Information Disparities as a Trigger of Currency Crises: Empirical Evidence

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Abstract: This paper empirically tests a main result of the literature on speculative attacks initiated by Morris and Shin (1998) in which agents receive noisy private signals. Changes in the distribution of information can trigger an attack. The impact of heterogeneous information between speculators on the probability of jumping to a crisis state is investigated within a Markov-switching framework. It is shown that less disparate information among domestic and foreign investors, proxied by the premia on country funds, lowers the probability of a currency crisis for the French Franc and the Italian Lira during the 1992 crises of the ERM.

Keywords: currency crisis, private information, global games, Markov-switching, country funds

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1 Introduction

The theoretical and empirical analysis of currency crises passed through different stages.[1] Following the crises of the 1980s, the so-called first generation of models emerged. In those models, an unsustainable policy eventually leads to a collapse of the pegged exchange rate. However, the experience in the European Exchange Rate Mechanism (ERM) challenged these models as macroeconomic imbalances turned out to be relatively modest when compared to crises countries in Latin America. This experience stimulated substantial research, leading to what is now known as the second generation of crises models. In those models, self-fulfilling expectations play a major role. Economies exhibit multiple equilibria that correspond to different levels of devaluation probabilities consistent with a given set of fundamentals. Although these models can explain the role of sudden shifts in expectations, they raise new questions. In particular, the selection of the equilibrium and thus the outbreak of the crisis is completely arbitrary. The literature refers to sunspots as a trigger mechanism that are, by definition, unexplainable.

Morris and Shin (1998) build on the concept of global games and provided a new stimulus by showing that this unsatisfactory result depends on too simplistic an assumption concerning the information structure. Once noisy private information is introduced, the lack of common knowledge results in a unique equilibrium. Thus, their model provides the basis for policy conclusions and comparative statics, since, in contrast to conventional second generation models, fundamentals play a role for the outcome. In these models it is not the amount of information per se that matters, but rather the heterogeneity of information, that is, the dispersion of information among investors.

The contribution of this paper is to quantify a central result of this modelling approach. It is shown that the information set of speculators matters for the relationship between fundamentals and the likelihood of a crisis. Specifically,

[1] For an excellent survey of these developments and a detailed presentation of the most relevant studies, see Jeanne (2000).

the crises of the French Franc and the Italian Lira in 1992 is modelled within a Markov-switching framework. In this paper, a new measure of the dispersion of information is proposed that is derived from closed-end country fund prices and their net asset value. These indicators can be employed as a proxy for the distribution of information between well informed domestic investors and relatively badly informed international speculators. The dispersion of information is shown to impact on the probability of a currency crises, given a set of fundamentals. A smaller dispersion of information lowers the probability of a speculative attack. Hence, the empirical exercise presented here gives some prima facie evidence on the role of the information structure for the stability of …nancial markets in open economies.

The remainder of the paper is organized as follows. Section 2 reviews the central result of the literature on speculative attacks under private information and derives testable implications on the role of information dispersion. Section 3 introduces the empirical framework and quanti…es the dispersion of information. Section 4 presents the results of the estimation. Finally, section 5 concludes.

2 Imperfect information and speculative attacks

Morris and Shin (1998) apply the concept of global games developed by Carlsson and van Damme (1993) to the problem of speculative attacks, stressing the importance of higher order beliefs in games.[2] What matters for the stability of …nancial markets is not only the amount of information, but also whether there is common knowledge. Under noisy private information, common knowledge no longer exists.

Speculative attacks are essentially a coordination problem. Consider the case of agents receiving signals about the fundamentals μ with an amount of noise " on both sides. The peg could survive if μ ¸ μ_l. If you observe a signal

[2] See Morris and Shin (2001) for a survey on various applications of global games to problems on …nancial markets.

greater than μ_l + ", you can be reasonably certain about the fundamental strength of the economy. However, when do you know that everyone knows that µ ¸ μ_l? The signals received by others can di¤er from yours by at most 2". Thus, you can be sure about the content of the signal received by others if your signal lies above μ_l + 3". There is nth order knowledge that µ ¸ μ_l if everyone has received a signal of at least μ_l + (2n ¡ 1) ". We speak of common knowledge if there is nth order knowledge for every n.[3] For some level of n, the idiosyncratic information cannot be higher or at least equal to μ_l + (2n ¡ 1) ". As a result, there is never common knowledge about the soundness of the fundamentals.[4]

Without common knowledge, there is no device on which agents could coordinate their attacks. Even if agents have relatively precise information about µ, they cannot easily infer how many other agents are that well informed. This introduces an additional equilibrium condition into the dynamic interaction that ultimately eliminates multiplicity of equilibria. Since the success of an attack is uncertain, remember that it is certain in the multiple equilibrium model whenever agents expect it to be successful, agents have to weight potential losses against potential gains from any strategy. The equilibrium is no longer indeterminate because this additional equation rules out all but one solution.

How relevant is private information in highly globalized markets? Morris and Shin (1999, 232) convincingly argue that

> "even vanishingly small di¤erences in information su¢ce to generate such uncertainty about others' beliefs. When we consider the sheer quantity of information available to market partici-

[3] Thus, common knwoledge about µ exists if every player knows µ and knows that everybody else knows µ and knows that everybody else knows that everybody elso knows µ and so forth to in…nity.

[4] Rigobon (1998) presents a model of a speculative attack under uncertainty driven by learning about the state of the fundamentals. A general set-up of an informational-frictions approach to exchange rate crises is provided by Calvo and Mendoza (2000). However, these authors examine the role of asymmetric information, not of private information.

> pants -the news wire services, in-house research, leaks from o¢cial sources, as well as the press and broadcasters- exact uniformity of information is the last thing we can expect. Indeed the fragmentation of the media in modern times has generated the paradoxical situation in which ever-greater quantities of information is generated and disseminated, but comes at the expense of the shared knowledge of its recipients. ... the receipt of information is rarely accompanied by the knowledge that everyone else is also receiving precisely this information at that time. Even among …nancial markets, the foreign exchange market is especially fragmented. Its market microstructure is characterized by the decentralized nature of the trade necessitated by round-the-clock trading and the geographical spread which goes with it."

The approach taken by Morris and Shin (1998) was subsequently extended in many directions. Corsetti, Pesenti and Roubini (2001) and Corsetti et: al (2001) show the impact of the existence of a large trader (a "Soros") on the informational structure of the game and on the likelihood of a speculative attack. Allsopp (2000) models lack of common knowledge about the government's type as a trigger of crises. Metz (2001) introduces noisy private and public information and Sbracia and Zaghini (2001) show that the results of Morris and Shin (1998) hold even when agents observe a public message that restores some common knowledge.
In the following subsections, the basic ingredients necessary to obtain the results of Morris and Shin (1998) are introduced in order to get an impression about the line of reasoning. Based on these results, empirical implications are derived.

2.1 The basic model

Here we brie‡y sketch the main result of Morris and Shin (1998). The model highlights the strategic interaction between an optimizing government and a group of speculators. Consider a continuum of speculators over the interval $[0;1]$. The economy is characterized by a set of fundamentals $\theta \in [0;1]$ which determines the exchange rate $e = f(\theta)$. Initially, this exchange rate is fixed at $e^* \geq f(\theta)$.

The individual speculator can attack the currency by short-selling activities. In this case he faces a transaction cost $t > 0$: If the attack is successful, each speculator receives a pay-off that depends on the magnitude of the devaluation and thus on the strength of the underlying fundamentals, $R(\theta; t) = e^* - f(\theta) - t$. Speculators face an optimizing government that derives a value v from maintaining the peg. Any attempt to defend the currency results in costs $c(\alpha; \theta)$ that depends positively on the share of speculators attacking the peg and negatively on the position of the fundamentals. The payoff to the government is then given by $v - c(\alpha; \theta)$. To keep the problem tractable, the following assumptions are made. If $c(0;0) > v$, that is, in the worst state of fundamentals, the costs exceed the benefit even if no speculator attacks. If $c(1;1) > v$, that is, if all agents attack, even the best state of fundamentals does not lead to a positive pay-off. If $e^* - f(1) < t$, that is, in the best state of fundamentals, any profit from a collapse of the peg is lower than the transaction costs.

The value of θ that solves $c(0;\theta) = v$ is denoted by θ_l: Thus, at this state of the fundamentals the government is indifferent between defending the peg and devaluing the currency, given that no speculator attacks. At the other extreme, the benchmark is given by $\theta_h > \theta_l$ that solves $f(\theta) = e^* - t$. At any θ above this level the floating rate is so close to e^* that no speculator would earn a profit. Following this partition of the fundamentals, the result of Obstfeld (1996) holds:

- If $\theta \in [0; \theta_l]$, the costs of defending the peg outweigh its benefit irrespective of the speculators' actions. Thus the peg is unstable.

- If $\theta \in [\theta_l; \theta_h]$, self-fulfilling expectations are possible which give rise to the emergence of multiple equilibria. A given set of fundamentals is consistent with an attack and a no-attack equilibrium. Hence, the peg will survive as long as speculators do not co-ordinate on the attack equilibrium The problem of equilibrium selection or co-ordination of expectations, respectively, is left open. Thus the peg is said to be ripe for attack.

- If $\theta \in [\theta_h; 1]$, no speculator will dare to attack because an attack would not result in positive pay-offs. Thus the peg is stable.

So far the existence of perfect information and common knowledge is assumed. In the following it is shown that the unsatisfactory results concerning the multiplicity of equilibria is the result of too simplistic an information structure. Consider the case of private information. Nature determines the realization of θ according to a uniform distribution. However, speculators know only the distribution of the fundamentals, not their precise value. Each speculator $i \in [0; 1]$ receives a noisy private signal x_i

$$x_i \in [\theta - \varepsilon; \theta + \varepsilon] \quad \text{for } \varepsilon > 0; \tag{1}$$

with ε denoting the dispersion of the private signal and $\frac{1}{\varepsilon}$ representing the signal's precision. Based on this signal, the speculator decides whether or not to attack the peg. The government then observes the proportion α attacking the currency and observes θ.
Under this information structure, it is possible to show that the game between speculators and the government has a unique equilibrium whenever private information is sufficiently precise:

Proposition 1 If there is sufficiently precise private information there exists a unique equilibrium consisting of a unique θ^* such that the government abandons the peg if and only if fundamentals fall below θ^* and a unique private signal x^* such that a speculator with signal x attacks the peg if and only if $x < x^*$ (Morris and Shin 1998, Metz 2001, Heinemann and Illing, 2000).

The higher the switching point θ^*, the higher is the probability of a speculative attack. A unique equilibrium prevails whenever the private signal is sufficiently precise. It is not the amount of information per se that makes the peg vulnerable to a speculative attack but rather that there is noisy private information that prevents the fundamentals from becoming common knowledge. Even if agents are provided with relatively precise information about the state of the fundamentals, they are uncertain whether and how many other agents get information of that quality. Technically, it is an additional equation that rules out multiplicity of equilibria. Agents are forced to compare potential gains and losses from an attack, whether successful or not. This constitutes an additional equilibrium condition that was missing under perfect information.

Heinemann and Illing (2000) generalize this result from Morris and Shin (1998) to a broader set of probability distributions. In addition, they analyze the impact of changes in the precision of private signals on the probability of a speculative attack under a uniform distribution of private signals and fundamentals. They find that

$$\frac{\partial \theta^*}{\partial \varepsilon} > 0 \quad \text{if } R' < 0; \tag{2}$$

hence the threshold below which an attack occurs with probability one increases when the precision of private information is reduced. Thus, a speculative attack becomes certain for relatively stronger fundamentals when agents are less certain about the signal received by others: "The lower transparency, the higher the likelihood of an attack. An intransparent policy may even trigger an attack when fundamentals are really good ..." (Heinemann and Illing 2000, 5).[5] Heinemann and Illing (2000) conclude that the government can reduce the probability of a speculative attack through more transparent policy. This would increase the precision of private signals and agents can infer

[5] In Metz (2001) and Sbracia and Zaghini (2001) agents receive both noisy private and noisy public information. They show that the impact of the signals' distribution parameters on the likelihood of an attack depends on the state of the fundamentals.

the fundamentals from their information more easily. The empirical investigation presented in this paper builds on this result. It is analyzed whether reduced dispersion of individual information, represented by ", lowers μ¤ and thus, the probability of a currency crisis.[6]

2.2 Testable implications

The models of Morris and Shin (1998) and Heinemann and Illing (2000) suggest that sudden movements in devaluation probabilities can be explained by changes in the information structure of speculators.[7] Suppose a given set of fundamentals determines a unique μ¤. However, when noisy information arrives, the threshold μ¤ above which an attack occurs increases and the same set of fundamentals is no longer consistent with exchange rate stability. Hence, the speculative attack, which is inherently a non-linear phenomenon, can occur although the fundamentals did not change. In contrast to standard second generation models of currency crises, the sudden dynamics of devaluation probabilities can be explained without referring to nebulous sunspots. Rey (2000) concludes that: "the key empirical implication of the Morris-Shin model is ... that the degree of information aggregation matters". As Morris and Shin (1998, 594) point out, "when looking for a cause or a trigger for a currency attack, we should look for the arrival of noisy information, i.e., news events that are not interpreted in exactly the same way by di¤erent speculators." An empirical validation of this central result of the literature that applies the concept of higher-order beliefs on currency crises should therefore include disparate information as a force driving shifts in the likelihood

[6] It is important to note that the models developed so far are essentially static. The arrival of new information and the dynamics of information are not modelled. This could be an interesting direction for further research. Morris and Shin (1999) explicitly model the dynamics of beliefs during the onset of an attack.

[7] In the title of their paper, Morris and Shin (1995) speak about "Informational events which trigger currency attacks".

of crises that are unrelated to economic fundamentals.[8] This is the approach taken in the next section. We aim to shed some light on the role of disparate information for the likelihood of attacks using country fund data as a proxy for information disparities.

3 Information dispersion and currency crises

In this section we investigate empirically whether disperse information of international speculators contributes to the likelihood of a crisis. As Rey (2000) points out, "a phenomenon like the 1992 ERM crisis could be modelled as unique equilibrium once dramatic shifts in information aggregation are incorporated explicitly." The econometric approach chosen here relies on the Markov-switching assumption popularized by Hamilton (1988, 1989, 1990). In these models, regression parameters depend on an unobservable state variable, the regime s_t, whose realization follows a …rst order Markov chain. Iterative …ltering algorithms are needed to infer the regime prevailing at each point in time and to estimate the parameters of the model. These …ltering algorithms are based on a Bayesian updating procedure. Markov-switching models turn out to be highly useful to model shifts in economic relationships and their interaction with economic fundamentals since they can track down structural shifts endogenously without relying on prior knowledge. In this sense they "let the data speak". They are particularly helpful to identify crisis and no-crisis episodes endogenously and to model the shifts between both states.

[8] Under private and public information, the e¤ect of information on the likelihood of a speculative attack depends on the strength of the fundamentals of the economy, see Sbracia and Zaghini (2001) and Metz (2001). Prati and Sbracia (2002) present the …rst empirical evidence on this result showing that uncertainty about the state of the fundamentals matters. They use the variance of Consensus forecasts of GDP growth rates for Asian countries as a proxy for the uncertainty of speculators. Moreover, they …nd that the sign of the impact of the variance of forecasts on an exchange rate pressure index depends on the state of the fundamentals.

Jeanne (1997) and Jeanne and Masson (2000), among others, employ a regime-switching framework to find out whether the ERM crises were in fact attacks driven by sunspots. Lyrio and Dewachter (2000) analyze the Brazilian peg in the late 1990s with a similar approach. The model in Jeanne and Masson (2000) is closely related to the specification estimated in the next section. These authors regress a measure of devaluation expectations on a set of fundamentals. In addition, they let the intercept term of the regression equation switch between two different states. Switches can then be interpreted as shifts between multiple equilibria since they are unrelated to fundamentals.

Here we ask how information dispersion affects the shifts between a speculative attack regime and a tranquil regime by means of time-varying transition probabilities introduced by Diebold, Lee and Weinbach (1994). Two papers analyze the crisis of the French Franc in 1992 by means of Markov-switching regressions in which the transition probabilities are a function of macroeconomic fundamentals. Piard (1998) and Martínez Pería (1998) find that both fundamentals and speculative forces explain the probability of a devaluation in the ERM. In this paper, their empirical approach is extended by including a measure of information dispersion in the equation that governs the probabilities of shifting between the crisis and the tranquil state.

The case of France during the ERM is of particular relevance since it is widely cited as being a case of self-fulfilling expectations. Analysts could not find a dramatic macroeconomic imbalance and thus saw expectations as a trigger behind the crisis. Note that the devaluation of the French Franc was the incident that motivated the academic literature to develop what is now known as the second generation of currency crises models.

3.1 Imprecise information as a trigger

In this section a regime-switching regression is used to model the devaluation probability for the French Franc and the Italian Lira. In equation (3), the interest rate differential between France or Italy, respectively, and Germany is regressed on three macroeconomic fundamentals, the temporary component of the real exchange rate ($tcreer$), the temporary component of the unemployment rate ($tcur$) and the inflation differential relative to Germany ($\Delta p - \Delta p^{DM}$). In addition, an intercept term is included.[9] The crucial feature of this regression equation is the fact that both the intercept term and the variance of the error terms depend on the unobservable regime prevailing in the economy:

$$\begin{aligned} i_t - i_t^{DM} &= \mu(s_t) + \beta_1 tcreer_t + \beta_2 tcur_t + \\ &\quad \beta_3(\Delta p - \Delta p^{DM})_t + u_t \\ \text{with } u_t &\sim NID(0; \sigma^2(s_t)). \end{aligned} \tag{3}$$

Hence, shifts in the intercept term and in the variance are inherently unrelated to economic fundamentals whose effects are represented in the coefficients β_1, β_2 and β_3. The discrete state variable s_t can shift between two realizations

$$s_t = m \text{ with } m \in \{1; 2\}; \tag{4}$$

and is governed by a first order Markov chain:

$$prob(s_t = j | s_{t-1} = i; s_{t-2} = k; \ldots) = prob(s_t = j | s_{t-1} = i) = p_{ij}. \tag{5}$$

Thus, the model endogenously separates two states that correspond to two levels of the intercept term and the variance of the interest rate differential that would otherwise be unobservable. We can then label one regime (with a low μ and a low σ^2) the "normal" state and a second regime (with a high μ and a high σ^2) the "crisis" state. In the light of the theory outlined in the previous sections, the transition from a "normal" state to a "crisis" state is particularly interesting. The probability of jumping between states only

[9] See Tillmann (2001) for a survey of the literature on the effect of fundamentals on interest rate differentials in the ERM.

depends on the realization of the regime variable in the previous period. All transition variables are collected in the (2×2) transition matrix

$$P = \begin{bmatrix} p_{11} & p_{21} = 1 - p_{22} \\ p_{12} = 1 - p_{11} & p_{22} \end{bmatrix}. \tag{6}$$

Throughout the paper, regime 1 will be denoted the "normal" state and regime 2 the "crisis" state. Since these probabilities give a reasonable characterization of the likelihood of jumping to a "crisis" state, we will refer to p_{12} as the probability of a speculative attack.

In contrast to most applications of Markov-switching models, the transition probabilities are assumed to be time-varying following Diebold, Lee and Weinbach (1994). They consider a logistical function of the following form relating the transition probabilities to explanatory variables

$$p_{12} = \frac{\exp\left(c_{01} + c_{12}\psi_{t-1}\right)}{1 + \exp\left(c_{01} + c_{12}\psi_{t-1}\right)} \tag{7}$$

$$p_{21} = \frac{\exp\left(c_{02} + c_{21}\psi_{t-1}\right)}{1 + \exp\left(c_{02} + c_{21}\psi_{t-1}\right)}; \tag{8}$$

so that the transition probabilities are forced to lie in the interval $[0; 1]$. Here, ψ_t denotes an indicator of the precision of the information or the dispersion of information of speculators to be constructed later. The coefficient c_{12} (c_{21}) represents the impact of the indicator ψ on the probability of jumping from regime 1 (2) to regime 2 (1). Following the theory outlined above we expect that the probability of jumping from a tranquil state to a crisis state is negatively affected by the precision of information. In other words, more disparate information is supposed to raise the probability of a speculative attack.

The model is estimated using non-linear algorithms to infer realizations of the regime variable.[10] As a by-product of the filter-inferences, a likelihood function can be maximized in order to obtain parameter estimates. The

[10] All estimations are carried out using RATS 5.0.

likelihood function $L(\theta|Y_T)$ is given by the sum of the densities $f(.)$ of the observation y_t conditional on the history of the process Y_{t-1}

$$L(\theta|Y_T) = \sum_{t=1}^{T} f(y_t|Y_{t-1};\theta) \tag{9}$$

with

$$\begin{aligned} f(y_t|Y_{t-1};\theta) &= f(y_t; s_t = 1|Y_{t-1};\theta) + f(y_t; s_t = 2|Y_{t-1};\theta) \\ &= \sum_{m=1}^{2} f(y_t|s_t = m; Y_{t-1};\theta) \cdot \mathrm{prob}(s_t = m|Y_{t-1};\theta) \end{aligned} \tag{10}$$

where the second part of this expression follows from applying the rules of conditional probabilities which say that $f(y_t; s_t = m|...) = f(y_t|...) \cdot \mathrm{prob}(s_t = m|...)$. The non-linear EM algorithm (Expectation-Maximization algorithm) is applied to solve the problem:

$$\hat{\theta}_{ML} = \arg\max \ln L(\theta|Y_T). \tag{11}$$

Note that the model does not rely on a priori knowledge about the characteristics of the regimes. All the model does is to fit the regimes to the data. The interpretation of the regimes requires economic reasoning.

3.2 Country fund premia and asymmetric information

Quantifying the degree of information disparities on financial markets is not straightforward. As a variable approximating the heterogeneity in the information structure, the so-called country fund discount will be proposed here. In recent years country funds became an increasingly popular instrument for investors seeking to diversify their portfolio internationally who do not have sufficient knowledge about the local market. These funds invest in equities from a specific country and are traded internationally at the fund price. The underlying assets are individually traded and constitute the net asset value (NAV) in dollar terms. In perfectly integrated markets that work efficiently, fund prices and NAVs should be equal as they are two market values of the same underlying asset. Hence, the difference between both prices should be equal or at least converging to zero. However, the difference between prices and NAVs, usually referred to as the country fund premium or discount, is found to be substantial. For the purpose of this paper it should be noted that both series, prices and NAVs, reflect how different investors value the same underlying asset. Since arbitrage between funds and underlying assets becomes impossible and shares cannot be redeemed, the existence of a premium or a discount is not surprising.

What makes these differences particularly interesting is the fact that they reflect the degree of informational asymmetry on international markets. Investors who have little country specific information are not willing to pay as much as a well informed investor for a particular asset. The discount of fund prices relative to NAVs therefore reflects the informational advantage of domestic investors relative to foreign investors. Note that domestic investors must not necessarily correspond to the residents of a particular country but refers to those investors that buy shares directly. As Frankel and Schmukler (2000) show, asymmetric information between well informed domestic investors and less informed foreign investors can explain the interaction between fund prices and NAVs.[11] They provide evidence on the cointegration properties of the NAV and price series and find that the hypothesis of a cointegration vector $[1; -1]$ cannot be rejected, hence, both series converge to a long-run equilibrium. In addition, the NAV series is found to be weakly exogenous and to Granger-causing the fund price. These results are consistent with the hypothesis that NAVs closely mirror local fundamentals and react first. This evidence of privileged information of domestic investors is further strengthened by Frankel and Schmukler (1996) who examine the dynamics of premia on Mexican country funds during the Mexican currency crises in 1994.[12] In turbulent crisis episodes, NAVs react first, thus discounts of fund

[11] See Chandar and Patro (2000) and Levy-Yeyati and Ubide (2000) for two recent empirical studies on the dynamics of country fund premia.

[12] Additional evidence on the information advantage of domestic investors is derived by Dvořák (2001) from data on Indonesian stock markets during the Asian crisis. Kim and

prices turn to premia during crisis. In terms of the evidence provided by Frankel and Schmukler (1996), fund premia can be explained by "divergent expectations" among investors.

3.3 Quantifying information disparities

Here we will use premia or discounts, respectively, on country fund NAVs paid on international markets as a measure of information disparity. If premia or discounts reflect the asymmetry of information between well informed local and relatively badly informed international investors, they could be employed to verify the argument presented by the literature on global games. The theory centers around noisy private information that removes common knowledge among speculators. To quantify the degree of heterogeneity in speculators' information sets, the group of well informed holders of local equities is contrasted to the group of badly informed investors that buy country funds. Hence, the difference between the NAVs and fund prices indicates the disparities of country specific information. In the following, data for the France Growth Fund (FRF) and the Italy Fund (ITA), converted in USD, from Frankel and Schmukler (1996) will be used to proxy information dispersion.[13] These funds are traded since May 1990 and February 1986 with an asset value of about 193 Mill USD and 101 Mill USD in 1996, respectively. From the weekly data set the first week of each month is selected to obtain a monthly series. Here three alternative indicators of information disparity are constructed for each country according to the following definitions:

$$\phi_t^1 \equiv (\text{fund price} - \text{net asset value})_t$$
$$\phi_t^2 \equiv |(\text{fund price} - \text{net asset value})|_t$$
$$\phi_t^3 \equiv (\text{fund price} - \text{net asset value})_t^2$$

Wei (2002) provide an extensive analysis of the behavior of foreign portfolio investors and domestic subsidiaries of foreign firms during crises that is based on differences in their information sets

[13] The dataset was kindly provided by Sergio Schmukler from the Worldbank.

The first index, ϕ_t^1, measures the absolute difference (in USD) between fund prices and net asset values. A negative ϕ_t^1 means that fund prices are higher than their NAV, hence, international investors are not willing to pay as much as domestic investors for the same underlying assets. Therefore, following the arguments of Frankel and Schmukler (2000), international investors have an informational disadvantage. Hence, we will interpret ϕ_t^1 as the quality of information of foreign investors relative to domestic investors. A rising ϕ_t^1 means that foreign investors gain relatively more information than domestic investors. The probability of a speculative attack is expected to decline in the quality of information of the group which is generally less well informed. However, this indicator mirrors the informational disadvantage of foreign investors when compared to domestic investors. Hence, the sign of ϕ_t^1 matters. To obtain a measure of the dispersion of information irrespective of which party is better informed than the other, we construct two other indices.

The second indicator, ϕ_t^2, measures the dispersion of information by taking the absolute difference of fund prices and the net asset value. A higher ϕ_t^2 reflects more disparate information. In the theory presented above it is the distribution of information that matters. Thus, it should make no difference whether foreign or domestic investors are better informed. The index ϕ_t^2, therefore, simply represents a measure of the distance between both information sets. Finally, the indicator ϕ_t^3 computes the squared difference between both series in order to obtain a positive value indicating the dispersion of information. The higher the indicators ϕ_t^2 and ϕ_t^3, the more disparate is the distribution of information and the less precise is the information flow. Hence, higher dispersion of information means less precise information. We expect the probability of a currency crisis to rise in the dispersion of information.

A first visual inspection of ϕ_t^1 for France, see figure (1), reveals that the difference between prices and NAVs was mostly negative with a remarkable peak in 1993 during which the series changed its sign. Throughout the sample period information is unevenly distributed as indicated by the substantial

distance of $Á_t^1$ from the zero line. The indicator starts to rise as soon as the currency crisis of the French Franc unfolds during 1992. Analogous to the Mexican country funds analyzed by Frankel and Schmukler (1996), the discounts on the FRF fund turn to premia for …ve months after the crisis. Thus, the devaluation of the currency seems to have revealed information that led to a homogeneous information set among both groups of investors for a short period of time. The dispersion of information, given by $Á_t^2$ and $Á_t^3$, decreases in the aftermath of the crisis and starts to increase in 1994.
For Italy, see …gure (2), the behavior of $Á_t^1$ reveals that, in general, domestic investors were better informed with slight exceptions in 1990 and 1993/94, during which the indicator lies above zero. The indicators $Á_t^2$ and $Á_t^3$ show that the dispersion of information varied substantially over the sample period. The indicators constructed here will now be employed as a trigger variable in regime-switching framework. Note that the premia on country funds do not represent private information in the strict sense of the model which is, by de…nition, impossible to measure directly. Rather, the premia re‡ect the dispersion of information. We expect the devaluation probability to increase in the dispersion of information or to fall in the precision of information, respectively.

4 Evidence from France and Italy 1992

The data set employed here consists of monthly data for France and Italy over the period 1990:11 through 1995:10 and 1987:11 through 1995:10, respectively.[14] On the left hand side of equation (3) the interest rate di¤erential is measured by the di¤erence between three-month Eurorates for France and Italy, respectively, and Germany, which was obtained from DG Bank. The macroeconomic fundamentals comprise the temporary component of the real exchange rate and the temporary component of the unemployment rate, both obtained from HP …ltering the original series and computing the di¤erence

[14] The choice of the sample period was dictated by the availability of country-fund data.

between the actual series and the HP trend. Data on the real exchange rate was obtained from JP Morgan, data on unemployment rates was taken from the International Monetary Fund's IFS database. A higher real exchange rate means a real appreciation of the domestic currency. In addition, the di¤erence between the French and the Italian, respectively, and the German in‡ation rate is included, which is computed as the di¤erence between yearly changes in consumer price indices obtained from the IFS database. As explained in the previous section, the proxy for the dispersion of information is build from data on the French Growth Fund and the Italy Fund, that is, from closed-end country funds traded in New York.

The parameter estimates are presented in table (1) for the case of France and in table (2) for the case of Italy, both shown in the appendix. For each country, a linear model is estimated (speci…cation I) that corresponds to a regime-switching model in which the number of regimes is set to unity. In addition, the model is estimated separately for each country using the three indicators of information dispersion (speci…cations II- IV).

First, note that the regime-switching speci…cations (II) - (IV) yield a higher value of the likelihood function than the linear model (I). This serves as an indicator of the quality of the regressions and lends some support to the choice of that particular non-linear approach. Second, the model separates a "normal" state and a "crisis" state for each country. In all speci…cations, the intercept terms and the variances are substantially higher in the "crisis" state than in the tranquil state. All regime dependent parameters are signi…cantly di¤erent from zero on the highest level of signi…cance. Not surprisingly, the model hardly detects any signi…cant relationship between the macroeconomic fundamentals and the interest rate di¤erential. The lesson from the literature on interest rate spreads and fundamentals is that it is extremely di¢ cult to establish reliable relations between those variables. Nevertheless it remains important to control for these fundamentals when searching for the impact of information dispersion. As a by-product of parameter estimation, the model delivers a series of conditional probabilities of the "crisis" regime. Hence, these series, which are displayed for each speci…cation in …gure (3) and …gure (4), represent the regime-inference at a particular point in time, given the history of the process until then. Therefore, these probabilities correspond to the outcome of a Bayesian learning algorithm of economic agents. All speci…cations track down the crises periods reasonably well. For France and Italy, the models clearly identify the crises of 1992/93 as sudden jumps to regime 2 which is referred to as the "crisis" state.

Having identi…ed and characterized the "crisis" and the "normal" regime, we can now turn to the determination of the transition probabilities, that is, the estimation results for the probability of a speculative attack. Remember that the probability of switching to a crisis state, p_{12}, is modelled as a function of the heterogeneity of information on …nancial markets. For all speci…cations, we …nd evidence that is broadly supportive to the main hypothesis formulated above. To illustrate the results, scatter plots are presented in …gures (5) through (10), showing the probability of switching to the "crisis" state against the measure of information dispersion as given by equation (7). The impact of $\acute{A}_t^1$ on the probability of a speculative attack is signi…cantly negative for both countries, as given by the parameter estimates for c_{12} and the scatter plots in …gure (5) and (8). Thus, the probability of a currency crisis decreases in the quality of information of foreign investors. If foreign agents can reduce their informational disadvantage, the crisis-probability can be reduced. The dispersion of information, measured by $\acute{A}_t^2$ and $\acute{A}_t^3$, a¤ects the probability of a speculative attack positively. The wider the distribution of information is, that is, the less homogeneous information sets are, the higher is the probability of a currency crisis. Figures (6), (7), (9) and (10) display the respective scatter plots. However, this e¤ect is signi…cant only for Italy. In general, these results validate the theory presented in previous sections in the sense that the distribution of information among speculators matters for the probability of a currency attack.

5 Conclusion

In this paper the role of information disparities as a trigger for speculative attacks was investigated empirically. Based on the theoretical models recently presented by Morris and Shin (1998), it was tested whether a wider dispersion of information among investors raises the probability of currency crises. The empirical strategy employed here builds on a regime-switching speci…cation of the interest rate di¤erential and assumes time-varying transition probabilities. It is shown that heterogeneous information sets, quanti…ed by the di¤erence between closed-end country funds and their underlying net asset values, lead to a higher probability of switching to a "crisis" regime. Thus, the empirical results presented here support the …ndings of the literature of speculative attacks under noisy private information.

These results are instructive for the debate about appropriate policy responses to prevent currency crisis from occurring. Transparency of policy matters because it contributes to a convergence of otherwise heterogeneous information sets. Not only the amount of information of agents matters, but also the distribution of information. Hence, any policy measure that reduces the dispersion of information can lower the probability of a crisis. This could include the disbursement of news about fundamentals and the public announcements of policy measures. International rescue packages initiated by the International Monetary Fund, can contribute to less heterogeneous country speci…c information.

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Table 1: Results for France from linear and Markov-switching regressions

coe¢cient	linear regression	regime-switching model		
	I	II	III	IV
		with $Á_t^1$	with $Á_t^2$	with $Á_t^3$
¹	0.911***			
¹ (s_t = 1) "normal"		0.502***	0.497***	0.469***
¹ (s_t = 2) "crisis"		1.867***	1.935***	2.441***
$¸_1$	0.289***	0.114***	0.105***	0.072**
$¸_2$	-0.961***	0.070	0.066	-0.013
$¸_3$	-0.012	0.041***	0.037***	0.036**
$¾^2$ (s_t = 1) "normal"		0.204***	0.204***	0.260***
$¾^2$ (s_t = 2) "crisis"		1.179***	1.184***	0.856***
c_{01}		-7.402***	-5.239***	-3.155***
c_{02}		0.691	51.214	0.689
c_{12}		-2.468**	1.278	0.028
c_{21}		6.553***	-273.167	-3.003*
sample		1990:11 - 1995:10		
convergence level	0.001	0.0001	0.0001	0.0001
max. L	-71.66	-30.61	-29.87	-30.35

Notes: A signi…cance level of 90, 95 and 99 percent is indicated by*, ** and ***.

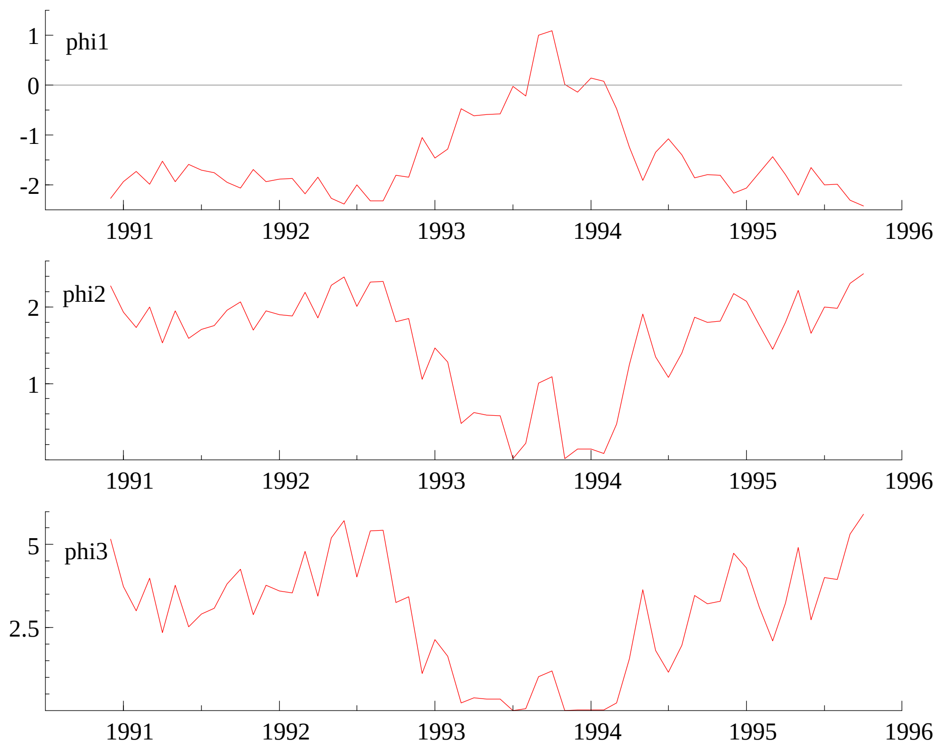

Figure 1: France - Indicators for the dispersion of information

Table 2: Results for Italy from linear and Markov-switching regressions

coe¢cient	linear regression	regime-switching model		
	I	II	III	IV
		with Á$_t^1$	with Á$_t^2$	with Á$_t^3$
¹	3.199***			
¹ (s_t = 1) "normal"		2.744***	2.645***	2.625***
¹ (s_t = 2) "crisis"		5.774***	5.587***	5.560***
¸$_1$	-0.088	-0.039*	-0.035	-0.028
¸$_2$	0.972	-0.109	0.297	0.412
¸$_3$	0.393***	0.041	0.017	0.024
¾^2 (s_t = 1) "normal"		0.680***	0.5222***	0.515***
¾^2 (s_t = 2) "crisis"		0.937***	1.075***	1.108***
c_{01}		-3.539***	-4.439***	-3.589***
c_{02}		15.939***	1.104	0.093
c_{12}		-0.383*	1.023**	0.225*
c_{21}		174.77	-6.494***	-7.547
sample		1987:11 - 1995:10		
convergence level	0.001	0.0001	0.0001	0.0001
max. L	-204.03	-118.47	-115.73	-115.50

Notes: A signi…cance level of 90, 95 and 99 percent is indicated by*, ** and ***.

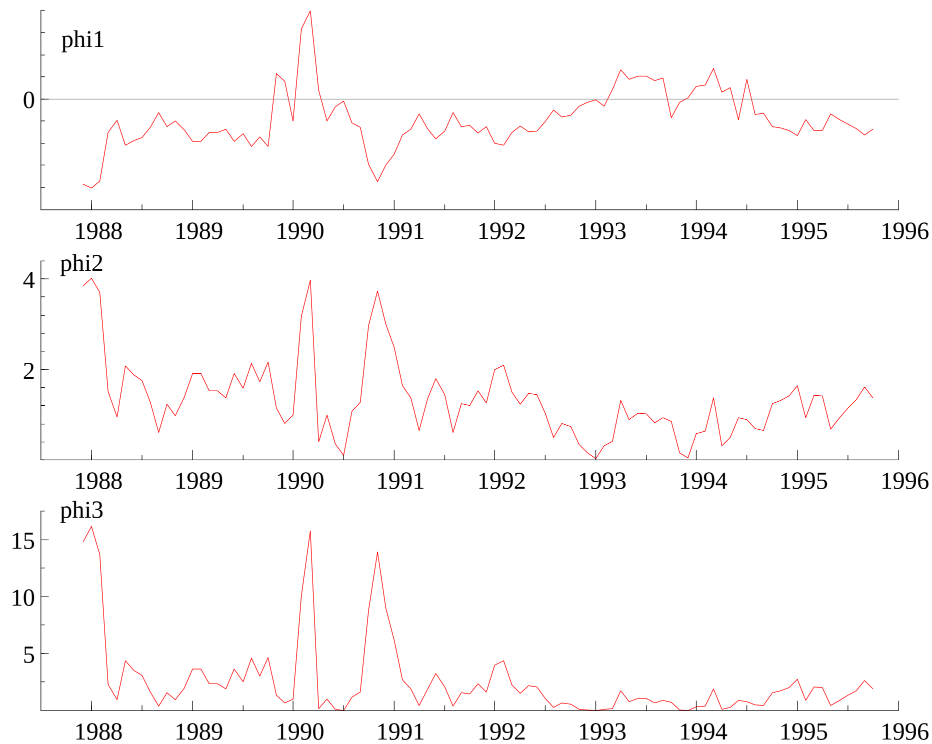

Figure 2: Italy - Indicators for the dispersion of information

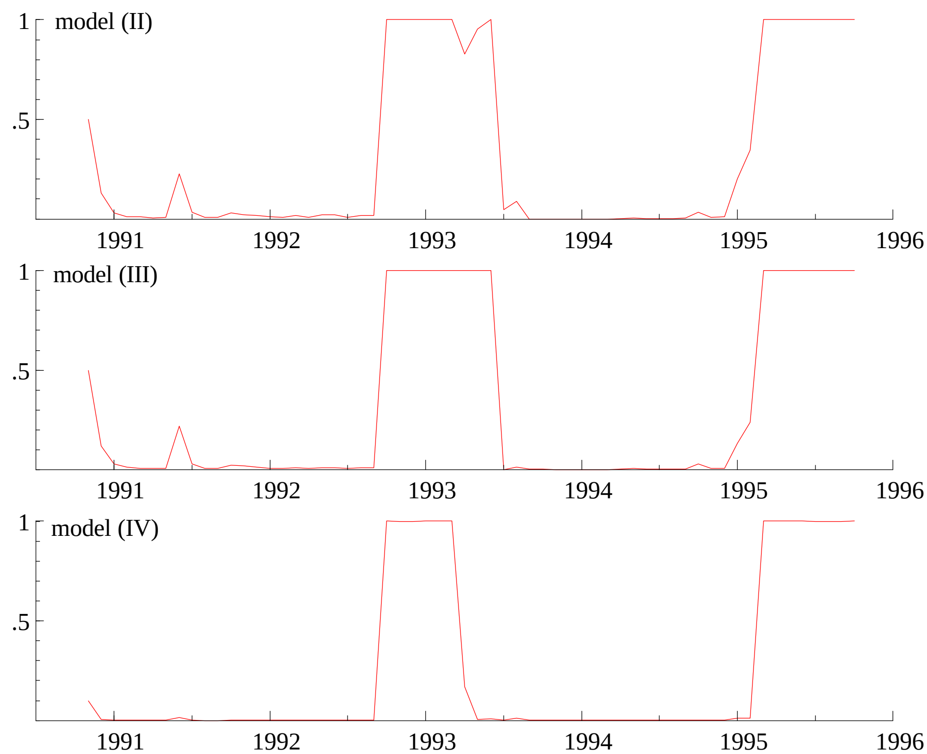

Figure 3: France - Conditional probabiliy of crisis-regime for specifications (II)- (IV)

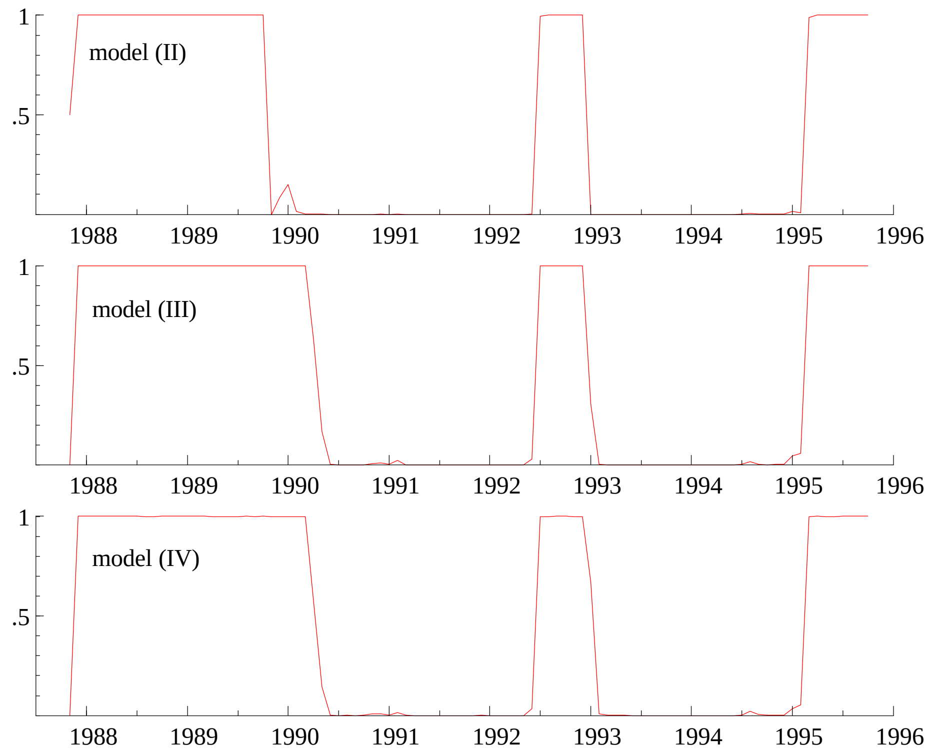

Figure 4: Italy - Conditional probability of crisis-regime for speci…cations (II) - (IV)

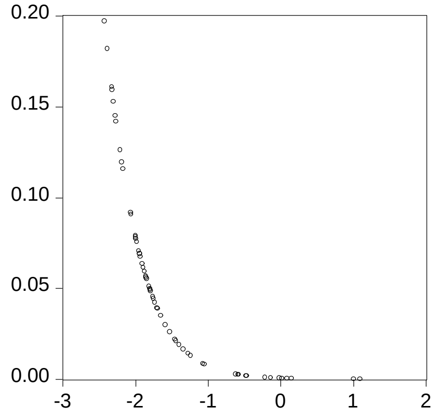

Figure 5: France - Probability of switching to crisis state (y-axis) against information quality of foreign investors Á^{1} (x-axis)

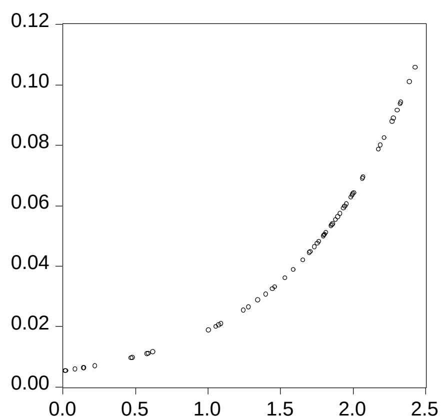

Figure 6: France - Probability of switching to crisis state (y-axis) against information dispersion Á^{2} (x-axis)

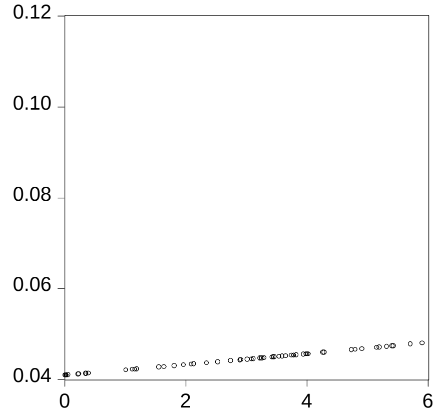

Figure 7: France - Probability of switching to crisis state (y-axis) against information dispersion Á^{2} (x-axis)

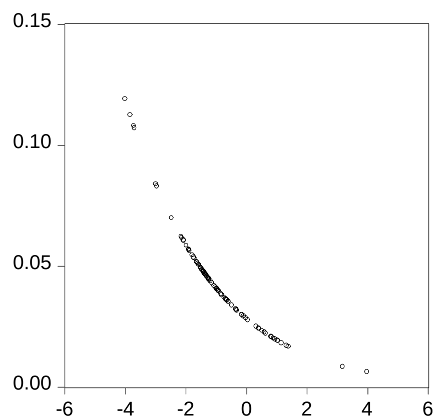

Figure 8: Italy - Probability og switching to crisis state (y-axis) against information quality of foreign investors Á^{1} (x-axis)

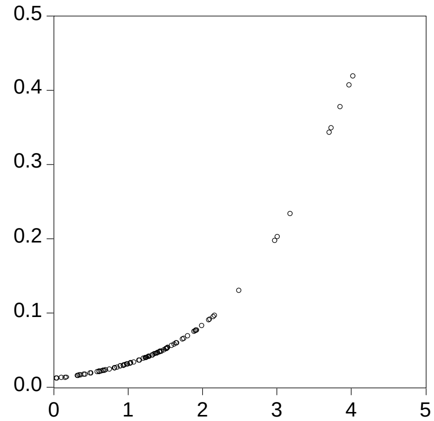

Figure 9: Italy - Probability of switching to crisis state (y-axis) against information dispersion Á^2 (x-axis)

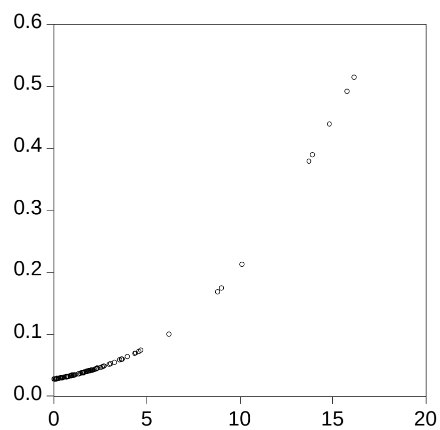

Figure 10: Italy - Probability of switching to crisis state (y-axis) against information dispersion Á^3 (x-axis)