows the preferential and non-preferential ‘expected’ returns for the positive feedback traders. Both returns are significantly above the anticipated market returns, which agrees with their participation in this market.\(^{32}\) Informed, rational investors, however, expect to systematically outperform the market only if they have preferential status.\(^{33}\)

---

\(^{32}\) Had it been the case in Figure 4.6 that the non-preferential feedback returns did not strictly dominate the market returns, we would still be left with explaining this segment’s participation in the new issues market. At this point, we would question the relevance of the market as the appropriate benchmark for the investor.

\(^{33}\) Keep in mind that these calculated ‘expected returns’ overstate the confidence of investors as we do not impose any liquidity constraints on trades, i.e., these returns are not necessarily obtainable and yet, these returns can also underestimate confidence as our model and calculation procedure allows for only one point in time trades, in contrast to what we might believe characterizes the market. These assumptions, however, are required for tractable return calculation.
Figure 4.6: Two Yr. Feedback Versus Market Return

Figure 4.7: Two Yr. Informed Versus Market Return

Portfolio Rebalancing versus Buy and Hold
Empirically how would the traders have fared investing in the IPOs with the respective strategies versus buying and holding? Recalling our expected return formulation, the two year buy and hold strategy
incurs the losses from holding the \{ LH \} IPO in period one and the \{ HL \} in the second, with probabilities, \text{Pr}(HL) and \text{Pr}(LH), respectively, as determined by the informed and uninformed investors.

Feedback traders' expected returns differ from the expected buy and hold returns by the fact that these uninformed traders flip their \{ LH \} shares in the first period and the fact that the sum of the first year unconditional expected return plus the second year conditional expected return does not equal the unconditional two year expected return. The uninformed expected buy and hold returns for preferential and non-preferential status are given by:

\[
ER^{U,B&H}(P) = Pr^U(LL)_{-1}r_{02}(LL_{-1}) + Pr^U(LH)_{-1}r_{02}(LH_{-1}) + Pr^U(HH)_{-1}r_{02}(HH_{-1}) + Pr^U(HL)_{-1}r_{02}(HL_{-1})
\]

\[
ER^{U,B&H}(NP) = Pr^U(LL)_{-1}r_{A2}(LL_{-1}) + Pr^U(LH)_{-1}r_{A2}(LH_{-1}) + Pr^U(HH)_{-1}r_{A2}(HH_{-1}) + Pr^U(HL)_{-1}r_{A2}(HL_{-1})
\]

Interestingly, the uninformed feedback returns dominate the buy and hold returns, as shown in Figure 4.8.

![Figure 4.8: Feedback Versus Buy & Hold Return](image)

For informed traders, the relevant expected returns are provided in Equations 4.18 or 4.19, with the
informed expected returns from a buy and hold strategy described by:

\[
ER^{I,BkH}(P) = Pr^U(LL)_{-1}\sigma_{02}(LL_{-1}) + Pr^U(LH)_{-1}\sigma_{02}(LH_{-1}) + Pr^U(HH)_{-1}\sigma_{02}(HH_{-1}) + Pr^U(HL)_{-1}\sigma_{02}(HL_{-1})
\]

(4.25)

\[
ER^{I,BkH}(NP) = [Pr^U(LL)_{-1}r_{A2}(LL_{-1}) + Pr^U(LH)_{-1}r_{A2}(LH_{-1}) + Pr^U(HH)_{-1}r_{A2}(HH_{-1}) + Pr^U(HL)_{-1}r_{A2}(HL_{-1})
\]

(4.26)

and graphically depicted in Figure 4.9.

![Figure 4.9: Informed Versus Buy & Hold Return](image)

The informed preferential investors expect to outperform a preferential buy and hold strategy, while the non-preferential informed strategy underperforms, on average, the buy and hold strategy. The gain to informed traders from rebalancing their portfolio diminishes without preferential status.

We can ask: What probability is required for investors to equate expected average market return with the expected average IPO return? For uninformed investors, they believe with probability one that they will outperform the market regardless of status. The informed traders' probability requirement to match the market return is lower than the probabilities required for buy and hold traders. We depict
these probabilities in Figure 4.10, where only true probabilities, between [0,1], are shown.

Figure 4.10: Required Preferential Probability

The positive feedback traders prove exceedingly confident they will reap positive returns in excess of the market and the buy and hold strategy. They require only a very small probability belief to receive offer shares, which is in accord with entry of non-preferential uniformed traders into the new issues market. The actual realized returns, however, fall short of this optimism.

4.6 Conclusion

Motivated by survey results and discussions in the popular press, we model investor behavior in the initial public offering market. We loosen the buy and hold restriction on investors and include positive feedback traders in the market. Within this framework, it is the overconfidence of uninformed investors and the anticipation of their behavior by informed traders which enables us to understand investor participation in the new issues market. Our model is consistent with short run underpricing and cycles in issue. The existence of significant short run profit taking, calls into question the validity of applying long run performance studies to a market with at best an asset viewed only conditionally as a long run investment vehicle. Such short run dynamics are ignored in the standard long horizon performance studies, leading to a downward bias in the return performance. We demonstrate that although the historical transition matrix for IPO types supports long run underperformance, the positive feedback or uninformed traders still expect to outperform the market, warranting their participation in the market.
Appendix A

Data

Data for issues 1975-1984, inclusive, was provided by Jay Ritter. The Securities Data Company provided the data for years 1985-1990. The sample consists of the 4,929 initial public offerings during 1975-1990 which meet the following criteria (set by Ritter and maintained in the later years): 1. an offer price of $1.00 per share or more; 2. gross proceeds, measured in terms of 1984 purchasing power, of $1,000,000 or more; 3. the offering involved common stock only, i.e., unit offers are excluded; 4. the company is listed on the CRSP daily AMEX-NYSE or NASDAQ tapes within 6 months of the offer date; and, 5. an investment banker took the company public. Managed subscription offerings, Real Estate Investment Trusts (REITs), American Depository Receipts (ADRs), and bond offerings with ‘equity kickers’ are excluded. This sample represents 87% of the total population and 96% of the aggregate gross proceeds.

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<thead>
<tr>
<th>Issue Year</th>
<th>Number of IPOs</th>
<th>Offer Annual Returns</th>
<th>Annual Returns</th>
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<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
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<tr>
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<td>1.247</td>
<td>3.810</td>
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<tr>
<td>1976</td>
<td>26</td>
<td>0.712</td>
<td>6.747</td>
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<td>1977</td>
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<td>0.746</td>
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<tr>
<td>1978</td>
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<td>4.875</td>
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<tr>
<td>1979</td>
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<td>0.197</td>
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<tr>
<td>1980</td>
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<tr>
<td>1981</td>
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<tr>
<td>1983</td>
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<tr>
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<td>0.136</td>
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<tr>
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<td>0.135</td>
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<tr>
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<td>1988</td>
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<tr>
<td>1989</td>
<td>222</td>
<td>0.261</td>
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<tr>
<td>1990</td>
<td>187</td>
<td>0.255</td>
<td>15.906</td>
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Table A.1 Descriptive Statistics
A.1 Issue Year Return Distributions

Figures A.1-17 depict the return distributions for issue years 1975-1990, where returns are calculated for the one, two, three, and five year horizon.

Figure A.1

Figure A.2

Figure A.3
A.2 Discretized Return Distributions

Figure A.18 First Year Offer Return Performance
Figure A.20 Second Year Annual Offer Performance
Figure A.21 Second Year Annual Performance

Figure A.22 Second Year Offer Return Performance
Figure A.23 Second Year Return: Performance

Figure A.24 Two Year Offer Return Performance
A.3 Conditional Return Distributions

Figures A.26-41 depict the conditional distributions for each issue year.
Figure A.40

Figure A.41
### A.4 Annual Transition Matrixes

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<th>Non-Offer</th>
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Table A.2 Transition Matrixes by Year
Bibliography


