

Do High Interest Rates Deter Speculative Attacks? ----Theory and Evidence*

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Abstract

This paper presents a signaling model of raising the interest rate as a deterrent to speculative attacks and then tests the model using a dataset that covers 54 countries from March 1964 through December 2000. Incorporating uncertainty over the speculator's type into a standard signaling model, we are able to show that unsuccessful signaling can be equilibrium behavior in either our pooling equilibrium or our semi-separating equilibrium. The model also implies that, although it is still possible for a weak monetary authority to hide his type in a pooling or semi-separating equilibrium, in both cases, the weak monetary authority faces a higher probability of an attack. In the empirical part of our paper, we find evidence that raising interest rates in advance has different impacts in different country groups. It significantly reduces the probability of attacks in countries that have a de facto hard peg but increases it in de facto soft-pegging countries. This finding is robust to alternative measure of monetary policy and to different specifications and samples. These results clearly support the predictions of the theoretical model.

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1. Introduction

Can raising interest rates ex-ante deter speculative attacks? Is the effect of interest rate signaling the same for all monetary authorities? If interest rate signaling is costly, why do we seem to see monetary authorities often use it to no effect?

Recent work (Drazen (1999), Drazen (2001), Angeletos et al. (2003)) emphasizes the signaling effect of high interest rates as a deterrent. In these papers, a monetary authority can potentially deter a potential attack in the first place by raising short-term interest rates ex ante to signal its willingness and ability to defend the currency.¹

These papers make important contribution to the literature by correctly pointing out the signaling effect of high interest rates. However, there is still room for further progress. First of all, none of these models is able to justify the failed signaling observed in reality without relying on out-of-equilibrium beliefs.² More importantly, they predict that the signal sent by different types of government will be equally effective, which, as we will see, is an idea that is strongly rejected by the empirical evidence we present below.

In the theoretical part of our paper, we incorporate uncertainty over the speculator's type to the standard signaling model. This simple modification generates novel results. It allows us to show that monetary authorities can be attacked in either a pooling equilibrium or a semi-separating equilibrium even when they signal. Therefore, the ex ante rationality of failed signaling can be justified in our model without relying on out-of-equilibrium beliefs. Further, we are also able to show explicitly that signaling is more effective for countries that have a strong commitment to exchange rate stability. This prediction is strongly supported by the evidence found in the empirical part of our paper.

¹ Many other papers study the effectiveness of an interest rate defense once an attack has been launched, which is a different issue than what we study here. See for example, Bensaid and Jeanne (1997), Flood and Jeanne (2000), Lahiri and Vegh (2003), and Grier and Lin (2005).

² Failed signaling can be justified in a semi-separating equilibrium in other standard signaling models.

Existing empirical studies in the literature have focused on testing whether raising interest rates influences the outcome of a speculative attack.³ In this paper we present the first empirical evidence on whether raising interest rates ex-ante can deter a speculative attack. Drawing evidence from a large unbalanced panel dataset that includes 54 countries over the period from March 1964 through December 2000, we find robust evidence that high rates do reduce the probability of a potential speculative attack in countries that have a credible de facto fixed exchange rate regime but not in soft-pegging countries. This evidence supports the predictions of our theoretical model.

The paper proceeds as follows: Section 2 provides a review of the literature. In Section 3, we present our theoretical model. Section 4 discusses data issues, section 5 contains our results, and section 6 concludes.

2. The Literature

Our paper develops a new twist on signaling models of interest rate defenses and then provides empirical evidence that supports the model. In this section we first review the theoretical papers that motivate our work and then the empirical papers closest to what we do.

A. Theory

The signaling hypothesis was first formalized by Allan Drazen. In a series of papers (Drazen 1999, 2001), he argues that a major effect of high interest rates is as a signal of the government's willingness or ability to defend the exchange rate. Given imperfect information about the government characteristics, speculators use observed government policies to update the probability they assign to future devaluation. Thus, a high interest

³ These studies include Kraay (2003), Hubrich (2000), and Drazen and Hubrich (2003).

rate can signal the government's high value of the peg or strong fiscal position and can potentially deter a speculative attack.

Angeletos et al. (2003) study the effectiveness of signaling in environments where market participants play a global coordination game with information heterogeneity. In their model, signals are received by speculators with idiosyncratic noise and government policy is endogenous. There is an inactive-policy equilibrium in which speculators coordinate on “ignoring” any attempt of the government to affect market behavior and the government chooses not to signal. This happens when the fundamentals are either very strong or very weak. If the fundamentals are neither too weak nor too strong, there exists a continuum of active-policy equilibria in which the government chooses to signal. Upon observing the signal, the speculators coordinate on either an aggressive or a lenient course of action. In an “active-policy” equilibrium, the government has to raise the interest rate to a certain level, which is determined by arbitrary aggressiveness of speculators, to meet the market expectation and thus avoid attacks.

As discussed earlier, these models all have difficulty allowing failed signaling, which seems to be often observed in reality as an equilibrium phenomenon. We resolve this difficulty in our model by allowing speculators to vary across two types with their type being private information.

B. Empirical Work

While direct empirical testing of this issue has not been done, there are related empirical studies which investigate whether high interest rates help defend currencies during speculative attacks. Kraay (2003) is probably the most influential examination of this issue. In his statistical analysis, he finds no evidence that high interest rates either

help or hinder defending an exchange rate peg.

Hubrich (2000) argues that Kraay's result is due mainly to how he defines the policy variable. Using variations of Kraay's policy variables, he finds significant, but contradictory, results. In his paper, raising discount rates significantly lowers the chances of a successful defense but reducing domestic credit significantly helps defend the exchange rate.

Drazen and Hubrich (2003) argue that such direct tests of the effectiveness of interest rate defenses are likely to get inconclusive results because they confound two competing effects. By disaggregating the impact of interest rate defense into the effects on future interest rates differentials, expectation of future exchange rates, and risk premia, they find that raising the interest rates strengthens the exchange rate over the short-run but leads to an expected depreciation and an increase in the risk premium at a horizon of a year and longer.

Furman and Stiglitz (1998) use daily data on interest rates and exchange rates of nine emerging economies from January 1992 to June 1998 to test whether high interest rates help defend the domestic currency. They find a negative relationship between either the magnitude of the interest rate hike or its duration and the eventual outcome of the exchange rate.

Using daily data for five Southeast Asian countries, Goldfajn and Baig (1998) fail to find any significant impacts of monetary policy on exchange rates. Using weekly data from Indonesia, Korea, Malaysia, the Philippines, Thailand, and Mexico, Gould and Kamin (2000) find that credit spreads and stock prices have significant impacts on exchange rates during financial crises, while interest rates do not.

In sum, evidence that interest rate increases significantly help monetary authorities win speculative attacks is mixed at best, while do date, there is no existing evidence on our question of interest: can ex-ante interest rate increases deter attacks?

3. A Simple Model of Signaling

To fix ideas and directly motivate our empirical tests, we present a simple two-stage signaling model. We show that, in both a pooling and a semi-separating equilibrium, both types of monetary authorities would signal, but one type of monetary authority can more effectively deter an attack than the other. In a separating equilibrium, only one type signals and deters attacks successfully.

A. Setup of the Model

There are two risk-neutral agents, a monetary authority and a representative speculator. The monetary authority has two possible types: Strong ($\theta = 1$) and Weak ($\theta = 2$). The strong monetary authority has a higher level of commitment to exchange rate stability than does the weak monetary authority. There are also two types of speculator: an informed speculator who can directly observe the monetary authority's type, and an uninformed speculator who cannot. The speculator's type is private information to both types of monetary authority, while by construction the monetary authority's type is only private to the uninformed speculator. Uncertainty over the speculator's type turns out to be crucial for generating ex ante rational, but unsuccessful, signaling in a pooling equilibrium or in a semi-separating equilibrium. Let s denote the prior probability that the monetary authority is strong and p denote the prior probability that the speculator is informed.

The model has two stages. In the first stage, the monetary authority chooses the interest rate. In the second stage, the speculator decides whether to launch an attack or not after observing the interest rate.⁴ Although the observed interest rate does not give any new information to the informed speculator, it can still be used by the uninformed speculator to update his prior belief, $\mu(\theta = 1) = s$.

Assuming no discounting, a monetary authority's loss function can be written as:

$$L_\theta = C(r) + ZV_\theta \quad \theta = 1; 2$$

where Z takes on the value one if a speculative attack occurs at the second stage and zero otherwise. $C(r)$ is strictly increasing for any $r \geq 0$ and $C(0) = 0$. This represents the cost of signaling for the monetary authority (the economic costs associated with deviating from the optimal interest rate). For simplicity, the optimal interest rate is normalized to be zero and the cost of signaling is assumed to be the same for both types of monetary authorities. V_θ can be interpreted as the expected cost (weighted cost conditional on the outcome) of defending the peg after an attack. As noted when describing the policymaker types, we assume that $V_1 > V_2$ (strong policymakers have a greater commitment to the peg than do weak policy makers).

Both types of speculators share a common payoff function:

$$U = Z(\pi M - K)$$

where Z is the indicator variable defined above. K can be interpreted as a fixed cost associated with launching a speculative attack. M is the potential benefit to the speculator if an attack turns out to be successful and is assumed to be greater than K .

π is the probability of a successful attack. Without loss of generality, the probability is

⁴ Allowing speculator to signal its own type before the monetary authority moves will not change the results of our model for there is no need for the informed speculator to reveal or hide its type.

assumed to be zero if the monetary authority is strong and one if the monetary authority is weak. Therefore, an informed speculator always attacks weak types but never attacks strong types. $C(r), V_1, V_2, K, M, p$ and s are all assumed to be common knowledge.

B. Solving for Equilibria

First, we solve for the separating equilibria of the model. A separating equilibrium is one where the two types of monetary authorities choose different actions in the first stage. The weak monetary authority will choose not to raise the interest rate because it is too costly for him to imitate the strong monetary authority. As a result, upon observing the interest rate any speculator can correctly infer the type of the monetary authority.

Therefore, the conditions for a separating equilibrium are:

$$(1-p)V_1 \geq C(r^*) \geq (1-p)V_2, \quad \mu(\theta = 1 | r = r^*) = 1, \quad \mu(\theta = 1 | r \neq r^*) = 0$$

The first condition states that, for a strong monetary authority, the cost of raising the interest rate to r^* at the first stage is less than the expected cost of not doing so. The second condition ensures that it does not pay for a weak monetary authority to imitate a strong monetary authority because the expected total loss conditional on signaling ($pV_2 + C(r^*)$) exceeds the expected loss of no signaling (V_2).⁵ Upon observing the interest rate, the uninformed speculator will assign a probability, $\mu(\theta = 1 | r = r^*) = 1$ and $\mu(\theta = 1 | r \neq r^*) = 0$ to the monetary authority's type.

It is easy to see that, for certain functional forms of $C(r)$ and values of V_1, V_2, K and M , there exists a continuum of separating equilibria in which a strong monetary authority chooses an interest rate r^* , $r^* \in [r_2, r_1]$, where $r_2 = C^{-1}((1-p)V_2)$ and

⁵ Note that the existence of a potential informed speculator at the second stage reduces both types of monetary authorities' incentive to signal.

$r_1 = C^{-1}((1-p)V_1)$, and a weak monetary authority chooses the optimal interest rate at the first stage. Both types of speculator would attack (not attack) the weak (strong) type.

Next, we solve for the pooling equilibria of the model. In a pooling equilibrium, both types of monetary authority would choose to signal at the first stage so the signal does not help an uninformed speculator update his prior belief. Therefore, there exists a continuum of pooling equilibria if:

$$r^* \in [0, r_2], \text{ and } \mu(\theta = 1 | r = r^*) = \mu(\theta = 1) = s > (M - K)/M, \mu(\theta = 1 | r \neq r^*) = 0$$

The first condition states that both types of monetary authority would find it profitable to signal. The next one ensures that an uninformed speculator would not attack at the second stage upon observing the signal. Note that in our pooling equilibrium the weak monetary authority will be attacked with probability p , the probability that the speculator is informed, even if he signals. However, signaling is still rational ex ante. Therefore, our model allows unsuccessful signaling in equilibrium.

No pooling equilibrium exists when $s < (M - K)/M$. However, there is a continuum of semi-separating equilibria in which the strong monetary authority signals and the weak monetary authority and the uninformed speculator play mixed strategies. The weak monetary authority randomly signals with probability q to make the uninformed speculator indifferent between attacking and not attacking in equilibrium and the uninformed speculator randomly attacks with a probability t so that the weak monetary authority will find itself indifferent between signaling and not signaling. The strong monetary authority still signals. The uninformed speculator updates his belief upon observing the monetary authority's action according to Bayes rule. Therefore, the conditions for having these equilibria are:

$$s < (M - K) / M, \quad r^* \in (0, r_2], \quad q = Ks / [(M - K)(1 - s)], \quad t = [(1 - p)V_2 - C(r^*)] / (1 - p)V_2,$$

$$\mu(\theta = 1 | r = r^*) = s / [s + (1 - s)q], \quad \mu(\theta = 1 | r \neq r^*) = 0$$

The first condition ensures that no pooling equilibrium exists. The next five conditions ensure that the strong monetary authority signals, the weak monetary authority is indifferent between signaling and not signaling, and the uninformed speculator is indifferent between attacking and not attacking. In a semi-separating equilibrium, both types can be attacked. The probability of attack for a strong monetary authority is $(1 - p)t$ while the probability of attack for a weak monetary authority is $p + (1 - p)t$.

This model, though simple, has important implications that are not found in the existing literature. In particular, our model allows for ex ante rational failed signaling without relying on any out-of-equilibrium beliefs. The other novel feature of the model is that it gives an explicit prediction on the relative effectiveness of signaling. We show that in either a pooling equilibrium or a semi-separating equilibrium, the probability of attack for a weak monetary authority who signals is greater than that for a strong monetary authority who signals.

This is exactly what we want to test in the following empirical part of our paper: do countries with strong preferences for exchange rate stability deter attacks by raising rates more effectively than countries with less strong preferences?

4. Data Issues

A. Sample Coverage and Data Sources

The unbalanced panel dataset that we created for this study covers 54 countries, both developed and developing, from March 1964 to December 2000. The data are drawn from the International Monetary Fund's *International Financial Statistics on CD-ROM*

(IFS) (February 2004 version), Penn World Tables 6.1, and the Polity 4 database. Detailed data sources are listed in the data appendix.

B. Identifying Speculative Attacks

In order to test the signaling hypothesis, we first have to identify speculative attacks. Our identification method follows that of Kraay (2003). However, we do three things that make our sample differ from Kraay's. First, we include lower income countries, as well as middle and upper income countries, into our sample for we do not see any obvious benefit in excluding these countries. Second, our sample covers a longer period, from March 1964 to December 2000. Third, and probably most important, we restrict our sample to countries that can reasonably be considered to have a fixed exchange rate to defend, which Kraay does not explicitly do.⁶

Theoretically, the exchange rate is not a policy objective of the monetary authority under a freely floating exchange rate regime. It is determined by the market. The monetary authority is not obligated to maintain the exchange rate at a certain level. In our view, it only makes sense to speak about speculative attacks and crises prevention in fixed exchange rate regimes. This issue is complicated, as recent research shows that the official classification of exchange rate regimes reported by the IMF's *Annual Report on Exchange Rate Arrangements and Exchange Restrictions* often fails to describe actual country practice.⁷ In particular, countries that have a *de facto* peg or crawling peg are often classified as floaters. To avoid this problem, we use Reinhart and Rogoff (2003)'s

⁶ Kraay restricts his sample to countries that have relatively stable nominal exchange rates 12 months prior to an attack though. However, the method is far from perfect and does identify some attacks in periods during which a country's exchange rate regime was freely floating. For example, Kraay identifies a successful attack in South Africa in July 1998 even though that country has had a freely floating regime ever since March 1995, according to Reinhart and Rogoff's *de facto* classification.

⁷ See Calvo and Reinhart (2002), Levy-Yeyati and Sturzenegger (2003) and Reinhart and Rogoff (2003).

de facto classification of exchange rate regimes.⁸ They classify different exchange rate arrangements into five broad categories, hard peg, soft peg, managed floating, freely floating and freely falling, according to their flexibility. We focus our attention primarily on the first two regimes. But we do extend our sample to including managed floating later as a robustness check.

Applying Kraay's method to our sample, we identify a total of 38 successful attacks and 60 failed attacks in countries whose exchange regime is either a hard peg or a soft peg. These attacks are listed in Table 1. Table 1 also lists speculative attacks that are identified in countries whose exchange rate regime is managed floating. There are an additional 15 successful and 24 failed attacks that fall into this category. These additional attacks will be used later as a robustness check of our empirical results.

C. Measures of Monetary Policy Signals and Policymaker Type

We use the monthly change in the central bank discount rate (*DIR*) as our primary measure of changes in monetary policy. These nominal discount rates are expressed as spreads over German (U.S.) nominal interest rates for the European (non-European) countries. In order to check the robustness of our empirical results, we also create an alternative measure of monetary policy. It is constructed as the monthly change in domestic credit growth (*DCCG*).

Our model predicts that, on average, interest rate signaling will affect attack decisions differently depending on whether the signal comes from a strong or weak monetary authority, where in this context strong means a greater commitment to the fixed

⁸ We use Levy-Yeyati and Sturzenegger (2003)'s classification for Bangladesh, Rwanda and Trinidad and Tobago because they are not available in Reinhart and Rogoff (2003). We treat a regime as hard peg, soft peg, or managed floating if it is classified as fixed, dirty floating/crawling peg, or dirty floating in Levy-Yeyati and Sturzenegger (2003). None of our results on interest rate signaling changes if we simply drop these three countries from the sample and use only Reinhart-Rogoff classified countries.

exchange rate regime. We operationalize the theoretical policymaker types by dummy variables for whether the country has a “hard” peg (corresponding to the strong type) or “soft” peg (the weak type) according to the Reinhart-Rogoff classification.⁹ The test of our model will be whether ex-ante signaling by *de facto* hard peggers is more effective in deterring attacks than when the signal is sent by a soft pegger.

D. Economic and Political Control Variables

We have discussed how we measure attacks and how we measure signaling. We wish to estimate an equation where the probability of an attack is affected by policy signaling, and the effect differs by the value each monetary authority places on maintaining the peg, which we measure by whether their peg is “hard” or “soft”.

We also want to include other control variables in the models. Our first such variable (*REROV*) is a measure of real exchange overvaluation constructed as the growth rate of the real effective exchange rate in the previous 12 months. This variable should have a positive influence on the probability of an attack as overvalued exchange rates are ultimately unsustainable.

The second control variable that we employ is a measure of adequacy of reserves (*RESIMP*). It is defined as total non-gold reserves relative to monthly import values. We expect *RESIMP* to have a negative effect on attack probabilities. Other things equal, higher reserves should discourage attacks.

The third control variable is defined as deviation of real per capita GDP growth in a country from its average in the five preceding years (*DGROWTH*). This variable is used

⁹ Given how we make the policymaker type operational, it would be fair to say that in our model, an informed speculator could be one that has read Calvo and Reinhart and Reinhart and Rogoff (or always knew the information contained therein), while the uninformed speculator is one that only had access to the official IMF listings.

to capture where a country is in any business cycle prior to the speculative attack.¹⁰ We create this variable because the cost of adopting tight monetary policies during a recession can be much higher than during a boom. The variables should have a negative effect on the probability of an attack.

The fourth control variable that we consider is a dummy variable for capital controls (*KAPCON*). This dummy variable takes on the value one if a country has restrictions on capital account transactions and zero otherwise. The effect of capital control on currency crisis is controversial in the literature. According to conventional wisdom, capital control reduces the probability of attacks by limiting volatile short-term capital flows and helping government buy time to improve the fundamentals.¹¹

Beyond economic aggregates, political factors may have significant effects on speculators' attack decision or the monetary authority's cost of signaling. For these reasons, we also include a measure of democracy (*DEMOC*) in our statistical models.¹² It is an eleven-point index that ranges from 0 to 10. A high index number represents a high level of democracy. The idea captured with this variable is that countries where the government can be removed by voters can less easily afford to defend against attacks, as defense measures are often stringent and generally unpopular with the electorate. Therefore, they are more likely to be attacked.

Due to publication lags or other information imperfection, contemporaneous information on the fundamentals is often unavailable for potential speculators in reality.

¹⁰ Since GDP data is only available annually, we use lagged variable in our regression. Using interpolated data does not significantly change our results.

¹¹ However, Glick et al. (2004) show that countries without controls have a lower likelihood of currency crisis after controlling for self-selection bias using a matching and propensity score methodology.

¹² We have also considered other political characteristics such as partisanship and policy decisiveness. We did not include them in our statistical models because we cannot find any significant impacts of these variables.

Therefore, we use lagged control variables rather than contemporaneous control variables in our statistical model.¹³ Table 2 provides the summary statistics of all the variables used in this study.

5. Empirical Results

A. The Baseline Model

As a first step, we consider the following simple baseline model:

$$ATTACK_{i,t}^* = \alpha_0 + \alpha_1 DMP_{i,t-1} + \alpha_2 F_{i,t-1} + v_{i,t} \quad (1)$$

where $ATTACK_{i,t}^*$ is a latent variable representing the propensity to launch an attack. We cannot not observe $ATTACK_{i,t}^*$, but we do observe an indicator variable $ATTACK_{i,t}$ which equals one if $ATTACK_{i,t}^* > 0$ and zero otherwise. In this case, $ATTACK_{i,t}^* > 0$ if an attack occurs. DMP is a measure of change in monetary policy. Since our goal is to test the signaling hypothesis, we are interested in the effects of monetary policies prior to a potential attack. For this reason, we use lagged changes in monetary policy in equation (1). F is a vector representing our economic and political control variables. v is a random error term with zero mean and variance σ^2 , which might be either logistically or normally distributed.

Since the dependent variable is a binary choice variable, the standard methodology would be to run a probit or logit model. This standard methodology, however, is not appropriate for this particular case. As is well known, standard finite sample maximum-likelihood estimates of probit or logit are biased. This bias vanishes as the sample size gets larger. However, King and Zeng (2001 a, b) show that this finite sample bias can be

¹³ Since observations on GDP, capital control, and democracy score are only available annually. We use the variables obtained in year t-1 for year t in our regressions.

greatly exaggerated when one observed choice occurs rarely in the data. They develop a method called “rare-events-logit” to correct this enlarged bias. Our sample contains a total of 6845 observations. The dependent variable takes on the value of one in only 98 out of these 6845 total possibilities. We, therefore, apply the rare-events-logit approach.

The first panel of Table 3 shows the regression results for the baseline model using a standard logit model.¹⁴ The two Wald Chi-square statistics are 55.46 and 55.56, respectively, indicating that the overall models are significant at 1% level. All control variables have expected signs. *REROV*, *RESIMP*, and *DEMOC* are significant, meaning that countries that have low reserves, high real exchange overvaluation, or a more democratic political system are more likely to be attacked. *KAPCON* has a positive but insignificant effect.

In terms of the monetary policy variables, the change in the discount rate is positive and statistically significant at 1% level. This evidence suggests that raising discount rates in advance actually increases the probability of a speculative attack. The estimated marginal effect is shown in brackets. Holding other variables at their means, a one percent increase in discount rate from its mean increases the probability of a speculative attack roughly from 0.82% to 0.85%. The change in domestic credit growth is positive but insignificant.

As discussed earlier, given the nature of our data, the logit estimates can be biased towards zero. In order to correct the potential bias due to rareness of observed attacks, we re-estimate equation (1) using the rare-events-logit model. The second panel of Table 3

¹⁴ We also estimate equation (1) using the probit model. The results are very close to those from the standard logit model and thus not reported here.

reports the results from the rare-events-logit regression.¹⁵ We get similar results for both the control variables and the monetary policy variables. The change in the discount rate is positive and significant while the change in domestic credit growth is still insignificant. In this model, raising the discount rate from its mean by one standard deviation (percent) increases the probability of a speculative attack roughly from 0.82% to 0.94% (0.86%). Clearly, this initial evidence does not show any general beneficial effects of tight monetary policy.

B. Testing our model's prediction

The baseline model shows the overall effects of tight monetary policy on speculators' attack decision but we are more interested in testing the conditional effects in different country groups.

Our model predicts that high rates should be more effective in deterring speculative attacks for countries that have a strong commitment to exchange rate stability. We have argued that countries with hard pegs care more about exchange rate stability than those with soft pegs. Therefore, if our model is correct, we expect to find a larger deterrent effect of high rates in these countries. To test this idea, we split the full sample into two subsamples according to their exchange rate regimes. We then run a rare-events-logit regression of equation (1) for each subsample.¹⁶ The results are shown in the first two rows of Table 4. The two panels in Table 4 correspond to the two measures of monetary policy. To save space, we only report the coefficients, standard errors and marginal effects of monetary policy variables.

An interesting result stands out: the effects of high rates are found to be significant

¹⁵ The models are estimated using the `relogit` program written by Tomz et al. (1999) for Stata. It does not report the overall significance of the model.

¹⁶ Exchange regime dummy is dropped for these regressions to avoid perfect multicollinearity.

but opposite in these two groups. In the hard peg subsample (*HARDPEG*), the coefficient on the discount rate is negative and the coefficient on domestic credit growth is positive. They are also both statistically significant. This result suggests that raising the discount rate or reducing domestic credit growth in advance lowers the probability of speculative attacks in countries that have de facto hard pegs. The estimated marginal effects show that, holding other independent variables at their means, raising discount rate (lowering domestic credit growth) by one standard deviation from its mean can lower the probability of a speculative attack from roughly 0.57% (0.56%) to 0.47% (0.44%). By contrast, the effect of high rates is significantly different in the soft peg (*SOFTPEG*) subsample in that raising the interest rate increases the probability of being attacked. Thus we find significant support for the predictions of our model.

C. Decomposing the Overall Effect in the Full Sample

The above subsample evidence suggests that an effective signaling effect exists in countries that have *de facto* hard pegs. As a formal test, in this section we re-estimate equation (1) using the full sample and replacing the monetary policy variable with two interaction terms of monetary policy and exchange rate regimes. This specification allows us to investigate the decomposed effect of high rates for each exchange rate regime. Table 5 reports the results. The interaction term between the discount rate and a *de facto* hard peg regime, $DIR * HARDPEG$, is negative and significant at 1% level. This evidence, again, suggests that high rates can effectively reduce the probability of a potential speculative attack in countries that have a *de facto* hard peg regime. The interaction term of discount rate and the soft peg exchange rate regime is also significant but with a positive sign, indicating that raising interest rates increases the probability of

speculative attacks.¹⁷ Overall, the above evidence shows that signaling has different effects for hard peggers and soft peggers. Specifically, hard pegger signaling deters attacks while soft pegger signaling does not.

D. Robustness Checks

This section checks the robustness of our empirical results and their sensitivity to different specifications and samples. Since it could be argued that speculative attacks can possibly occur in countries that have a managed floating regime, our first robustness check is to extend our sample to including these countries. This extended sample contains 9917 observations with 137 attacks. The rare-events-logit regression results are reported in Table 6.

The evidence remains strong in the extended sample as both $DIR * HARDPEG$ and $DDCG * HARDPEG$ are significant and show that tight policy deters attacks in hard peg countries. It is also interesting to note that raising rates in managed floating countries increases the probability of attack even more than it does in soft peg countries. The general pattern is, the less commitment to the exchange rate regime, the less effective is interest rate signaling.

To further investigate the robustness of our results, we divide the full sample into two subsamples. One subsample contains only OECD countries and the other contains only non-OECD countries. We run the same regressions for both subsamples. The results from these two subsamples are shown in Table 7 and Table 8.

These results are quite similar to those from the full sample as in both cases raising the interest rate significantly reduces the probability of attacks in the *de facto* hard peg

¹⁷ The two interaction terms between domestic credit growth variable and exchange rate regimes also reflect the idea that tight policy is a credible signal only in the hard pegging regimes, though the coefficients in this case are not significant.

countries but increases the probability in the soft peg countries. When comparing the two sets of results, it is interesting to note that a one standard deviation increase in the interest rate has a bigger deterrent effect in the OECD country sample, and that democracies are more prone to attacks only in the non-OECD sample.

All in all, the results here tell a very consistent story: countries with a high degree of commitment to their fixed exchange rate regime can help deter an attack via interest rate signaling in a way that other countries cannot.

6. Conclusion

This paper presents and tests a simple signaling model of high interest rates as a deterrent to speculative attacks. The theoretical model produces outcomes that are novel to in the literature. Assuming both agents have two possible types, our model is able to rationalize failed signaling in a pooling equilibrium or a semi-separating equilibrium without relying on any out-of-equilibrium beliefs. Our model also shows that, although it is still possible for a weak monetary authority to hide his type in a pooling or semi-separating equilibrium, the effectiveness of signaling for weak types, however, is much less effective than that for strong types. In both equilibria, the weak monetary authority faces a higher probability of attack. In the empirical part of our paper, we find strong evidence that raising interest rates in advance has significantly different impacts in different country groups. It reduces the probability of attacks in hard-pegging countries but increases it in soft-pegging countries. This finding is robust to alternative measure of monetary policy and to different specifications and samples. Our results lend support to the hypothesis proposed by our theoretical model.

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Data Appendix

Variable	Source	Description
Nominal Exchange Rate	IFS	local currency units per US dollar
Non-gold Reserves	IFS	in US dollar
Money Market Rate	IFS	
Discount Rate*	IFS	
Domestic Credit	IFS	in local currency units
Monthly Imports	IFS	in US dollar
CPI	IFS	
Real GDP per capita	Penn World Table 6.1	in US dollar
SOFT/HARDREG*/ MANAGEDFLOATING	Reinhart and Rogoff (2003)	<i>de facto</i> exchange rate regimes
DEMOC*	POLITY 4	an index of democracy ranges from 0 to 10
KAPCON	IMF's Annual Report on Exchange Rate Arrangements and Exchange Restrictions	a dummy variable takes on the value one if a country has restrictions on capital account transactions

Notes: We use Bank of England base rate for United Kingdom because its discount rate is not available in IFS after February 1981.

We use Levy-Yeyati and Sturzenegger (2003)'s exchange rate regime classification for Bangladesh, Rwanda and Trinidad and Tobago because they are not available in Reinhart and Rogoff (2003). We treat a regime as hard peg, soft peg, or managed floating if it is classified as fixed, dirty floating/crawling peg, or dirty floating in Levy-Yeyati and Sturzenegger (2003).

Hong Kong's economic data are drawn from the Hong Kong Monetary Authority. We use Singapore's democ score as a proxy for Hong Kong because it is not available in POLITY4.

Country List

COUNTRIES

Bangladesh	Denmark	Latvia	Rwanda
Belgium	Ecuador	Malaysia	South Africa
Benin	Egypt	Mauritius	Spain
Bolivia	Finland	Mexico	Sweden
Botswana	France	Morocco	Thailand
Brazil	Ghana	Nepal	Trinidad and Tobago
Bulgaria	Greece	Netherlands	Tunisia
Burundi	Hong Kong	Nigeria	Turkey
Cameroon	Indonesia	Norway	United Kingdom
Canada	Ireland	Pakistan	Uruguay
Chile	Israel	Peru	Venezuela
Colombia	Italy	Philippines	Zimbabwe
Costa Rica	Kenya	Poland	
Croatia	Korea	Portugal	

Table 1. Identified Successful and Failed Attacks**A. Identified Successful Attacks**

Country	Time	Country	Time	Country	Time
<u>Botswana</u>	1992M7	<u>Indonesia</u>	1997M9	Rwanda	1990M11
<u>Brazil</u>	1999M1	Israel	1989M1	<u>South Africa*</u>	1975M10
Burundi	1983M12	<u>Italy</u>	1992M11	<u>South Africa*</u>	1984M7
Canada	1992M11	Korea*	1971M7	South Africa*	1985M7
<u>Costa Rica*</u>	1981M1	Korea	1974M12	Spain	1967M11
<u>Denmark</u>	1993M8	<u>Korea</u>	1980M1	<u>Spain</u>	1982M12
<u>Ecuador</u>	1982M5	<u>Korea</u>	1997M11	<u>Spain</u>	1995M3
<u>Ecuador*</u>	1985M11	Malaysia*	1981M10	<u>Sweden</u>	1977M9
Egypt*	1989M8	<u>Mauritius</u>	1979M11	Sweden	1982M11
Egypt*	1991M2	<u>Mauritius</u>	1981M10	<u>Sweden</u>	1992M11
Finland	1967M10	<u>Mexico</u>	1994M12	<u>Thailand</u>	1984M11
<u>Finland</u>	1977M4	<u>Mexico*</u>	1998M9	<u>Thailand</u>	1997M7
<u>Finland</u>	1982M10	Nigeria*	1986M10	<u>Trinidad and Tobago</u>	1993M4
<u>Finland</u>	1991M11	Nigeria*	1999M1	Uruguay	1982M12
<u>Finland</u>	1992M9	<u>Norway*</u>	1986M5	<u>United Kingdom</u>	1992M9
Ghana	1967M7	Peru	1967M8	<u>Venezuela*</u>	1984M3
Ghana*	1972M1	Philippines	1970M3	<u>Venezuela*</u>	1986M12
Greece*	1983M1	<u>Philippines</u>	1997M8		

Notes: * denotes the attack is identified in countries that have a *de facto* managed floating exchange rate regime. __ indicates that this attack is also identified in Kraay (2003).

B. Identified Failed Attacks

Country	Time	Country	Time	Country	Time
<u>Brazil</u>	1997M11	<u>Greece</u>	1997M10	Philippines	1990M1
Brazil	1998M9	Hong Kong	1998M8	<u>Portugal</u>	1985M1
<u>Canada</u>	1976M3	<u>Indonesia</u>	1991M3	<u>Portugal</u>	1990M10
<u>Canada</u>	1978M2	Ireland	1997M4	<u>South Africa*</u>	1975M3
<u>Canada</u>	1981M7	Italy*	1980M2	<u>South Africa*</u>	1976M8
Canada	1982M2	<u>Italy*</u>	1981M5	<u>South Africa*</u>	1980M7
<u>Canada</u>	1984M6	<u>Italy</u>	1986M1	<u>South Africa*</u>	1981M9
<u>Canada</u>	1990M5	<u>Italy</u>	1990M12	South Africa*	1982M3
<u>Colombia*</u>	1995M12	<u>Korea</u>	1980M6	<u>South Africa*</u>	1982M9
<u>Costa Rica</u>	1979M8	<u>Korea</u>	1983M1	South Africa*	1983M3
<u>Denmark*</u>	1975M3	Korea	1986M1	South Africa*	1988M7
<u>Denmark*</u>	1976M9	<u>Korea</u>	1989M11	<u>Spain</u>	1987M5
Denmark*	1977M12	<u>Korea</u>	1996M8	<u>Sweden</u>	1976M4
Denmark	1980M2	<u>Malaysia*</u>	1980M9	Sweden	1976M10
Denmark	1984M12	Malaysia*	1986M8	<u>Sweden</u>	1980M2
<u>Denmark</u>	1987M2	<u>Mauritius</u>	1976M8	<u>Sweden</u>	1988M5
<u>Denmark</u>	1993M2	Mexico		<u>Sweden</u>	1990M2
Finland	1976M2	Morocco*	1980M8	<u>Sweden</u>	1991M11
Finland	1979M11	Morocco*	1982M9	<u>Thailand</u>	1978M2
Finland	1980M11	Morocco*	1985M4	<u>Thailand</u>	1984M1
Finland	1986M8	Netherlands	1976M7	<u>Thailand</u>	1985M3
Finland	1990M11	<u>Netherlands</u>	1979M12	<u>Thailand</u>	1990M9
Finland	1991M5	<u>Netherlands</u>	1981M8	<u>Thailand</u>	1992M9
France	1968M10	<u>Norway*</u>	1976M4	<u>Thailand</u>	1994M6
France	1969M10	<u>Norway*</u>	1979M6	<u>Trinidad and Tobago</u>	1988M1
<u>France</u>	1979M9	<u>Norway*</u>	1992M11	<u>Trinidad and Tobago*</u>	1994M5
<u>Greece</u>	1988M3	Pakistan	1991M3	<u>Tunisia</u>	1991M4
<u>Greece</u>	1989M5	<u>Philippines*</u>	1983M2	<u>Uruguay</u>	1998M9

Notes: * denotes the attack is identified in countries that have a *de facto* managed floating exchange rate regime. __ indicates that this attack is also identified in Kraay (2003).

Table 2. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ATTACK	6845	0.0140	0.1176	0	1
DIRt-1	6845	-0.0690	2.4959	-84.2000	95.0000
DDCGt-1	6845	-0.2969	12.2017	-185.3830	90.2631
DGROWTH	6845	-0.0386	4.8054	-34.7229	52.2454
REROV	6845	0.0523	2.8515	-35.3055	82.7842
RESIMP	6845	4.0526	4.6304	0.0071	46.5559
DEMOC	6845	6.3644	4.0553	0	10
KAPCON	6845	0.7313	0.4433	0	1
HARDPEG	6845	0.4383	0.4962	0	1
SOFTPEG	6845	0.5617	0.4962	0	1

Table 3. The Baseline Model

	LOGIT		RARE-EVENTS-LOGIT	
	DMP=DIR	DMP=DDCG	DMP=DIR	DMP=DDCG
CONSTANT	-4.8557*** (0.5327)	-4.8554*** (0.5307)	-4.8038*** (0.5320)	-4.8040*** (0.5300)
DMPt-1	0.0418*** (0.0148) [0.0003]	0.0013 (0.0038) [0.00001]	0.0527*** (0.0148) [0.0012]	-0.0002 (0.0038) [0.00002]
DGROWTH	-0.0313 (0.0223) [-0.0003]	-0.0309 (0.0222) [-0.0003]	-0.0331 (0.0223) [-0.0013]	-0.0328 (0.0222) [-0.0012]
REROV	0.2506*** (0.0458) [0.0020]	0.2491*** (0.0458) [0.0020]	0.2484*** (0.0457) [0.0088]	0.2471*** (0.0458) [0.0088]
RESIMP	-0.1104** (0.0460) [-0.0009]	-0.1105** (0.0457) [-0.0009]	-0.1025** (0.0459) [-0.0032]	-0.1026** (0.0456) [-0.0033]
KAPCON	0.1720 (0.1897) [0.0014]	0.1804 (0.1883) [0.0014]	0.1605 (0.1895) [0.0014]	0.1758 (0.1881) [0.0015]
DEMOC	0.1033** (0.0496) [0.0008]	0.1034** (0.0494) [0.0008]	0.0993** (0.0495) [0.0009]	0.0994** (0.0493) [0.0009]
HARDPEG	-0.6475 (0.4071) [-.0052]	-0.6521 (0.4059) [-0.0052]	-0.6282 (0.4066) [-0.0051]	-0.6368 (0.4054) [-0.0052]
Wald Chi2(7)	55.46***	50.56***		
TOTAL OBS	6845	6845	6845	6845

Notes: DMP denotes a certain measure of policy change. Cluster adjusted robust standard errors and estimated marginal effects are in parenthesis and brackets, respectively. * p<0.10. ** p<0.05. *** p<0.01. Marginal effects are estimated using the relogitq program written by Tomz et al. (1999) for Stata. They are estimated as change in the probability of a speculative attack for a one standard deviation change in continuous independent variables, a one unit change in the variable democ, and a zero to one change in the dummy variables holding all other variables at their means.

Table 4. Subsample Evidence

SUBSAMPLES	OBS	DISCOUNT RATE			DOMESTIC CREDIT GROWTH		
		COEF	STD.E	MGE	COEF	STD.E	MGE
HARDPEG	3000	-0.1423***	(0.0405)	[-0.0010]	0.0160*	(0.0089)	[0.0012]
SOFTPEG	3845	0.0532***	(0.0150)	[0.0021]	-0.0013	(0.0042)	[-0.0002]

Note: DMP denotes a certain measure of policy change. Cluster adjusted robust standard errors and estimated marginal effects are in parenthesis and brackets, respectively. * p<0.10. ** p<0.05. *** p<0.01. The hard peg dummy is dropped for these regressions to avoid perfect multicollinearity.

Table 5. Decomposing the Signaling Effect

	DIR	DDCG
CONSTANT	-4.8050*** (0.5322)	-4.8196*** (0.5306)
DMPt-1*HARDPEG	-0.1128*** (0.0359) [-0.0007]	0.0141 (0.0096) [0.0009]
DMPt-1*SOFTPEG	0.0530*** (0.0153) [0.0011]	-0.0015 (0.0044) [-0.0001]
DGROWTH	-0.0333 (0.0222) [-0.0012]	-0.0324 (0.0223) [-0.0012]
REROV	0.2483*** (0.0457) [0.0086]	0.2465*** (0.0457) [0.0089]
RESIMP	-0.1028** (0.0461) [-0.0032]	-0.0998** (0.0457) [-0.0031]
KAPCON	0.1620 (0.1897) [0.0014]	0.1827 (0.1881) [0.0014]
DEMOC	0.0994** (0.0495) [0.0009]	0.1000** (0.0493) [0.0009]
HARDPEG	-0.6238 (0.4077) [-0.0051]	-0.6174 (0.4069) [-0.0052]
TOTAL OBS	6845	6845

Note: DMP denotes a certain measure of policy change. Cluster adjusted robust standard errors and estimated marginal effects are in parenthesis and brackets, respectively. * p<0.10. ** p<0.05. *** p<0.01.

Table 6. Results From the Extended Sample

	DIR	DDCG
CONSTANT	-4.9832*** (0.4603)	-4.9914*** (0.4594)
DMPt-1 *HARDPEG	-0.1245*** (0.0352)	0.0173* (0.0098)
	[-0.0007]	[0.0009]
DMPt-1 *SOFTPEG	0.0498*** (0.0153)	-0.0009 (0.0040)
	[0.0009]	[-0.0001]
DMPt-1 *MNFLOATING	0.1352** (0.0565)	0.0035 (0.0095)
	[0.0012]	[0.0002]
DGROWTH	-0.0267 (0.0220)	-0.0263 (0.0219)
	[-0.0010]	[-0.0010]
REROV	0.1789*** (0.0406)	0.1779*** (0.0396)
	[0.0119]	[0.0113]
RESIMP	-0.1593** (0.0607)	-0.1588*** (0.0604)
	[-0.0042]	[-0.0043]
KAPCON	0.2808 (0.1923)	0.2980 (0.1916)
	[0.0023]	[0.0023]
DEMOC	0.0945*** (0.0352)	0.0954*** (0.0351)
	[0.0009]	[0.0009]
HARDPEG	-0.2070 (0.4548)	-0.2043 (0.4566)
	[-0.0017]	[-0.0016]
SOFTPEG	0.3915 (0.3066)	0.3895 (0.3072)
	[0.0036]	[0.0036]
TOTAL OBS	9917	9917

Note: DMP denotes a certain measure of policy change. Cluster adjusted robust standard errors and estimated marginal effects are in parenthesis and brackets, respectively. * p<0.10. ** p<0.05. *** p<0.01.

Table 7. Results from the OECD Subsample

	DIR	DDCG
CONSTANT	-3.8041*** (0.7800)	-3.9405*** (0.7295)
DMPt-1*HARDPEG	-0.7885*** (0.2360)	0.1289** (0.0649)
	[-0.0029]	[0.0057]
DMPt-1*SOFTPEG	0.3093*** (0.0596)	-0.0005 (0.0034)
	[0.0053]	[-0.0001]
DGROWTH	-0.0394 (0.0385)	-0.0458 (0.0374)
	[-0.0013]	[-0.0016]
REROV	0.2401*** (0.0512)	0.2370*** (0.0494)
	[0.0103]	[0.0112]
RESIMP	-0.2413** (0.0962)	-0.1860** (0.0811)
	[-0.0046]	[-0.0042]
KAPCON	0.1743 (0.1845)	0.2353 (0.1636)
	[0.0022]	[0.0034]
DEMOC	0.0331 (0.0835)	0.0388 (0.0705)
	[0.0004]	[0.0006]
HARDPEG	-0.9221* (0.5228)	-0.9284* (0.5105)
	[-0.0105]	[-0.0113]
TOTAL OBS	3109	3109

Note: DMP denotes a certain measure of policy change. Cluster adjusted robust standard errors and estimated marginal effects are in parenthesis and brackets, respectively. * p<0.10. ** p<0.05. *** p<0.01.

Table 8. Results from the Non-OECD Subsample

	DIR	DDCG
CONSTANT	-5.4651*** (0.7972)	-5.5176*** (0.7985)
DMPt-1*HARDPEG	-0.1514*** (0.0317) [-0.0008]	0.0003 (0.0075) [0.00003]
DMPt-1*SOFTPEG	0.0545* (0.0296) [0.0010]	-0.0306*** (0.0101) [-0.0009]
DGROWTH	-0.0319 (0.0342) [-0.0010]	-0.0257 (0.0339) [-0.0008]
REROV	0.2581*** (0.0855) [0.0072]	0.2660*** (0.0861) [0.0074]
RESIMP	-0.0424 (0.0306) [-0.0012]	-0.0343 (0.0299) [-0.0010]
KAPCON	-0.1455 (0.4740) [-0.0008]	-0.1408 (0.4734) [-0.0007]
DEMOC	0.1364** (0.0598) [0.0008]	0.1322** (0.0597) [0.0008]
HARDPEG	0.0360 (0.6093) [0.0005]	0.0734 (0.6105) [0.0004]
TOTAL OBS	3736	3736

Note: DMP denotes a certain measure of policy change. Cluster adjusted robust standard errors and estimated marginal effects are in parenthesis and brackets, respectively. * p<0.10. ** p<0.05. *** p<0.01.