WP/02/3

IMF Working Paper

Currency Crises and Uncertainty About Fundamentals

Alessandro Prati and Massimo Sbracia

INTERNATIONAL MONETARY FUND

 WP/02/3

IMF Working Paper

Research Department

Currency Crises and Uncertainty About Fundamentals

Prepared by Alessandro Prati and Massimo Sbracia[1]

Authorized for distribution by Miguel Savastano

January 2002

Abstract

This paper studies how uncertainty about fundamentals contributed to currency crises from both a theoretical and an empirical perspective. We find evidence—based on a monthly dataset of Consensus forecasts for six Asian countries in the period January 1995-May 2001—confirming the theoretical predictions (from both unique- and multiple-equilibria models) that: (i) speculative attacks depend not only on actual and expected fundamentals but also on the variance of speculators' expectations about them; and (ii) the sign of the effect of the variance depends on whether expected fundamentals are "good" or "bad." These results are robust to the definition of exchange rate pressure indices, the estimation sample (precrisis vs. full sample), the method chosen to avoid spurious correlations, and possible time-varying coefficients for the mean, the variance, and the threshold separating good from bad expected fundamentals.

JEL Classification Numbers: F31, D84, D82

Keywords: Speculative attack, exchange rate crisis, public and private information

Author's E-Mail Address: Aprati@imf.org

---

[1] IMF Research Department and the Bank of Italy. The authors thank Nikila Tarashev for helpful comments and Bianca Bucci, Rosanna Gattodoro, Alessandra Liccardi, and Giovanna Poggi for valuable research assistance. The views expressed in the paper are those of the authors and do not necessarily reflect those of the IMF or the Bank of Italy.

Contents Page

I. Introduction

Whether uncertainty about fundamentals plays a role in currency crises is an issue that has important implications for both the theoretical and empirical literature in international finance. The matter is also critical for policy purposes. If, for example, uncertainty about fundamentals increases the probability of a speculative attack, then exchange rate regimes will be more vulnerable in periods of higher uncertainty and policymakers should adjust their policies accordingly. Moreover, to the extent that public authorities control–at least in part–the precision of information about fundamentals, a relevant role of uncertainty in currency crises may have consequences for the optimal degree of transparency and the formulation of disclosure policies, as well as the timeliness of data releases.

In this paper, we study the effect of uncertainty about fundamentals with a dataset that includes forecasts of key macro variables for six Asian countries collected by Consensus Economics. Figures 1 and 2 show that, during the Asian crisis, not only expected GDP growth deteriorated but also the growth outlook became more uncertain, with a large increase in the dispersion of forecasts.[2] The question we address is whether the increase in uncertainty shown in Figure 2 played a role in determining exchange rate pressures that is additional to the deterioration of the mean of expected fundamentals shown in Figure 1.

Whereas almost no empirical paper on currency crises has made uncertainty about fundamentals its central focus, several papers have developed theoretical models in which the variance of fundamentals plays a role. In stochastic "first-generation" models of currency crises, for example, the variance of fundamentals has an effect on the probability of a speculative attack at each point in time (Flood and Garber (1984)). In this class of models, greater uncertainty about fundamentals tends to increase the probability of a speculative attack as long as certain conditions are satisfied.[3] In a recent paper, Flood and Marion (2000) extend Flood and Garber model to show that an increase in the expected post-attack variance of the exchange rate may lead the economy into an attack equilibrium even if the first moment of fundamentals is consistent with a no-attack equilibrium. In the related literature on stochastic target zone models, Dumas and Svensson

[2]The shaded area marks the period from July 1997 to the end of 1998, which includes the Asian crisis, the Russian crisis, and the near-collapse of the hedge fund Long Term Capital Management. The evolution over time of the mean and variance of other macro forecasts in the Consensus dataset is similar to that of GDP.

[3]In Goldberg (1991), domestic credit growth follows a random walk process with errors distributed as a displaced exponential with zero mean; as long as the variance of the errors does not exceed an upper bound, greater uncertainty increases the probability of an attack. In counterfactual simulations, Goldberg (1994) finds, however, that a higher variance of domestic credit growth would have *reduced* the probability of an attack in Mexico between 1980 and 1986. In Grilli (1986), fundamentals follow an AR(1) process with normal errors; as long as fundamentals are "good," the effect of the variance on the probability of an attack is positive, but with sufficiently "bad" fundamentals it may become negative.

(1994) show that the higher is the variance of the fundamentals the shorter is the expected survival time of a target zone. Similarly, Bartolini and Prati (1999) find that the benefits of soft exchange rate bands decline as the variance of fundamentals increases.

"Second-generation" models of currency crises have paid less attention to the role of uncertainty about fundamentals. These models are usually complete information models in which only the mean of the fundamentals matters (see, for example, Obstfeld (1996)). In a second-generation model of currency crises with incomplete information, Sbracia and Zaghini (2001) show that an increase in the variance of public information about fundamentals can make a unique equilibrium with a speculative attack prevail in a range of parameters in which, for lower levels of variance, there would be multiple equilibria.

Following Morris and Shin (1998), several papers have recently considered models with incomplete public *and* private information about fundamentals. These models would be characterized by multiple equilibria with complete information, but a unique equilibrium emerges whenever the private signal about the state of fundamentals is sufficiently precise relative to the public signal. Nevertheless, "coordination failures" still characterize this unique equilibrium because the entire structure of beliefs (including the precision of public and private information), and not only the level of fundamentals, determines whether an attack or a no-attack equilibrium prevails. This means that, even though there is a unique equilibrium, exchange rate pegs could collapse for values of the fundamentals that would have been consistent with the peg if only fewer speculators had attacked the currency. In this class of models, the presence of private information generates empirically-plausible equilibria in which only a fraction of speculators attacks the currency with or without success. By contrast, only equilibria in mixed strategies could have similar features in models with complete–or incomplete but only public–information. Finally, a unique equilibrium allows to perform rigorous comparative statics exercises that are not possible in multiple-equilibrium models à la Obstfeld (1994 and 1996).

Models à la Morris and Shin provide a natural framework for studying the role of uncertainty about fundamentals in currency crises, as they allow to consider the effect of changes in the precision of public or private information on the likelihood of a currency crisis. Heinemann and Illing (1999), using a model with a uniform distribution for noisy private signals, prove that an increase in the precision of private information reduces the likelihood of a currency crisis. Morris and Shin (1999) question, however, the robustness of this result and, in a somewhat different framework, find that greater precision of information does not always mitigate the coordination problem of speculators. Finally, Metz (2001) shows that the effect of changes in the variance of information on the decision rule of the government depends on the expected level of fundamentals and on whether it is the public or the private information precision that varies.

In the first part of the paper, we extend Metz's results in order to obtain predictions about the effects of the precision of public and private information on the share of speculators attacking the currency, which is the correct theoretical counterpart of the indices of exchange rate pressure that we use in the econometric analysis. We also show that a model with only public incomplete information–which yields either a unique or multiple equilibria–would support predictions on the effects of the mean and variance of public information that are consistent with those obtained in the more general model with both public and private information. Specifically, this model indicates that *also in the presence of multiple equilibria* the way in which uncertainty contributes to currency crises would depend on the expected level of fundamentals.

In the second part of the paper, we verify empirically whether uncertainty about fundamentals contributes to currency crises and whether this effect depends on the level of expected fundamentals, as the theory predicts. The previous empirical literature on exchange rate dynamics has not focused on uncertainty. Exceptions are Hodrik (1989)–who has unsuccessfully tried to use estimated conditional variances of money supply, industrial production, and consumer prices, to account for the dynamics of the forward exchange rate premium–and Kaminsky and Peruga (1990)–who have estimated a GARCH-in-Mean restricted VAR model . The prevailing empirical literature on currency crises, initiated by Eichengreen et al. (1996) and including, among others, Berg and Patillo (1998) and Kaminsky and Reinhart (1999), has also generally neglected the role of uncertainty about fundamentals. The focus on the role of uncertainty in currency crises distinguishes then our paper from this previous empirical literature. In addition, to explain exchange rate pressures, we also use forward-looking survey forecasts of fundamentals from Consensus Economics rather than only the current level of fundamentals. This paper also provides the first empirical test of models of currency crises à la Morris and Shin. Our results confirm the theoretical predictions that both the mean and the variance of GDP forecasts contribute to explain exchange rate pressures and that the effect of the variance depends on the level of expected fundamentals.

The paper is organized as follows. After introducing a benchmark model with complete information and multiple equilibria, Section II presents the main theoretical results for a model with incomplete public information (which yields either a unique or multiple equilibria) and for a model with incomplete public and private information (and a unique equilibrium). Section III derives the testable implications of the latter, relating its predictions to Consensus Economics' forecasts of fundamentals. Section IV presents the results of our estimates of exchange rate pressures in six Asian countries (Thailand, Korea, Indonesia, Malaysia, Singapore, and Hong Kong) for the period January 1995 - May 2001 for which Consensus Economics' forecast data are available. Section V concludes.

II. Theoretical Background

This section presents a simple formulation of a currency crisis game, that builds on Morris and Shin (1999) and Metz (2001). We start by considering a complete information model with multiple equilibria. We then allow for incomplete information. First, we assume that speculators receive public information and show that the model may entail either multiple equilibria or a unique equilibrium. Second, we suppose that both public and private information are available to speculators, and we characterize the unique equilibrium that emerges when private information is sufficiently precise.

Our incomplete information analysis focuses on the effects of changes in three key parameters: the mean of speculators' expectations about the fundamentals and the precisions of public and private information. Changes in the first two parameters tend to have comparable effects in the public information model (independently on the number of equilibria) and the unique-equilibrium framework with both public and private information. An improvement in the *mean* of speculators' expectations always makes a speculative attack less likely.[4] The effect of the *precision of public information* depends, instead, on the expected fundamental: when this is sufficiently good (bad), an increase in the precision of public information makes speculative attacks less (more) likely. The *precision of private information* has two distinct effects. On the one hand, the precision of private information *directly affects* the likelihood of an attack, since it is (inversely) related to the dispersion of speculators' private signals around the actual fundamental. On the other hand, private information *indirectly influences* the likelihood of an attack, as the ratio between the precision of public and private information represents the extent to which speculators expect their beliefs to be shared by the other speculators, thereby affecting their "degree of aggressiveness". We find that while these two effects have opposite consequences on the likelihood of an attack, the net effect of private information tend to be similar to that of public information, provided that actual and expected fundamentals are either both sufficiently good or both sufficiently bad; otherwise, the effect of private information precision turns out to be opposite to that of public information precision.

A. Complete Information Model

Let us consider a continuum of speculators in an economy characterized by a state of fundamentals θ that can take values over the real line $\Re$, with $\theta = +\infty$ corresponding to a situation of "sound fundamentals". We assume that public authorities ("the government") are pegging the exchange rate and that speculators decide whether to attack it. If a speculator attacks and the government abandons the peg, the speculator obtains $D - t$, with $D > t > 0$; when the attack is not successful, the speculator looses the transaction cost t. If speculators refrain from attacking, they get 0. The government's utility from defending the currency is increasing in the fundamental θ, and decreasing in the share of speculators that attack the currency, denoted by l. Specifically, we assume that the government gets $\theta - l$, when he maintains the peg and zero when he abandons it.

We consider a very simple two-stage game with complete information. In the first stage, speculators observe θ and simultaneously decide whether to attack the currency. In the second stage, the government–who knows θ–observes the share of speculators attacking the currency and decides whether to maintain the peg.

[4]In the unique-equilibrium model with both public and private information, comparative statics exercises predict the likelihood of a speculative attack. In the model with only public information, which may yield multiple equilibria, we refer to the likelihood of an attack more loosely to indicate–as it is common in the literature on speculative attacks–that the *range of parameters* in which an attack takes place has either widened or shrunk.

This game can be solved backward, by finding the government's optimal strategy, which is simply the function:[5]

$$\psi(\theta, l) = \begin{cases} \textit{abandon}, \text{ if } \theta \leq l \\ \textit{defend}, \text{ otherwise} \end{cases} .$$

Given ψ, the solution of the reduced-form game of speculators provides the tripartition of the space of fundamentals that characterizes second generation models of currency crises. Specifically, if the fundamental θ lies in:[6]

- $(-\infty, 0] \Longrightarrow$ there is a unique equilibrium: all agents attack the currency and the government devalues.
- $(0, 1] \Longrightarrow$ there are multiple equilibria: agents can either attack the currency (and force a devaluation) or refrain from attacking (and allow the peg to be maintained);
- $(1, +\infty) \Longrightarrow$ there is a unique equilibrium: all agents refrain from attacking and the government maintains the peg.

Hence, outside the interval $(0, 1]$, maintaining the currency peg is solely a function of the fundamental θ. By contrast, when θ falls in $(0, 1]$ the outcome depends on which (self-fulfilling) equilibrium speculators coordinate. If speculators expect the currency peg to fail, they attack the currency and force the government to devalue. If they expect the peg to hold, they do not attack the currency and allow the government to maintain the peg. This feature of the game is shared also by the incomplete information model that we present in the following Section, at least for some speculators' beliefs.

B. Incomplete Public Information

Let us assume that speculators do not know the fundamental θ, but only have expectations about it, in the form of a normal probability distribution with mean y and variance $1/\alpha$ (with $\alpha > 0$)–denoted by Θ. Note that the complete information model can be obtained as a special case, for $\alpha = +\infty$. Since Θ is common knowledge to all speculators, this probability distribution represents the public information available to them. Thus, we will refer to α as the "precision of public information".

In this paper, we do not use the term *public information* as a synonym of *official* information (i.e., information provided by the authorities of a country or by other national or international bodies) but as the opposite of *private information.* Public information consists of signals on the level of fundamentals which are common (publicly observable) to all agents,

[5]We assume–without altering the analysis–that the government chooses to abandon the peg when he is indifferent.

[6]Hereafter we restrict our attention to pure strategies.

whereas private information differs from one agent to the other. In this framework, an increase in the variance of the distribution of public information does *not* necessarily reflect noisier official information but it could be due to greater uncertainty–common to all agents–about the economic outlook.[7] Virtually any event which is publicly observable and affects economic fundamentals–including a currency crisis elsewhere or rumors of political troubles–could be classified under that label. The crisis in Thailand, for example, may have made the growth outlook of other Asian countries equally more uncertain for all agents. At the same time, uncertainty about the policies that each country would have followed in the midst of the crisis may well have contributed to the overall uncertainty. In this paper, we do not distinguish between these two sources of uncertainty, which would both affect the precision of public information. An implication of this approach is that, differently from Morris and Shin (2000), we do not perform any welfare analysis on the provision of public information.

As the government knows θ and observes l, his optimal strategy is the same function ψ of the complete information model. Therefore, if θ falls in $(-\infty, 0]$ the government devalues the currency, whilst if θ falls in $(1, +\infty)$ the government maintains the peg. When θ belongs to $(0, 1]$, speculators' expectations will determine the outcome of the game.

Given ψ, we can focus on the reduced-form game of speculators. We need to calculate the expected payoff of a speculator who attacks the currency, when all other speculators also attack–denoted by $u(a_i, a_{-i})$ –, and the expected payoff of a speculator who attacks the currency when all other speculators do not attack–denoted by $u(a_i, d_{-i})$. Analytically these expected payoffs are given by:

$$
\begin{aligned}
u(a_i, a_{-i}) &= \int_{-\infty}^{1} (D - t)\,\eta(\theta)d\theta - \int_{1}^{+\infty} t\eta(\theta)d\theta \\
u(a_i, d_{-i}) &= \int_{-\infty}^{0} (D - t)\,\eta(\theta)d\theta - \int_{0}^{+\infty} t\eta(\theta)d\theta
\end{aligned}
$$

where η is the probability density function of Θ. The following proposition specifies the equilibria of the reduced-form game of speculators:

Proposition 1 *The ("attack") strategy profile in which all agents attack the currency is an equilibrium iff* $u(a_i, a_{-i}) \geq 0$. *The ("don't-attack") strategy profile in which all agents refrain from attacking is an equilibrium iff* $u(a_i, d_{-i}) \leq 0$.

---

[7]The sharp increase in the dispersion of GDP forecasts in the aftermath of currency crises documented in Figure 2 may reflect an increase in "model uncertainty" (i.e., an increase of the uncertainty about the "true" model of Asian economies), as defined by Routledge and Zin (2001). In the theoretical framework of our paper, an increase in model uncertainty may translate into a higher variance of public or private information depending on whether uncertainty increased in a similar or different way across agents.

Being always $u(a_i, a_{-i}) \geq u(a_i, d_{-i})$, the "attack," the "don't-attack," or both strategy profiles are equilibria of this game. Let us rewrite the two expected payoffs as:

$$\begin{aligned} u(a_i, a_{-i}) &= D \cdot \Phi\left[\sqrt{\alpha}\,(1-y)\right] - t \\ u(a_i, d_{-i}) &= D \cdot \Phi\left(-\sqrt{\alpha} y\right) - t\,, \end{aligned} \tag{1}$$

where Φ is the cumulative distribution function of a standard normal distribution. By rearranging those expressions, we obtain a necessary and sufficient condition for the attack and the don't attack strategy profiles being both equilibria of this game; namely:

$$y \in \left[-\frac{\Phi^{-1}(t/D)}{\sqrt{\alpha}}, 1 - \frac{\Phi^{-1}(t/D)}{\sqrt{\alpha}}\right]. \tag{2}$$

Therefore, this incomplete information model may have multiple equilibria or a unique equilibrium depending on whether condition (2) is or is not fulfilled.[8] We can now examine the effects of y and α on both the attack and the don't attack strategy profiles, irrespectively of the number of equilibria. These effects are summarized by the following proposition (see Appendix A.1):

Proposition 2 *(i) Both $u(a_i, a_{-i})$ and $u(a_i, d_{-i})$ are decreasing in y. (ii) $u(a_i, a_{-i})$ is decreasing (increasing) in α if $y > 1$ ($y < 1$). (iii) $u(a_i, d_{-i})$ is decreasing (increasing) in α if $y > 0$ ($y < 0$).*

An increase in y, by reducing $u(a_i, a_{-i})$ and $u(a_i, d_{-i})$, shrinks the range of parameter values for which the attack strategy profile is an equilibrium and enlarges the range of parameter values for which the don't-attack strategy profile is an equilibrium. In other words, an improvement in the expected fundamental always makes it less likely that the attack strategy profile is an equilibrium and more likely that the don't attack strategy profile is an equilibrium.

Proposition 2 also states that the effect of the precision of the public signal, α, depends on the expected fundamental y. Specifically, if α increases and expected fundamentals are sufficiently good (bad), it becomes less (more) likely that the attack strategy profile is an equilibrium and more (less) likely that the don't attack strategy profile is an equilibrium. In order to understand this dependence of the effect of α on the mean y, recall that an increase in α makes speculators more confident that the fundamental θ is in a neighborhood of y. Therefore, when y is sufficiently good, the increase in α makes all speculators more confident that the peg will hold, dampening their willingness to attack. Conversely, when y is sufficiently bad, more precise public signals

[8] Note that, given D, t, and y, changes in α (i.e. changes in speculators' uncertainty about θ) may produce a *shift* from a model with multiple equilibria to a model with a unique equilibrium. Hence, one can find examples in which modifications in uncertainty trigger a speculative attack, even if the mean of speculators' expectations y does not change. This feature of currency crisis games is further analyzed in Sbracia and Zaghini (2001).

strengthen speculators' belief that the exchange rate will depreciate, driving them to attack the currency peg.[9]

In the next section, we examine a more general game in which speculators also hold private information, under a condition which grants that a unique equilibrium exists. Despite the differences in the number of equilibria and in the information structure, we find that public information has the same effects of the incomplete information game considered in this section.

C. Incomplete Public and Private Information

Suppose that each speculator i has expectations about θ given by the probability distribution Θ and receives a private signal x_i drawn from the following normal distribution

$$X_i \mid \theta \sim Norm(\theta, 1/\beta) \,,$$

with $\beta > 0$, X_i and X_j independent given θ for each $i \neq j$. Note that by setting $\beta = 0$ we get back to the public information model, while the complete information model obtains with either $\alpha = +\infty$ or $\beta = +\infty$ (or both).

Private information in economic models may arise from a variety of sources. In general, a noisy private signal may represent discrepancies in how public information is interpreted by different speculators (on this point, see Morris and Shin, 1998). Heterogeneity in speculators' information sets may also be produced by costs of information acquisition. On exchange rate markets, international banks may gather valuable private information from monitoring the activity of their customers.

If private information is sufficiently precise with respect to public information, this model entails a unique equilibrium. As first shown by Carlsson and van Damme (1993), this result is driven by the lack of common knowledge induced by the presence of private information. The mechanism leading to a unique equilibrium can be explained using the *infection argument*, as in Morris et al. (1995). Suppose that a speculator is known to take a certain action at some (private) information set. This knowledge might imply a unique best response by the other speculators at some of their information sets where the first information set is thought possible. This, in turn, may imply that the original speculator responds to that knowledge choosing that same action at a larger information set, and so on. In the currency crisis game, if private information is sufficiently precise, this chain of reasoning results in a unique action profile, eliciting a unique equilibrium.[10]

[9]Note also that for intermediate values of y ($0 < y < 1$), if α increases, there is a widening of the range of parameters in which both the attack and the don't attack strategy profiles are equilibria of the game.

[10]Using a somewhat different framework, Chan and Chiu (2001) show that if the complete information game does not include both regions characterized by a unique equilibrium, than private information may not select a unique equilibrium. In other words, for the unique-equilibrium result it is also crucial that there is a non-negative probability that θ belongs to $(-\infty, 0)$ and to $(1, +\infty)$. This condition is fulfilled when we assume normal distributions.

A sufficient condition for this mechanism to select a unique equilibrium is:

$$\beta > \frac{\alpha^2}{2\pi}. \tag{3}$$

The intuition for this condition is straightforward. If private signals were not sufficiently informative with respect to the public signal, speculators would regard them as unreliable and continue to ground their decisions mostly on public information, restoring a high degree of common knowledge. Under condition (3), the following proposition holds (see Appendix A.2):

Proposition 3 (Morris and Shin, 1999; Metz, 2001) *If $\beta > \frac{\alpha^2}{2\pi}$, there exists a unique equilibrium, consisting of a unique value of the private signal x^* (such that each speculator receiving a signal lower than x^* attacks the currency peg) and a unique level of the fundamentals θ^* (such that the government abandons the peg when fundamentals are lower than θ^*).*

It is easy to verify that $\theta^* \in [0,1]$. As a consequence of the unique equilibrium result, the maintenance of the currency peg solely depends on the actual fundamental θ. However, speculators' expectations still matter, as they determine the equilibrium trigger points θ^* and x^*. Note also that the existence of a unique equilibrium does not eliminate all the "inefficiencies" of the model: when $\theta^* \in (0,1)$ we can still have currency crises (for $0 < \theta < \theta^*$) that could have been avoided with a different information structure and speculators coordinating on a good equilibrium.

The presence of a unique equilibrium allows for rigorous comparative statics. Instead of calculating the effects on the range of parameters for which two strategy profiles are equilibria of the game (see Section II.B), within this model we can simply analyze the effect of y, α, and β *on the unique equilibrium*. Specifically, by assuming that condition (3) holds–so that the existence of unique values for θ^* and x^* is granted–we can study the effects of the parameters y, α, and β on θ^* and x^*. In addition, we can calculate the effects of the parameters on the probability that speculator i attacks, $\Pr(X_i \leq x^* \mid \theta)$, which also represents *the share of speculators attacking the currency* and, therefore, has an empirical counterpart in indices of exchange rate pressure. Given the assumptions on Θ and $X_i \mid \theta$, we find that the share of speculators attacking the currency varies continuously with the parameter values. Indeed, this is a distinguishing feature of models with private information that is not shared by complete information models or models with only public information which are, instead, characterized by equilibria in which either all speculators attack or nobody attacks.[11]

---

[11] An exception is given by equilibria in mixed strategies that–in both complete and public information models–could give rise to shares of speculators attacking the currency that are neither zero nor one.

Expectation effects on the equilibrium

In line with Proposition 2, we can show that both θ^* and x^* are decreasing in y and that the effect of the precision of public information depends on the expected fundamental: if y is sufficiently good (bad), then an increase in α makes θ^* and x^* to decrease (increase). Moreover, we prove that an increase in the precision of public information β has the reverse effect, making θ^* and x^* to increase (decrease) when y is sufficiently good (bad).

The three conditions for α to reduce θ^* and x^*, for β to raise θ^*, and for β to raise x^* respectively are:

$$y > \theta^* - \frac{1}{2\sqrt{\alpha+\beta}}\Phi^{-1}\left(\frac{t}{D}\right) \equiv s_1 \tag{4}$$

$$y > \theta^* - \frac{1}{\sqrt{\alpha+\beta}}\Phi^{-1}\left(\frac{t}{D}\right) \equiv s_2 \tag{5}$$

$$y > \theta^* - \frac{\alpha^2\phi - 2\sqrt{\beta}\alpha - \left(\sqrt{\beta}\right)^3}{\alpha\sqrt{(\alpha+\beta)}\left(\alpha\phi - \beta\phi - 2\sqrt{\beta}\right)}\Phi^{-1}\left(\frac{t}{D}\right) \equiv s_3. \tag{6}$$

More precisely, the effects of expectations on the trigger point of the government, θ^*, can be summarized by the following result by Metz (2001):

Proposition 4 (Metz, 2001) *Assume that $\beta > \frac{\alpha^2}{2\pi}$. Then θ^* is: (i) decreasing in y; (ii) decreasing (increasing) in α if $y > s_1$ ($y < s_1$); (iii) increasing (decreasing) in β if $y > s_2$ ($y < s_2$).*

The effects of the parameters on the decision rule of speculators (i.e. on the trigger point x^*), which are crucial to obtain the results on the share of attackers presented in the next Section, are given by the following proposition (see Appendix III):

Proposition 5 *Assume that $\beta > \frac{\alpha^2}{2\pi}$. Then x^* is: (i) decreasing in y; (ii) decreasing (increasing) in α if $y > s_1$ ($y < s_1$); (iii) increasing (decreasing) in β if $y > s_3$ ($y < s_3$).*

The effects of the parameters on θ^* and x^* are essentially the same.[12] The most striking result from these propositions concerns the opposite effects of α and β. Key to this result is the role of *coordination* in currency crisis games. In deciding whether to attack the currency, speculators need to consider not only their expectations about fundamentals, but also what other

[12]Note, in particular, that if $D = 2t$, then the conditions (4), (5) and (6) coincide.

speculators expect about fundamentals, what other speculators expect about others' expectations about fundamentals, and so on. These expectations depend on the parameters α and β, which can assume values that either strengthen or dampen the beliefs of each individual on the other speculators' decision to attack the currency. If a speculator, for example, expects other speculators to have similar beliefs, he will be more confident in his beliefs and more willing to base the decision of attacking the currency on them. In other words, when a speculator thinks that his beliefs are shared, he will be more willing to act on them.

These beliefs on others' beliefs depend on the ratio between the precision of the two signals, $\frac{\alpha}{\beta}$, because this ratio determines the weights in the posterior beliefs given to public and private information and, in turn, the extent to which individuals can expect their beliefs to be shared. When speculator i receives a message x_i, in fact, his expected fundamental is

$$f_i^e(x_i) = E[\Theta \mid x_i] = \frac{\alpha y + \beta x_i}{\alpha + \beta}\,. \tag{7}$$

Suppose that y is sufficiently high (i.e., conditions (4)-(6) hold) so that speculators will on average expect "good" fundamentals. In this situation, if the precision ratio $\frac{\alpha}{\beta}$ is also high, speculators know that all other speculators have formed their expectation giving a large weight to the "good" public signal y and will be less willing to attack the currency. As a result, speculators will be less aggressive than in a situation in which $\frac{\alpha}{\beta}$ is low. In the latter case, speculators will be more willing to rely on their belief because they know that the other speculators will be forming their expectations giving a large weight to their random private signals. In other words, coordination on a "good" public signal is more difficult when the random component x_i in each individual expectation has a large weight. When y is low, the same reasoning applies; however, in this case, a relatively precise private information helps the government by making it more difficult for speculators to coordinate on attacking the currency.[13]

Expectation effects on the share of attackers

We can finally derive the effects of the parameters on the share of speculators attacking the currency. This share is given by $\Pr(X_i \leq x^* \mid \theta)$, which is equal to $\Phi\left[\sqrt{\beta}(x^* - \theta)\right]$, and which depends on the actual fundamental θ and on the parameters y, α and β. By differentiating

[13] Heinemann and Illing (1999) obtain a different result on the effect of private information. In their model, an increase in the precision of private information, β, always decreases θ^*, making speculative attacks less likely. However, Heinemann and Illing assume that θ is uniformly distributed over the unit interval. In terms of our model, this assumption would correspond to a fixed y, set equal to $1/2$. Hence, their result is consistent with our model–which, for a fixed y, predicts that an increase in β always reduces θ^*, provided that condition (5) is not fulfilled. It should also be noted that, when uncertainty is high, Heinemann's and Illing's model tends to favor the attack strategy profile because, in case of a successful attack, speculators' payoffs are assumed to depend negatively on θ. This assumption means that, if the attack is successful and θ is low, speculators may obtain a large payoff, whereas they loose only the transaction cost t if their attack is not successful. As a result, in their model, an increase in uncertainty–making extreme values of θ more likely–tends to drive speculators on the attack strategy profile.

$\Phi\left[\sqrt{\beta}(x^* - \theta)\right]$, it is easy to obtain the following results:

Proposition 6 *Assume that* $\beta > \frac{\alpha^2}{2\pi}$*; then the probability* $\Pr(X_i \leq x^* \mid \theta)$ *is: (i) decreasing in* θ*; (ii) decreasing in* y*; (iii) decreasing (increasing) in* α *if* $y > s_1$ $(y < s_1)$*. (iv) decreasing (increasing) in* β *if* $\frac{(x^*-\theta)}{2\sqrt{\beta}} + \sqrt{\beta}\frac{dx^*}{d\beta} < 0$ $\left(\frac{(x^*-\theta)}{2\sqrt{\beta}} + \sqrt{\beta}\frac{dx^*}{d\beta} > 0\right)$.

As expected, an improvement in θ and/or in y reduces the share of speculators attacking the currency. Similarly, the effect of the precision of public information is in line with previous results, since it only depends on the expected fundamental y: when y is sufficiently good (bad), an increase in α makes the share of speculators to decrease (increase). However, unlike the prediction of Propositions 4 and 5, the effect of the precision of private information is not necessarily opposite to that of public information. In order to understand this new result, we need to consider that β not only affects the equilibrium trigger point x^* (and, thus, it indirectly influences the share of speculators attacking the currency), but it also directly affects the probability $\Pr(X_i \leq x^* \mid \theta)$, since it determines the dispersion of the messages x_i around the actual fundamental θ.

Consider the following example. Assume that y is good $(y > s_3)$, so that an increase in β makes x^* to increase $(\frac{dx^*}{d\beta} > 0)$, making speculators more aggressive. One could expect that the share of speculators attacking the currency increases as well. Notwithstanding, if the actual fundamental θ is sufficiently good $(\theta > x^*)$, the increase in β reduces the dispersion of the distribution around the good fundamental and, therefore, a larger number of speculators receives good signals. When this second effect is sufficiently strong, it offsets the indirect effect of β on x^* and the resulting share of attackers decreases. Figure 3 provides an illustration the effect of an increase in β for a good value of y. When β raises, the resulting increase in x^* (indirect effect) tends to increase the share of attackers for each value of θ (dotted line). However, as a consequence of the direct effect, the slope of the curve changes, so that the share of attackers only increases for low values of θ, while it decreases for large values of θ.

In general, the net effect of an increase in β on the share of speculators depends on the relative strength of these two effects. When the direct effect prevails, the effect of the precision of private information is analogous to that of public information. Note, also, that the direct effect tends to prevail either when θ and y are both sufficiently good or when they are both sufficiently bad. Conversely, the effect of the precision of private information tends to be opposite to that of public information when the indirect effect dominates, which occurs when either θ is good and y is bad or when θ is bad and y is good.

III. Testable Implications

We use forecasts of fundamentals collected by Consensus Economics to verify whether the mean and variance of agents' expectations about economic fundamentals contribute to explain actual exchange rate pressures. The Consensus Economics' dataset collects individual forecasts of economic variables (GDP, current account, inflation, ...) formulated by a set of professional forecasters. To relate these predictions to the theoretical model of Section II.C, we assume that each forecaster declares to Consensus Economics the mean of his posterior probability distribution. Recall that, given the message x_i, the posterior probability distribution is

$$\Theta \mid x_i \sim N\left(\frac{\alpha y + \beta x_i}{\alpha + \beta}, \frac{1}{\alpha + \beta}\right) .$$

Our assumption implies that the prediction about the fundamental θ that agent i (i.e., the agent receiving the message x_i) reports to Consensus Economics is the posterior mean $f_i^e(x_i)$ given by equation (7). Let us consider the mean of the individual forecasts; namely consider:

$$f^e(x_1, ..., x_n) = \frac{\sum f_i^e(x_i)}{n} = \frac{\alpha}{\alpha + \beta} y + \frac{\beta}{\alpha + \beta} \frac{\sum x_i}{n} \qquad (8)$$

where n is the number of forecasters. Given the fundamental θ, for n that goes to $+\infty$ this random variable converges to:

$$f(\theta) = E\left[f^e(X_1, ..., X_n) \mid \theta\right] = \frac{\alpha}{\alpha + \beta} y + \frac{\beta}{\alpha + \beta} \theta .$$

Thus, if n is sufficiently large, by using the mean of the individual forecasts in the empirical analysis we use a variable that is influenced by θ and y. Recall that θ and y have the same effects on the share of attackers: when actual or expected fundamentals improve (deteriorate), pressures on the exchange rate will diminish (increase). Note also that the theoretical model suggests that $E\left[f(\Theta)\right] = y$; thus, *on average* the mean of individual forecasts is equal to the expected fundamental y and does not depend in any systematic way on α and β. Similarly, in our empirical work we expect that, *along the time-series dimension*, the mean of individual forecasts does not depend on α and β.

The theoretical model also implies that the precision of public and private information affect exchange rate pressures (points *(iii)-(iv)* in Proposition 6) in a way which is separate and independent from that of actual and expected fundamentals (points *(i)-(ii)* in Proposition 6). In other words, Proposition 6 suggests that, even if actual and expected fundamentals remain unchanged, speculative pressures on the exchange rate vary with the variance of public or private information. Empirically, changes in the precision of public and private information will be reflected in the variance of the individual forecasts:

$$\left[\sigma^e(x_1, ... x_n)\right]^2 = \sum \frac{\left[f_i^e(x_i) - f^e\right]^2}{n} = \frac{\beta^2}{(\alpha + \beta)^2} \frac{\sum (x_i - \overline{x})^2}{n} , \qquad (9)$$

where $\overline{x} = n^{-1} \sum x_i$. Given the fundamental θ, for n that goes to $+\infty$ this random variable converges to:

$$\sigma^2 = E\left[(\sigma^e(X_1, ..., X_n))^2 \mid \theta\right] = \frac{\beta}{(\alpha + \beta)^2} . \qquad (10)$$

Hence, for n sufficiently large, a change in y affects individual forecasts f_i^e but does not affect their variance σ^2, which only depends on α and β. According to the model of section II, changes in the mean of Consensus Economics' forecasts shown in Figure 1 cannot explain coincident changes in the dispersion of the forecasts shown in Figure 2.

It is apparent from expression (10) that while an increase in α always implies a decrease in σ^2, an increase in β does not necessarily reduce σ^2. This result can be easily explained. On the one hand, β tends to reduce σ^2 as it decreases the dispersion of the messages x_i. On the other hand, for given messages x_i, the increase in β raises the weight of the private messages in the individual predictions (7), making them more heterogeneous across the forecasters. The first (second) effect dominates when $\beta > \alpha$ ($\beta < \alpha$).

We conduct our empirical investigation under the assumption $\beta > \max\left\{\alpha, \frac{\alpha^2}{2\pi}\right\}$. The condition $\beta > \alpha$ ensures that σ^2 is decreasing in β, so that we can always interpret a decline in σ^2 as due to an increase either in α or in β or in both. The condition $\beta > \frac{\alpha^2}{2\pi}$ ensures the existence of a unique equilibrium and that Proposition 6 holds.[14]

From Proposition 6 we know that the effect of σ^2 on speculative pressures will depend on whether it is α or β that changes and on the level of the expected fundamental y. We estimate a specification of the following general form:

$$ERP_t = \gamma_0 + \gamma_1 f^e_{t-1} + \gamma_2 \sigma^e_{t-1} \cdot (f^e_{t-1} - \underline{\gamma}) + \gamma_3 e_{t-1} + \varepsilon_t \tag{11}$$

where ERP is a measure of exchange rate pressure, f^e is the mean of the individual forecasts from (8), σ^e is the standard deviation corresponding to the square root of (9), $\underline{\gamma}$ represents the threshold separating "good" from "bad" expected fundamentals and e is the level of the exchange rate. All regressors are lagged one period to avoid simultaneity bias.

We expect the coefficient γ_1 to be negative because an improvement in the expected level of fundamentals reduces pressures on the exchange rate.

The effect of an increase in the dispersion of the individual forecasts, σ^e, depends on the expected fundamentals and the source of uncertainty. The parameter $\underline{\gamma}$ is the empirical proxy for the right-hand side of equations (4) and (6). If changes in the precision of *public* information are at the origin of most changes of σ^e in our sample, then γ_2 should be positive because, according to Proposition 6, imprecise public information (i.e., a high σ^e due to a low α) with good expected fundamentals (i.e., $f^e_{t-1} > \underline{\gamma}$) increases exchange rate pressures. We also expect γ_2 to be positive if changes in σ^e are due to changes in the precision of *private* information and actual and expected fundamentals are either both sufficiently good or both sufficiently bad, so that the *direct effect* of β on the likelihood of an attack dominates (see previous Section). In principle, γ_2 could also be negative provided that changes in σ^e are due to changes in the precision of *private* information and either the actual fundamental is good and the expected fundamental is bad or the actual

[14] In Section II, we show that the variance of public information has similar effects in a model with only public information, independently on the number of equilibria. A proper test of a model with multiple equilibria would, however, require a different econometric approach that allows for jumps across multiple equilibria.

fundamental is bad and the expected fundamental is good.

The theoretical model of Section II is a static model. To test its implications on a dataset with a time-series dimension, we include the exchange rate e among the regressors. As exchange rates vary over time (our sample includes both periods of fixed exchange rates and periods of floating exchange rates), speculative pressures are likely to vary even if f^e and σ^e, remain unchanged. When, for example, a peg is abandoned and the exchange rate depreciates, unchanged (mean and variance of) expected fundamentals could be associated with lower speculative pressures. Given that this effect is likely to depend on what happens to domestic prices, we consider not only nominal but also real exchange rate indices. We define e to be high when the exchange rate is appreciated, thus expecting the coefficient γ_3 to be positive.

IV. Empirical Evidence

In this Section, we verify whether the mean and variance of agents' expectations about economic fundamentals contribute to explain actual exchange rate pressures. For this purpose, we build a monthly dataset with indices of exchange rate pressure and means and variances of Consensus Economics' forecasts of GDP growth for six Asian countries (Thailand, Korea, Indonesia, Malaysia, Singapore, and Hong Kong) from January 1995 to May 2001.

A. The Data

To verify whether expected fundamentals and their dispersion affect the fraction of speculators attacking the currency, we build an index of exchange rate pressure.[15] In recent years, several empirical studies developed indicators of exchange rate pressure aimed at identifying currency crisis periods and trying to predict them. In this paper, we follow a similar methodology but we do not transform the index of exchange rate pressure into a discrete zero-one variable separating tranquil from crisis periods as this previous literature does.[16] The reason is that, in practice, some speculators attack a currency while others do not, consistently with the prediction of a private information model in which the number of speculators attacking a currency varies continuously with fundamentals and the distribution of beliefs about them.

Our index of exchange rate pressure $IND3$ is the sum of normalized values of three indicators of exchange rate pressure:[17] *i)* the percentage depreciation of the domestic currency

[15] Girton and Roper's (1977), Roper and Turnovsky (1980), and Weymark (1998) discuss the assumptions needed to justify different definitions of indices of exchange rate pressure in theoretical macro models.

[16] An exception is Sachs et al. (1996) who use a weighted sum of the percent decrease in reserves and the percent depreciation of the exchange rate in a cross-country regression.

[17] To normalize, we subtract from each indicator the country-specific mean and divide the result by the country-specific standard deviation.

against the U.S. dollar over the previous month; *ii)* the fall in international reserves over the previous month as a percentage of the 12-month moving average of imports; and *iii)* the three-month interest rate less the annualized percentage change in consumer prices over the previous six months. To check the robustness of our results, we also compute an index $IND2$, which sums only normalized values of *i)* and *ii)*,[18] and an index BIS, which is the continuous version of an index recently developed by the Bank for International Settlements for monitoring purposes.[19] Figure 4 shows the time-series behavior of these three indices.

Every month, Consensus Economics collects forecasts of a series of macro variables for the current and the following year. Following Brooks et al. (2001), to reproduce a constant forecast horizon of one year, we compute a weighted average of current and following year forecasts with weights equal respectively to 11/12 and 1/12 in January, 10/12 and 2/12 in February, and so on until 0/12 and 12/12 in December.[20] To reduce the effect of possible outliers on the results, we use the median (instead of the mean) of Consensus Economics' forecasts at each date and the mean absolute median difference as a measure of dispersion. We limit our analysis to the forecasts of GDP growth. Consensus Economics' forecasts for other variables–like CPI inflation, current account balance, trade balance, and exports–are available, but the number of forecasts is generally smaller than for GDP growth making mean and dispersion measures less reliable. Moreover, in preliminary estimates, these other variables tended not to perform as well as GDP growth and, when measures of the mean and variance of expected GDP growth were included in

---

[18]Indices based only on exchange rate and reserve changes are the most common in the empirical work on early warning systems because of the lack of reliable data on interest rates for panel datasets with a large number of developing countries and a long time series dimension. This is the case of the early warning system used by the IMF (see Berg et al. (2000)).

[19]The BIS index is based on four indicators of exchange rate pressure: *i)* the percentage depreciation of the domestic currency against the U.S. dollar over three months; *ii)* the percentage depreciation of the domestic currency against the U.S. dollar over one year; *iii)* the three-month interest rate less the annualized percentage change in consumer prices over the previous six months; and *iv)* the fall in international reserves over three months as a percentage of the 12-month moving average of imports. The BIS transforms the values taken over time by each indicator into scores which are then weighted to compute an index that can take 21 different values from -10 (maximum appreciating pressure) to +10 (maximum depreciating pressure). Annex B of Hawkins and Klau (2000) describes in detail the construction of this index. By contrast, we compute a continuous index by adding normalized values of each of the four indicators of exchange rate pressure.

[20]Multicollinearity of current and following year forecasts prevents us from including both variables in the regression. We obtained, however, very similar estimates by including only the following year forecast or the following year forecast together with the difference between the following and current year forecasts. In this case, we seasonally adjusted the dispersion measures to account for the smaller dispersion of forecasts–documented by Loungani (2001)–at the end of the year than at the beginning of the year and after data releases.

the regression, hardly any other Consensus Economics' forecast variable was significant.

The real exchange rate index is computed by JP Morgan and is generally available with one-month lag. We found it to perform somewhat better than the nominal exchange rate. Preliminary estimates showed that actual values of GDP growth and other variables used in previous studies–such as international reserves, the ratio of M2 to international reserves, and the ratio of BIS external short-term debt to international reserves–had little effect on exchange rate pressures once we included the mean and variance of expected GDP growth in the estimated regression.

B. Benchmark Regression

Our benchmark regression is the following estimated version of equation (11):

$$IND3_{j,t} = \hat{\gamma}_{0,j} + \hat{\gamma}_1 f^e_{GDF_j,t-1} + \hat{\gamma}_2 \sigma^e_{GDF_j,t-1} \cdot (f^e_{GDF_j,t-1} - \underline{\hat{\gamma}_j}_{GDP})$$
$$+\hat{\gamma}_{3,j} e_{j,t-1} + u_{j,t} \quad , \quad u_{j,t} = \hat{\rho}_j u_{j,t-1} + \varepsilon_{j,t} \tag{12}$$

where $IND3_{j,t}$ is our index of exchange rate pressure for country j (Thailand, Korea, Indonesia, Malaysia, Singapore, Hong Kong) at time t. First, we estimated this system as a set of seemingly unrelated regressions (SUR) with country-specific coefficients and a country-specific AR(1) term to correct for serial correlation. We chose the SUR estimation method to allow for the likely correlation of the errors across countries during the Asian crisis. Second, we performed a Wald test of equality of parameters across countries, which showed that the coefficients $\hat{\gamma}_1$ and $\hat{\gamma}_2$ could be constrained to be the same across countries (the null hypothesis of equality was accepted with a p-value of 0.745). Table 1 shows the results of this restricted estimation of (12). We use the restrictions accepted by the data to simplify the presentation and to conduct robustness tests involving recursive estimation (see below) on a specification with a limited number of parameters. The restriction is by no means necessary to obtain statistically significant coefficients. In the unrestricted estimates, all $\hat{\gamma}_{1,j}$ $(j = 1,..,6)$ were negative and statistically significant at the 5 percent confidence level and all $\hat{\gamma}_{2,j}$ $(j = 1,..,6)$ were positive and statistically significant at the 1 percent confidence level.

The results shown in table 1 confirm that higher expected GDP growth reduces exchange rate pressures. More interestingly, these estimates indicate that uncertainty about GDP growth has an additional independent effect, which depends on the level of expected GDP growth as our theoretical models predict. A higher dispersion of GDP growth forecasts tends to increase exchange rate pressures when expected GDP growth is above the estimated country-specific threshold and to reduce them when expected GDP growth is below the threshold. The threshold is statistically different from zero only for Singapore. These results are consistent with changes in the precision of public information being the main factor behind the time-series variation of the dispersion of the forecasts or, if it is the precision of private signals that has changed, with the direct effect of precision changes on the distribution of the signals dominating the indirect effect on the trigger point x^* (see Proposition 6).

C. Sensitivity Analysis

This section presents a series of robustness tests of our benchmark specification (12) confirming our main result that uncertainty about fundamentals plays a role in currency crises and that such role depends on the expected level of fundamentals.

Tables 2 and 3 present estimates of the specification (12) with two alternative measures of exchange rate pressure as dependent variable ($IND2$ and BIS). The coefficient measuring the effect of uncertainty ($\hat{\gamma}_2$) remains positive and strongly significant. Also the coefficient measuring the effect of expected fundamentals ($\hat{\gamma}_1$) remains negative and statistically significant.

Table 4 reports the results of estimating a restricted version of our benchmark regression (12) only on the precrisis sample 1995:01-1997:07. Because of the dramatic reduction in the number of observations, we now restrict also $\underline{\hat{\gamma}}$, $\hat{\gamma}_3$, and $\hat{\rho}_j$ to be the same across countries, allowing only the intercepts $\hat{\gamma}_{0,j}$ in each equation to be country-specific. This is equivalent to estimating a panel model with fixed effects. The effect of uncertainty is positive and statistically significant also in this precrisis sample. The negative effect of higher expected fundamentals on exchange rate pressures is also confirmed. These results hold with all measures of exchange rate pressure.

Table 4 shows that uncertainty affected exchange rate pressures prior to the breakdown of the exchange rate regime. This result implies that the breakdown of the exchange rate regime that most countries in our panel experienced during the second half of 1997 is not the sole determinant of the estimated effect of uncertainty on exchange rate pressures.[21] This is consistent with the increase in uncertainty about GDP growth prior to the crisis in Thailand (from mid 1996), Korea (from end 1996), and, to a smaller extent, Malaysia (Figure 2). The increase of uncertainty in Hong Kong–which maintained a currency board for the entire period–also suggests that the breakdown of the exchange rate regime might not be the only cause of the uncertainty about fundamentals that we observe in the data.[22]

More generally, the correction for serial correlation used in all regressions allows us to exclude that spurious correlation between exchange rate pressures and uncertainty about

[21]Jeanne and Rose (2000) show, for example, that market expectations should be noisier under a floating exchange rate regime.

[22]Some related evidence is the fact that the peak in uncertainty about GDP growth is at the time of the Russian crisis (between August and October 1998) whereas the peak of exchange rate depreciation is in January 1998 for Thailand, Korea, and Malaysia, in July 1998 for Indonesia, and in August 1998 for Singapore and Taiwan.

fundamentals might affect our results.[23] This problem would emerge if uncertainty about fundamentals were a function of exchange rate pressures and the time series of exchange rate pressure were serially correlated. In this case, the estimated coefficient on the lagged variance of GDP forecasts would mainly reflect the serial correlation of the exchange rate pressure series. By including a correction for serial correlation, we avoid this potential spurious regression problem (see Hamilton (1994), pp. 561-62). Results remained unchanged when we tried the alternative approach of introducing a lagged dependent variable.

Another robustness check regards the coefficients $\hat{\gamma}_1$ and $\hat{\gamma}_2$. Proposition 6 implies that the predicted effect of expected fundamentals on exchange rate pressures is always negative but may vary over time together with the precision of public and private information. We allow for this possibility by estimating $\hat{\gamma}_1$ recursively with state-space techniques. Figure 5 (top panel) shows that the estimated $\hat{\gamma}_1$ varies within a relatively narrow range over the sample remaining always negative and strongly significant. Similarly, the effect of uncertainty on exchange rate pressures may change over time depending not only on the level of expected fundamentals (for which we control) but also on whether it is the precision of public or private information that changes and on the difference between actual fundamentals θ and the cutoff point x^*. In particular, there may be instances in which changes in the precision of private information may make the parameter $\hat{\gamma}_2$ become negative. We check this possibility by estimating $\hat{\gamma}_2$ recursively. Figure 5 (bottom panel) shows that the recursive estimate changes over time but remains always positive and significantly different from zero.[24]

The last robustness check regards the estimation of the thresholds separating "high" from "low" expected GDP growth. These are also likely to be time-varying reflecting changes in the parameters in s_1, s_2, and s_3, or, more simply, because investors might have revised estimates of potential growth rates as the crisis progressed. To address this potential concern, we estimate recursively the six parameters $\underline{\hat{\gamma}_j}$ in (12). Figure 6 shows the recursive estimates of the $\underline{\hat{\gamma}_j}$ parameters. In all countries except Hong Kong, the estimated thresholds tend to decline until end-1997 before rebounding and stabilizing below their precrisis level. Nevertheless, Table 5 shows that allowing for time-varying thresholds is of little consequence for the estimates $\hat{\gamma}_1$ and $\hat{\gamma}_2$, with the latter remaining strongly significant and positive. Note that the overall estimated effect of $\sigma^e_{GDP_j,t-1}$ on exchange rate pressures (measured by $\hat{\gamma}_2 \cdot (f^e_{GDP_j,t-1} - \underline{\hat{\gamma}_j}_{GDP,t-1}))$ may also vary as GDP forecasts ($f^e_{GDP_j,t-1}$) and country-specific thresholds ($\underline{\hat{\gamma}_j}_{GDP,t-1}$) change.

[23]Note that this problem is distinct from the possible contemporaneous feedback effect of exchange rate pressures onto the mean and variance of fundamentals, which would cause a potential endogeneity problem that we address by lagging all regressors.

[24]We also estimated separate recursive coefficients $\hat{\gamma}_{2,j}$ for each country. Because of the smaller number of observations, country-specific recursive estimates had larger RMSE bands than those in Figure 6 at the beginning of the period. The estimated coefficients were, however, mostly positive with a statistically significant negative coefficient only for the early part of the Hong Kong sample.

Figure 7 shows that this estimated effect varies substantially over time but remains mostly positive with the main exception of Indonesia in 1998-99 and Singapore at end-1998.

V. Conclusions

This paper studies how uncertainty about fundamentals contributes to currency crises from both a theoretical and an empirical perspective. The theoretical model shows that speculative attacks depend not only on the current and the expected level of fundamentals but also on the variance of speculators' expectations about fundamentals. This variance affects exchange rate pressures in different ways depending on the level of current and expected fundamentals and on whether it is the precision of public or private information that varies. Specifically, if the level of expected fundamentals is sufficiently good (bad), then an increase in the precision of *public* information makes speculative attacks less (more) likely. The effect of the precision of *private* information turns out to be twofold. First, the precision of private information *directly affects* the likelihood of an attack, since it is (inversely) related to the dispersion of speculators' private signals around the actual fundamental. Second, private information *indirectly influences* the likelihood of an attack, as the ratio between the precision of public and private information represents the extent to which speculators expect their beliefs to be shared by the other speculators, thereby affecting their 'degree of aggressiveness'. We find that while these two effects have opposite consequences on the likelihood of an attack, the net effect of private information tends to be similar to that of public information when actual and expected fundamentals are both sufficiently good or both sufficiently bad; otherwise, it turns out to be exactly opposite.

Our estimates on a monthly dataset of forecasts for six Asian countries confirm that both the mean and the variance of agents' expectations about economic fundamentals contribute to explain exchange rate pressures. Specifically, exchange rate pressures diminish with an improvement in the expected level of GDP growth, while they increase with the dispersion of GDP growth forecasts when expected growth is relatively high.

Estimates of the threshold separating good from bad expected GDP growth imply that, in all the countries in our sample, uncertainty about GDP growth has increased exchange rate pressures in the precrisis period (before July 1997) and since mid-1999 (Figure 7). By contrast, in a few countries during the intermediate period, uncertainty about the growth outlook has had a significant negative effect on exchange rate pressures. This effect has, however, been temporary and has peaked at the time of the Russian crisis (end-1998), which coincided with a period of low expected growth.

These results are robust to the definition of exchange rate pressure indices and the selection of the threshold separating good from bad fundamentals. Moreover, the fact that we find a significant role of uncertainty when we estimate the model only on the *precrisis* period implies that the breakdown of the exchange rate regime in most countries in the sample is not the sole determinant of our results.

While a welfare analysis of the provision of public information is beyond the scope of this paper, our results shed some light on whether a country may better resist a speculative attack on its currency when the precision of the official information it publicly provides is high. Both the theoretical and empirical results suggest that the precision of public information may either help or hurt a country under attack depending on the state of fundamentals. The theoretical model predicts that a high precision of public information helps when expected fundamentals are good but it hurts when they are bad. Transparent policies may then benefit "virtuous" countries. The empirical results suggest that, at the onset of the Asian crisis, when expected fundamentals were still relatively good but uncertainty about the economic outlook was increasing, a higher precision of official information would have been beneficial. At the same time, there seems to be some indication that, during some phases of the crisis, uncertainty about the economic outlook might have dampened speculative pressures. An appropriate discussion of the welfare implications of the precision of official information would, however, require the development of a theoretical model in which speculators make their decisions by taking into account the authorities' strategic approach to information release.

Future theoretical research may also try to verify whether the predicted effect of the precision of public and private information on the share of speculators attacking the currency is robust to the choice of the payoff function and the probability distribution. Relaxing the maintained assumption of exogenous fundamentals and exploring the consequences of changes in the exchange rate that have feedback effects on economic fundamentals could also have interesting implications.

Future empirical research is also needed to verify whether data on other well-known currency crises in Latin America and Europe confirm the statistical significance of the uncertainty about fundamentals. There may also be scope for an empirical verification of the multiple equilibria model with regime switching econometric techniques as in Jeanne (1997) and Jeanne and Masson (2000). While testing the leading indicator properties of the mean and variance of Consensus Economics' forecasts is beyond the scope of this paper, it would be worthwhile exploring whether these variables could enhance the predictive power of early warning systems currently based only on past fundamentals. In this regard, the results of our estimates on the precrisis period are promising.

PROOF FOR PROPOSITION 2

Differentiating $u(a_i, a_{-i})$ and $u(a_i, d_{-i})$ with respect to y, using equations (1) yields:

$$\begin{aligned}\frac{d}{dy}u(a_i, a_{-i}) &= -D\sqrt{\alpha}\cdot\phi\left[\sqrt{\alpha}\,(1-y)\right]\\ \frac{d}{dy}u(a_i, d_{-i}) &= -D\sqrt{\alpha}\cdot\phi\left(-\sqrt{\alpha}y\right)\ .\end{aligned}$$

where ϕ is the probability density function of a standard normal distribution. Thus, both derivatives are always negative.

Differentiating with respect to α we obtain:

$$\begin{aligned}\frac{d}{d\alpha}u(a_i, a_{-i}) &= (1-y)\,\frac{D}{2\sqrt{\alpha}}\cdot\phi\left[\sqrt{\alpha}\,(1-y)\right]\\ \frac{d}{d\alpha}u(a_i, d_{-i}) &= -y\frac{D}{2\sqrt{\alpha}}\cdot\phi\left(-\sqrt{\alpha}y\right)\ .\end{aligned}$$

Therefore, the derivative of $u(a_i, a_{-i})$ is negative (positive), provided that $y > 1$ $(y < 1)$; the derivative of $u(a_i, d_{-i})$ is negative (positive), provided that $y > 0$ $(y < 0)$.

EQUILIBRIUM OF THE PUBLIC AND PRIVATE INFORMATION GAME

In this Section we characterize the unique equilibrium of the game with both public and private information. Morris and Shin (1998 and 1999) and Metz (2001) have shown that the unique equilibrium can be specified by a couple (x^*, θ^*), such that speculators use a trigger strategy

$$\delta(x) = \begin{cases} \textit{attack} & \text{if } x \leq x^* \\ \textit{don't attack} & \text{if } x > x^* \end{cases} .$$

In addition, when all speculators use a decision rule like δ, the optimal strategy for the government turns out to be a rule:[25]

$$\psi(\theta) = \begin{cases} \textit{abandon} & \text{if } \theta \leq \theta^* \\ \textit{defend} & \text{if } \theta > \theta^* \end{cases} .$$

Here, we assume that agents use a trigger strategy like δ, we derive a sufficient condition granting that unique values of x^* and θ^* exist, and we find the equations that characterize these values. We do not show that, under the sufficient condition, a trigger strategy for speculators is the unique optimal strategy, as this result follows directly from Morris and Shin (1999) or, in a more general framework, from Frankel et al. (2001).

Cut-off points

Assume that agents use the trigger strategy δ defined above and let us find the trigger point of the government's optimal strategy. Given x^* and θ, the share of speculators who attack the currency is

$$\Pr(X < x^* \mid \theta) = \Phi\left[\sqrt{\beta}\,(x^* - \theta)\right] .$$

As the expected utility from abandoning the peg is nil, the government is indifferent between defending and abandoning the peg, for the level of fundamentals θ^* that solves:

$$\theta^* - \Phi\left[\sqrt{\beta}\,(x^* - \theta^*)\right] = 0 . \qquad \text{(A-1)}$$

Equation (A-1)gives the value of θ^* as a function of x^*. Note that Φ is decreasing and continuous in θ^*, and takes all the values in the open interval $(0, 1)$. Therefore, there exists a unique value of θ^* that solves (A-1), for any $x^* \in \Re$.

Let us find the trigger point for speculators. Given ψ, the expected utility of a speculator who receives a message x and attacks the currency is:

$$(D - t) \cdot \Pr(\widetilde{\Theta} \leq \theta^* \mid x) - t \cdot \Pr(\widetilde{\Theta} > \theta^* \mid x) = D \cdot \Pr(\widetilde{\Theta} \leq \theta^* \mid x) - t .$$

[25]Given θ, the share of attackers is completely determined by δ, since we have assumed that there is a continuum of speculators. Therefore, the function ψ below is equivalent to the government's decision rule of section II (which was denoted by the same symbol ψ).

As the expected utility from *don't attack* is nil, a speculator is indifferent between attacking and refraining from the attack when he receives the message x^* that solves:

$$D \cdot \Phi\left[\sqrt{\alpha+\beta}\left(\theta^* - \frac{\alpha}{\alpha+\beta}y - \frac{\beta}{\alpha+\beta}x^*\right)\right] - t = 0 \tag{A-2}$$

Sufficient condition for a unique equilibrium

Unlike equation (A-1), equation (A-2) does not necessarily have a unique solution. Note that, as x^* goes to $+\infty$, the left hand side of equation (A-2) goes to $-t < 0$; when x^* goes to $-\infty$, the left hand side of equation (A-2) goes to $D - t > 0$. By the continuity of the left hand side of (A-2), a sufficient condition granting that a unique solution to equation (A-2) exists may be obtained by requiring that the derivative of the left hand side of (A-2) with respect to x^* is smaller than zero; namely:

$$D \cdot \sqrt{\alpha+\beta} \cdot \left(\frac{d\theta^*}{dx^*} - \frac{\beta}{\alpha+\beta}\right) \cdot \phi\left[\sqrt{\alpha+\beta}\left(\theta^* - \frac{\alpha}{\alpha+\beta}y - \frac{\beta}{\alpha+\beta}x^*\right)\right] < 0\,.$$

The previous inequality holds provided that

$$\frac{d\theta^*}{dx^*} - \frac{\beta}{\alpha+\beta} < 0\,. \tag{A-3}$$

Differentiating implicitly equation (A-1) we can obtain

$$\frac{d\theta^*}{dx^*} = \frac{\sqrt{\beta}\phi\left[\sqrt{\alpha+\beta}\left(\theta^* - \frac{\alpha}{\alpha+\beta}y - \frac{\beta}{\alpha+\beta}x^*\right)\right]}{1 + \sqrt{\beta}\phi\left[\sqrt{\alpha+\beta}\left(\theta^* - \frac{\alpha}{\alpha+\beta}y - \frac{\beta}{\alpha+\beta}x^*\right)\right]}\,,$$

and, substituting into (A-3),

$$\frac{\sqrt{\beta}}{\frac{1}{\phi\left[\sqrt{\alpha+\beta}\left(\theta^* - \frac{\alpha}{\alpha+\beta}y - \frac{\beta}{\alpha+\beta}x^*\right)\right]} + \sqrt{\beta}} < \frac{\beta}{\alpha+\beta}\,. \tag{A-4}$$

A sufficient condition for the inequality (A-4) to hold is:

$$\frac{\sqrt{\beta}}{\frac{1}{\max_x \phi(x)} + \sqrt{\beta}} < \frac{\beta}{\alpha+\beta}\,.$$

Rearranging the previous inequality–and recalling that the maximum of ϕ is $1/\sqrt{2\pi}$–we obtain the sufficient condition (3).

Equilibrium

Given the sufficient condition (3), the unique equilibrium is characterized by (x^*, θ^*)

which are determined by the unique solution of the following system of equations:

$$\begin{aligned} 0 &= \theta^* - \Phi\left[\sqrt{\beta}\,(x^* - \theta^*)\right] \\ 0 &= D \cdot \Phi\left[\sqrt{\alpha+\beta}\left(\theta^* - \frac{\alpha}{\alpha+\beta}y - \frac{\beta}{\alpha+\beta}x^*\right)\right] - t\,. \end{aligned} \tag{A-5}$$

PROOF FOR PROPOSITIONS 4, AND 5

In order to derive the effects of the parameters y, α, β on (x^*, θ^*) the system (A-5) can also be written as

$$\begin{aligned} x^* &= \theta^* + \frac{1}{\sqrt{\beta}}\Phi^{-1}(\theta^*) \\ x^* &= \frac{\alpha+\beta}{\beta}\theta^* - \frac{\alpha}{\beta}y - \frac{\sqrt{\alpha+\beta}}{\beta}\Phi^{-1}\left(\frac{t}{D}\right) \end{aligned} \tag{A-6}$$

that, by substitution, yields:

$$\theta^* = \Phi\left[\frac{\alpha}{\sqrt{\beta}}\left(\theta^* - y - \frac{\sqrt{\alpha+\beta}}{\alpha}\Phi^{-1}\left(\frac{t}{D}\right)\right)\right]. \tag{A-7}$$

Effects of y

By differentiating the system of implicit equations (A-5) with respect to y, we can obtain:

$$\begin{aligned} 0 &= \frac{d\theta^*}{dy} - \sqrt{\beta}\left(\frac{dx^*}{dy} - \frac{d\theta^*}{dy}\right)\phi \\ 0 &= \frac{d\theta^*}{dy} - \frac{\alpha}{\alpha+\beta} - \frac{\beta}{\alpha+\beta}\frac{dx^*}{dy}, \end{aligned}$$

where we have neglected the argument of ϕ. Solving by substitution, we get:

$$\begin{aligned} \frac{d\theta^*}{dy} &= -\frac{\alpha\phi}{\sqrt{\beta}-\alpha\phi} \\ \frac{dx^*}{dy} &= -\frac{\alpha}{\beta} + \frac{\alpha+\beta}{\beta}\frac{d\theta^*}{dy}. \end{aligned}$$

Therefore, the derivative of θ^* with respect to y is negative, provided that $\beta > \alpha^2\phi^2$. But this inequality certainly holds under the sufficient condition (3). Hence, $d\theta^*/dy$ is negative and, in turn, dx^*/dy is negative too.

Effects of α

In order to derive the effect of α on θ^*, we can simplify our calculations starting by differentiating equation (A-7):

$$\frac{d\theta^*}{d\alpha} = \left(\frac{\theta^*}{\sqrt{\beta}} + \frac{\alpha}{\sqrt{\beta}}\frac{d\theta^*}{d\alpha} - \frac{y}{\sqrt{\beta}} - \frac{1}{2\sqrt{\beta}\sqrt{\alpha+\beta}}\Phi^{-1}\left(\frac{t}{D}\right)\right)\cdot\phi$$

where we have neglected the argument of ϕ. Solving for $d\theta^*/d\alpha$ we obtain:

$$\frac{d\theta^*}{d\alpha} = \phi\cdot\left(1 - \frac{\alpha\phi}{\sqrt{\beta}}\right)^{-1}\cdot\left(\frac{\theta^*}{\sqrt{\beta}} - \frac{y}{\sqrt{\beta}} - \frac{1}{2\sqrt{\beta}\sqrt{\alpha+\beta}}\Phi^{-1}\left(\frac{t}{D}\right)\right).$$

The sufficient condition for a unique equilibrium (3) grants that the second term in the right hand side of the previous equation is positive. By rearranging the third term, we find that the derivative of θ^* with respect to α is negative, provided that condition (4) holds.

Let us turn to the effect of α on x^*. Differentiating the first equation of system (A-5) with respect to α we get:

$$\frac{d\theta^*}{d\alpha} - \left(\sqrt{\beta}\frac{dx^*}{d\alpha} - \sqrt{\beta}\frac{d\theta^*}{d\alpha}\right) \cdot \phi = 0\,,$$

from which we can obtain:

$$\frac{dx^*}{d\alpha} = \left(1 + \frac{1}{\phi\sqrt{\beta}}\right)\frac{d\theta^*}{d\alpha}\,.$$

As the term in brackets is positive, the sign of the derivative of x^* is the same as the sign of the derivative of θ^*.

Effect of β on θ^*

Let us differentiate equation (A-7) with respect to β:

$$\frac{d\theta^*}{d\beta} = \left(-\frac{\alpha}{2\sqrt{\beta^3}}\theta^* + \frac{\alpha}{\sqrt{\beta}}\frac{d\theta^*}{d\beta} + \frac{\alpha}{2\sqrt{\beta^3}}y + \frac{\alpha}{2\beta^2}\sqrt{\frac{\beta}{\alpha+\beta}}\Phi^{-1}\left(\frac{t}{D}\right)\right) \cdot \phi$$

where we have neglected the argument of ϕ. Solving by substitution, we get:

$$\frac{d\theta^*}{d\beta} = \phi \cdot \left(1 - \frac{\alpha\phi}{\sqrt{\beta}}\right)^{-1} \cdot \left(-\frac{\alpha}{2\sqrt{\beta^3}}\theta^* + \frac{\alpha}{2\sqrt{\beta^3}}y + \frac{\alpha}{2\beta^2}\sqrt{\frac{\beta}{\alpha+\beta}}\Phi^{-1}\left(\frac{t}{D}\right)\right)\,.$$

The first two terms of the right hand side of the previous equation are positive. By rearranging the third term, we get that the derivative of θ^* with respect to β is positive, provided that condition (5) holds.

Effect of β on x^*

Consider the second equation in system (A-1) and differentiate it with respect to β:

$$\frac{dx^*}{d\beta} = \frac{\alpha+\beta}{\beta}\frac{d\theta^*}{d\beta} + \frac{\alpha\,(y-\theta^*)}{\beta^2} + \frac{2\alpha+\beta}{2\beta\sqrt{\alpha+\beta}}\Phi^{-1}\left(\frac{t}{D}\right)\,.$$

Substituting the expression of $d\theta^*/d\beta$ previously found we can get–after some tedious algebra–that $dx^*/d\beta > 0$ *iff*

$$y > \theta^* - \frac{\alpha^2\phi - 2\sqrt{\beta}\alpha - \left(\sqrt{\beta}\right)^3}{\alpha\sqrt{(\alpha+\beta)}\left(\alpha\phi - \beta\phi - 2\sqrt{\beta}\right)}\Phi^{-1}\left(\frac{t}{D}\right).$$

References

Bartolini L. and Prati A. (1999), "Soft Exchange Rate Bands and Speculative Attacks: Theory, and Evidence from the ERM since August 1993," *Journal of International Economics*, No. 49, pp. 1-30.

Berg A., E. Borensztein, G.M. Milesi-Ferretti, and C. Pattillo (2000), "Anticipating Balance of Payments Crises. The Role of Early Warning Systems," *IMF Occasional Paper*, No. 186, (Washington: International Monetary Fund).

Berg A., and C. Pattillo (1999), "Are Currency Crises Predictable? A Test," *IMF Staff Papers*, Vol. 2 No. 46, (June), pp. 107-38.

Brooks R., H. Edison, M. Kumar, and T. Sløk, (2001), "Exchange Rates and Capital Flows," *IMF Working Paper*, (forthcoming).

Carlsson H., and E. van Damme (1993), "Global Games and Equilibrium Selection," *Econometrica*, No. 61, pp. 989-1018.

Caramazza F., L. Ricci, and R. Salgado, (2000), "Trade and Financial Contagion in Currency Crises," *IMF Working Paper*, N. 00/55, (Washington: International Monetary Fund).

Chan K.S., Y.S. Chiu (2001), "The Role of (Non)transparencies in a Currency Crisis Model," *European Economic Review*, (forthcoming).

Corsetti G., A. Dasgupta, S. Morris, and H.S. Shin, (2000), "Does One Soros Make a Difference? The Role of a Large Trader in Currency Crises," Yale University, (*unpublished paper)*.

Dumas B. and Svensson L.E.O., (1994), "How Long Do Unilateral Target Zones Last?," *Journal of International Economics*, No. 36, pp. 467-81.

Eichengreen B., A. Rose, and C. Wyplosz, (1996), "Contagious Currency Crises," *CEPR Discussion Papers*, No. 1453.

Flood R.P., and P. Garber, (1984), "Collapsing Exchange-Rate Regimes: Some Linear Examples," *Journal of International Economics*, No. 17, pp. 1-13.

Flood R.P., and N. P. Marion, (2000), "Self-fulfilling Risk Predictions: an Application to Speculative Attacks" *Journal of International Economics*, No. 50, pp. 245-68.

Frankel D., S. Morris, and A. Pauzner, (2001), "Equilibrium Selection in Global Games with Strategic Complementarities," *Journal of Economic Theory*, (forthcoming).

Girton L., and D. Roper, (1977), "A Monetary Model of Exchange Market Pressure Applied to the Postwar Canadian Experience," *American Economic Review*, No. 67, pp. 537-48.

Goldberg L.S., (1991), "Collapsing Exchange Rate Regimes: Shocks and Biases," *Journal oj International Money and Finance*, 10, pp. 252-63.

Goldberg L.S., (1994), "Predicting Exchange Rate Crises. Mexico Revisited," *Journal oj International Economics*, 36, pp. 413-30.

Grilli V.U., (1986), "Buying and Selling Attacks on Fixed Exchange Rate Systems," *Journal of International Economics*, no. 20, pp. 143-56.

Hamilton J. D., (1994), *Time Series Analysis*, Princeton University Press, (Princeton, New Jersey).

Hawkins J., and M. Klau, (2000), "Measuring Potential Vulnerabilities in Emerging Market Economies," *BIS Working Papers*, (October), No. 91.

Heinemann F., and G. Illing, (1999), "Speculative Attacks: Unique Sunspot Equilibrium and Transparency," University of Frankfurt, *Working Paper*, No. 97.

Hodrik R.J., (1989), "Risk, Uncertainty, and Exchange Rates," *Journal of Monetary Economics*, No. 23, pp. 433-59.

Jeanne O., (1997), "Are Currency Crises Self-fulfilling? A Test," *Journal of International Economics*, No. 43, pp. 263-86.

Jeanne O., and P. Masson (2000), "Currency Crises, Sunspots, and Markov-Switching Regimes," *Journal of International Economics*, no. 50, pp. 327-50.

Jeanne O., and A.K. Rose, (2000), "Noise Trading and Exchange Rate Regimes," *Quarterly Journal of Economics*, (forthcoming).

Kaminsky G.L., and R. Peruga (1990), "Can a Time-Varying Risk Premium Explain Excess Returns in the Forward Market for Foreign Exchange?" *Journal of International Economics*, No. 28, pp. 47-70.

Kaminsky G.L., and C.M. Reinhart (1999), "The Twin Crises: The Causes of Banking and Balance-of-Payments Problems," *American Economic Review*, Vol. 3 No. 89, pp. 473-500.

Loungani P., (2001), "How Accurate Are Private Sector Forecasts. Cross-Country Evidence from Consensus Forecasts of Output Growth," IMF Working Paper 00/77, *International Journal of Forecasting*, (forthcoming).

Metz C.E. (2001), "Private and Public Information in Self-Fulfilling Currency Crises," *Journal of Economics*, (forthcoming).

Morris S., R. Rob, and H.S. Shin, (1995), "p-Dominance and Belief Potential," *Econometrica*, Vol. 1 No. 63, pp. 145-57.

Morris S., and H.S. Shin, (1998), "Unique Equilibrium in a Model of Self-Fulfilling Crises," *American Economic Review*, 88, pp. 587-97.

Morris S., and H.S. Shin, (1999), "Coordination Risk and the Price of Debt," Yale University, *unpublished paper*.

———, ——— (2000), "Welfare Effects of Public Information," paper prepared for the Bundesbank/CFS Conference on "Transparency of Monetary Policy", (Frankfurt, October 16-17).

Obstfeld M., (1994), "The Logic of Currency Crises," *Cahiers Economiques et Monetaires*, No. 43, pp. 189-213.

Obstfeld M. (1996), "Models of Currency Crises with Self-Fulfilling Features," *European Economic Review*, No. 40, pp. 1037-47.

Roper D., and S.J. Turnovsky, (1980), "Optimal Exchange Market Intervention in a Simple Stochastic Macro Model," *Canadian Journal of Economics*, No. 13, pp. 296-309.

Routledge B. R., and S. E. Zin, (2001), "Model Uncertainty and Liquidity," (July), *mimeo*.

Sachs J., A. Tornell, and A. Velasco, (1996), "Financial Crises in Emerging Markets: The Lessons from 1995," *Brookings Papers on Economic Activity*, No. 1, pp. 147-215.

Sbracia M., and A. Zaghini, (2001), "Expectations and Information in Second Generation Currency Crises Models," *Economic Modelling*, No. 18, pp. 203-22.

Weymark D.N., (1998), "A General Approach to Measuring Exchange Market Pressure," *Oxford Economic Papers*, No. 50, pp. 106-21.

Table 1. Exchange Rate Pressure (**IND3** Index) Estimates
(SUR estimates; standard errors in parenthesis; sample: 1995:03-2001:05)[1]

	Thailand	*Indonesia*	*Korea*	*Malaysia*	*Singapore*	*Hong Kong*
$\gamma_{0,j}$	-10.645 ***	-1.654	-17.254 ***	-13.830 ***	-18.052 ***	6.885 **
	(3.234)	(1.347)	(3.521)	(2.318)	(6.509)	(3.439)
γ_1	-0.520 ***					
	(0.085)					
γ_2	0.592 ***					
	(0.066)					
γ_j	1.360	1.151	0.495	0.160	3.468 ***	-0.710
	(0.971)	(0.946)	(1.312)	(1.249)	(1.310)	(1.439)
$\gamma_{3,j}$	0.142 ***	0.047 ***	0.238 ***	0.165 ***	0.184 ***	-0.046 *
	(0.035)	(0.015)	(0.042)	(0.022)	(0.058)	(0.027)
ρ_j	0.340 ***	0.283 **	0.503 ***	0.345 ***	0.203 **	0.294 ***
	(0.088)	(0.125)	(0.090)	(0.082)	(0.085)	(0.092)
R^2	0.330	0.647	0.518	0.475	0.227	0.389
DW	1.626	1.971	1.538	1.806	1.695	2.276
Observations	76	76	76	76	76	76

[1] Data are monthly.
Three (***), two (**), and one (*) stars mark statistical significance respectively at one, five, and ten percent levels.
The coefficients γ_1 and γ_2 are restricted to be the same across countries.

Table 2. Exchange Rate Pressure (**IND2** Index) Estimates
(SUR estimates; standard errors in parenthesis; sample: 1995:03-2001:05)[1]

	Thailand	*Indonesia*	*Korea*	*Malaysia*	*Singapore*	*Hong Kong*
$\gamma_{0,j}$	-6.720 ***	-1.193	-11.187 ***	-4.630 ***	-8.223	6.385 **
	(2.569)	(1.528)	(2.865)	(1.775)	(5.484)	(2.719)
γ_1	-0.203 **					
	(0.081)					
γ_2	0.333 ***					
	(0.067)					
γ_j	0.954	-1.582	-0.592	0.933	4.719 **	0.328
	(1.447)	(1.699)	(2.204)	(1.857)	(2.140)	(2.162)
$\gamma_{3,j}$	0.083 ***	0.018	0.144 ***	0.056 ***	0.084 *	-0.048 **
	(0.029)	(0.017)	(0.034)	(0.017)	(0.049)	(0.022)
ρ_j	0.173 **	0.308 **	0.304 ***	0.138	0.089	0.135
	(0.088)	(0.126)	(0.098)	(0.087)	(0.086)	(0.090)
R^2	0.233	0.281	0.440	0.221	0.087	0.121
DW	1.590	1.912	1.500	1.706	1.593	2.252
Observations	76	76	76	76	76	76

[1] Data are monthly.
Three (***), two (**), and one (*) stars mark statistical significance respectively at one, five, and ten percent levels.
The coefficients γ_1 and γ_2 are restricted to be the same across countries.

Table 3. Exchange Rate Pressure (**BIS** Index) Estimates
(SUR estimates; standard errors in parenthesis; sample: 1995:03-2001:05)[1]

	Thailand	*Indonesia*	*Korea*	*Malaysia*	*Singapore*	*Hong Kong*
$\gamma_{0,j}$	-30.862 ***	-7.491 ***	-26.437 ***	-23.790 ***	-26.928 ***	19.706 ***
	(7.044)	(2.184)	(4.356)	(3.528)	(7.693)	(7.097)
γ_1	-0.641 ***					
	(0.130)					
γ_2	0.623 ***					
	(0.094)					
γ_j	1.511	-0.702	0.505	-1.660	5.530 ***	2.820
	(1.254)	(1.080)	(1.076)	(1.746)	(1.532)	(2.018)
$\gamma_{3,j}$	0.374 ***	0.117 ***	0.361 ***	0.269 ***	0.275 ***	-0.136 **
	(0.076)	(0.026)	(0.054)	(0.034)	(0.069)	(0.056)
$\rho_{1,j}$	0.568 ***	0.443 ***	1.076 ***	0.330 ***	0.514 ***	0.510 ***
	(0.096)	(0.102)	(0.083)	(0.081)	(0.075)	(0.088)
$\rho_{2,j}$	-0.123 *	0.148 *	-0.452 ***	0.037	-0.255 ***	0.170 **
	(0.072)	(0.081)	(0.069)	(0.074)	(0.071)	(0.078)
R^2	0.258	0.452	0.599	0.323	0.297	0.353
DW	1.815	2.170	1.853	1.894	1.959	2.245
Observations	76	76	76	76	76	76

[1] Data are monthly.
Three (***), two (**), and one (*) stars mark statistical significance respectively at one, five, and ten percent levels.
The coefficients γ_1 and γ_2 are restricted to be the same across countries.

Table 4. Exchange Rate Pressure Estimates on Pre-Crisis Sample
(fixed-effect panel estimates with SUR standard errors in parenthesis; sample: 1995:03-1997:07)[1]

	IND3	*IND2*	*BIS*
γ_1	-1.450 *** (0.328)	-1.140 *** (0.227)	-1.632 *** (0.427)
γ_2	3.073 *** (0.862)	2.198 *** (0.642)	3.185 *** (1.098)
$\underline{\gamma}$	7.297 *** (0.267)	7.572 *** (0.344)	6.996 *** (0.244)
γ_3	-0.008 (0.024)	-0.025 (0.018)	0.029 (0.029)
ρ	0.375 *** (0.066)	0.149 * (0.077)	0.608 *** (0.065)
R^2	0.384	0.094	0.392
DW	1.507	1.477	1.577
Observations	174	174	174

[1] Data are monthly.
Three (***), two (**), and one (*) stars mark statistical significance respectively at one, five, and ten percent levels.
The panel includes Thailand, Indonesia, Korea, Malaysia, Singapore, Hong Kong.

Table 5. Exchange Rate Pressure (**IND3** Index) Estimates with Recursive Threshold
(state-space estimates; standard errors in parenthesis; sample: 1995:03-2001:05)[1]

	Thailand	*Indonesia*	*Korea*	*Malaysia*	*Singapore*	*Hong Kong*
$\gamma_{0,j}$	-9.609 (8.147)	-1.294 (1.604)	-12.448 (8.576)	-14.402 * (8.020)	-18.941 (12.549)	7.397 (6.090)
γ_1	-0.290 * (0.159)					
γ_2	0.400 *** (0.085)					
χ_j	*estimated recursively (see Fig. 6)*					
$\gamma_{3,j}$	0.113 (0.087)	0.034 * (0.020)	0.168 * (0.102)	0.153 ** (0.071)	0.178 (0.113)	-0.062 (0.046)
ρ_j	0.385 ** (0.159)	0.250 (0.182)	0.487 * 0.264	0.418 (0.273)	0.285 (0.209)	0.154 (0.207)
Observations	76	76	76	76	76	76

[1] Data are monthly.
Three (***), two (**), and one (*) stars mark statistical significance respectively at one, five, and ten percent levels.
The coefficients γ_1 and γ_2 are restricted to be the same across countries.

Figure 1. Mean and Median Forecasts of GDP Growth
(weighted average of current and following year forecasts; 1995:01-2001:05)

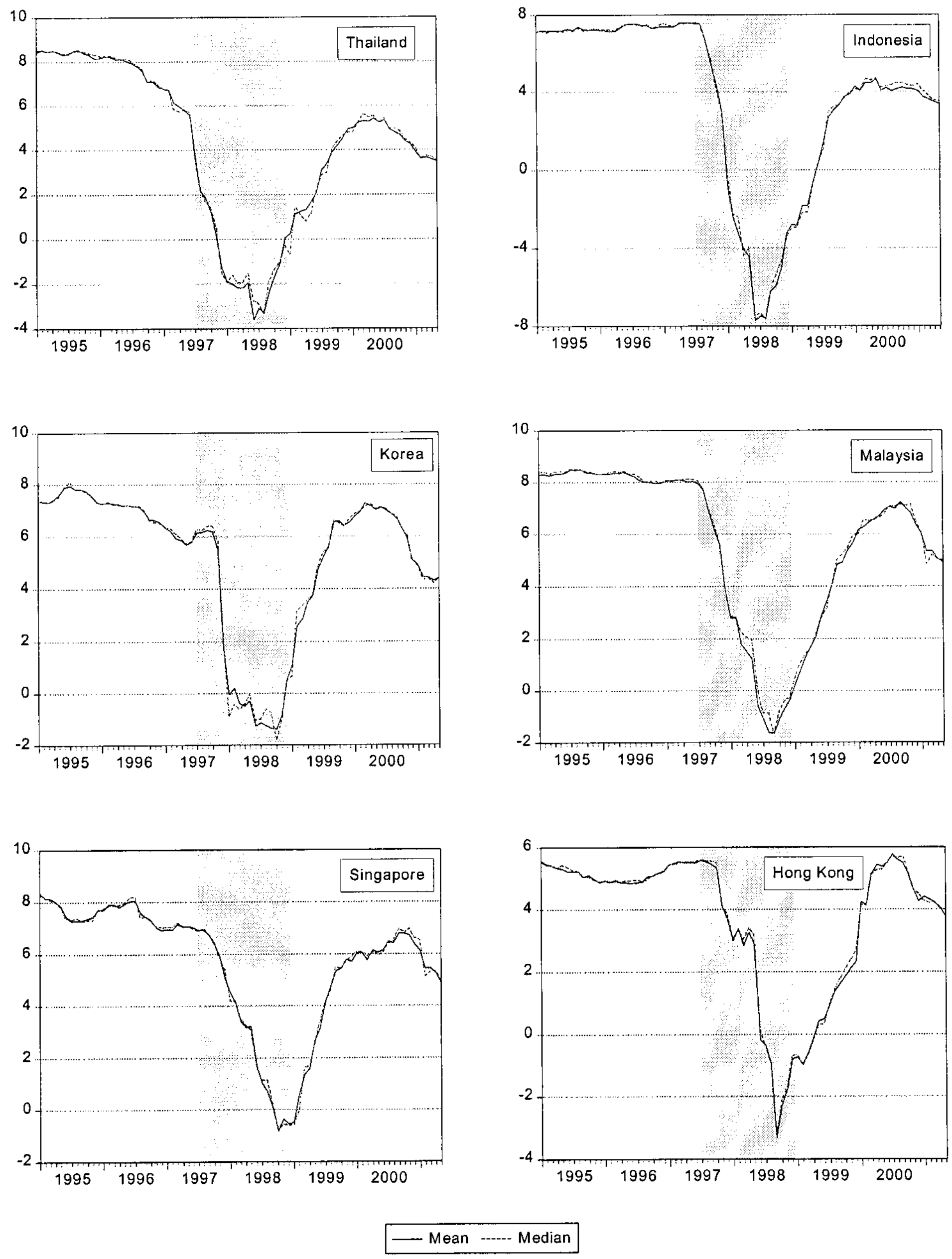


Figure 2. Standard Deviation and Mean Absolute Median Difference of GDP Growth
(weighted average of current and following year forecasts; 1995:01-2001:05)

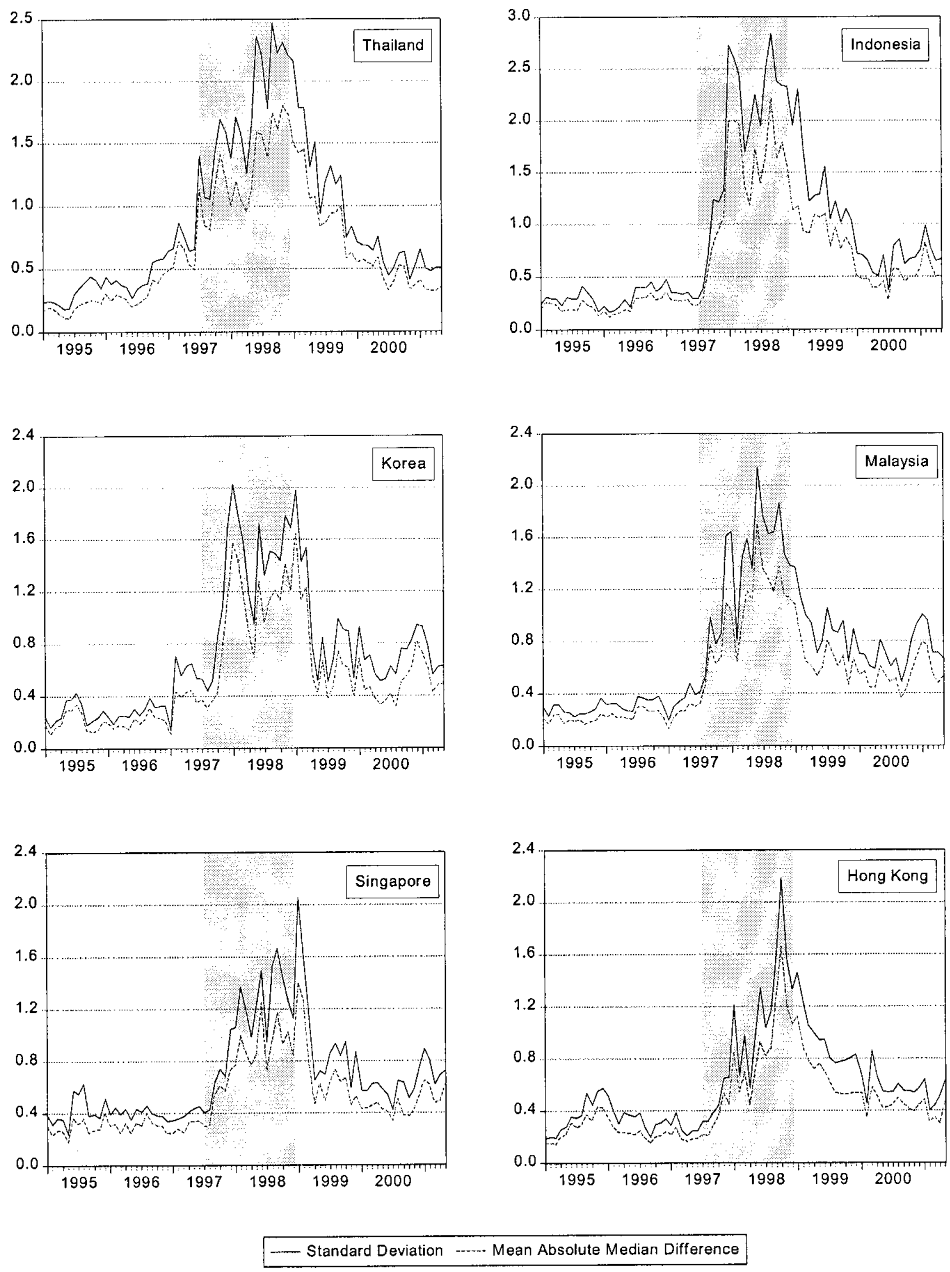
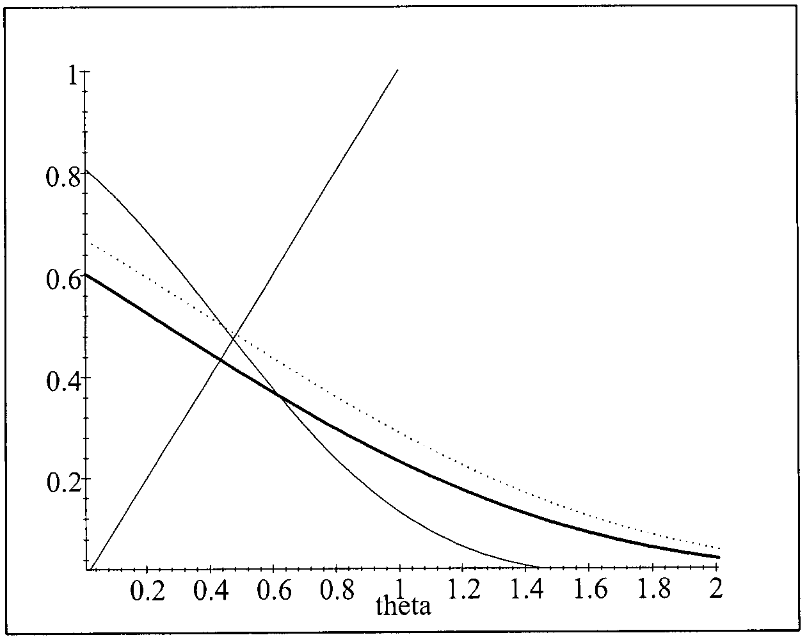


Figure 3. Effects of an Increase in β for y "Good"



Note: the thick line is the share of attackers (as a function of θ) for $\alpha = \beta = t = 1$, $D = 2$, and $y = 0.6$ (y is "good" since $x^* \simeq 0.268$). The thin line is the share of attackers for β increased to 4 (x^* raises to 0.444). The dotted line singles out the *indirect effect* of β as it shows the share of attackers with the new $x^* = 0.444$ and the old $\beta = 1$.

Figure 4. Indices of Exchange Rate Pressure
(1995:01 - 2001:05)

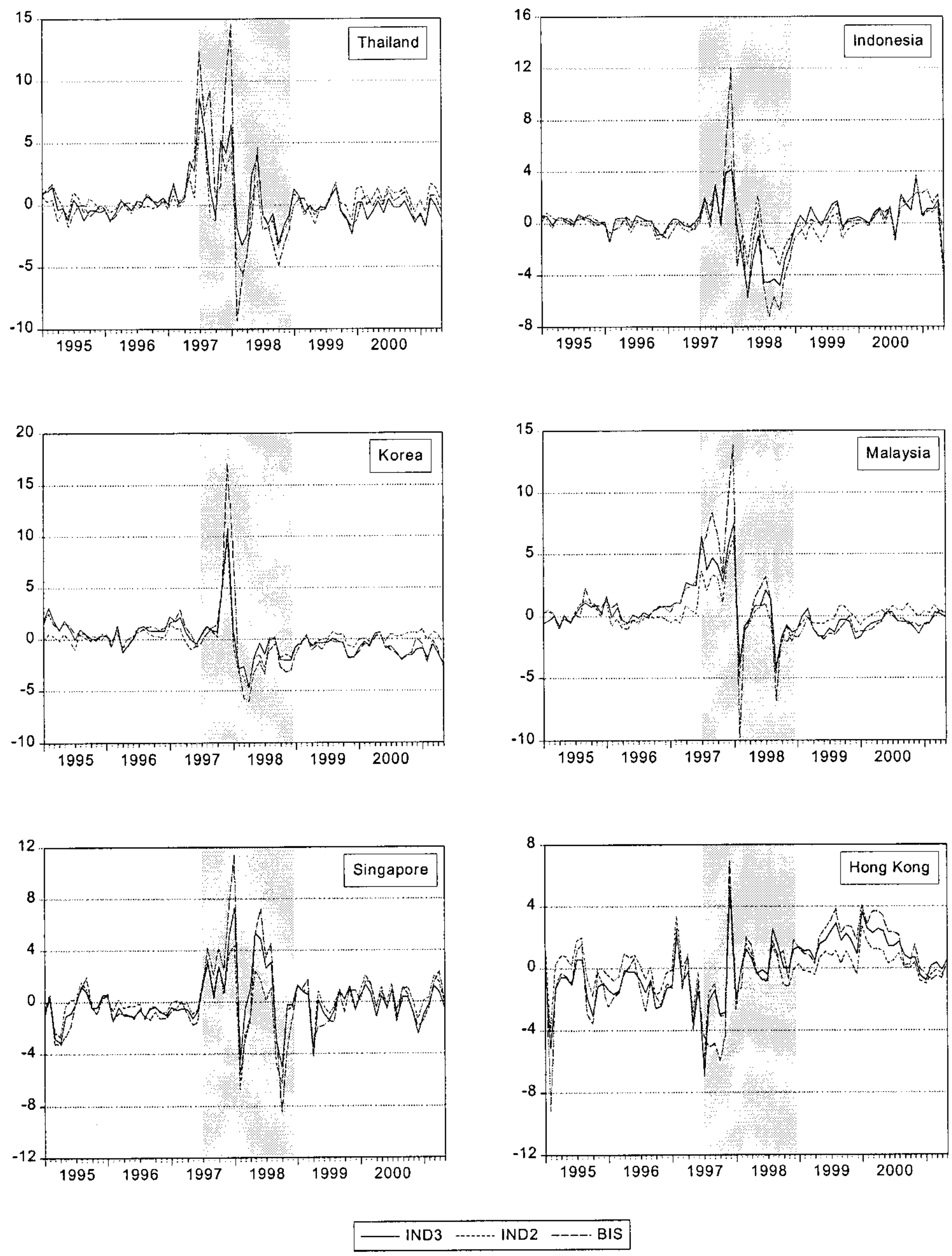


Figure 5. Recursive Estimates of $\hat{\gamma}_1$ and $\hat{\gamma}_2$
(1995:08-2001:05)

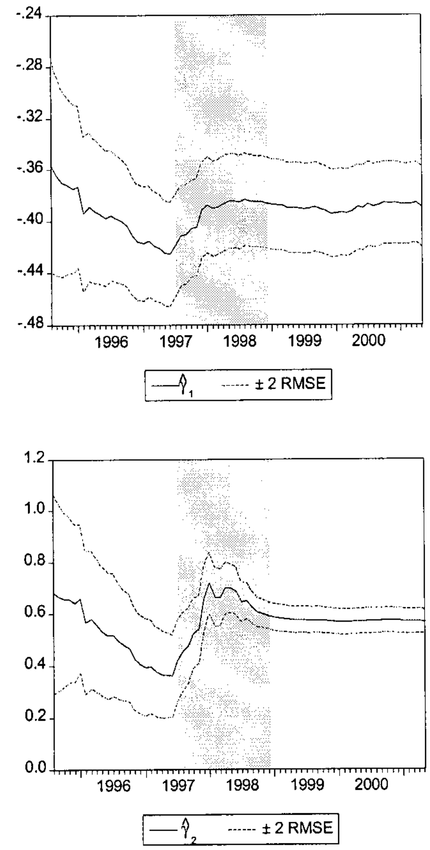


Figure 6. Recursive Estimates of the Threshold
Separating High from Low Expected GDP Growth
(1996:07 - 2001:05)

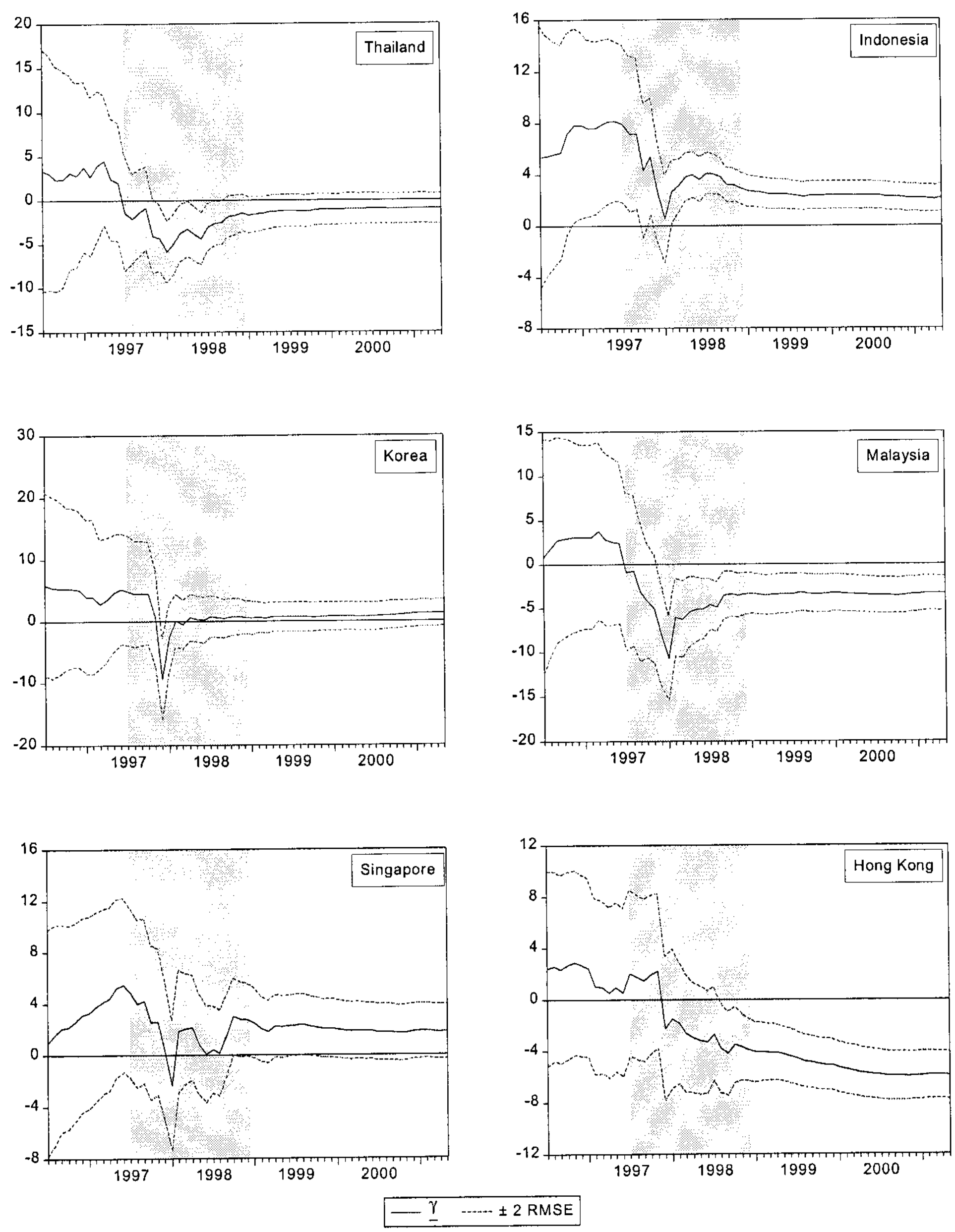


Figure 7: Overall Effect of Uncertainty on Exchange Rate Pressures in Estimates with Recursive Threshold (1996:07-2001:05)