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by

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'Large' vs. 'small' players: A closer look at the dynamics of speculative attacks*

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Abstract

What is the role of "large players" like hedge funds and other highly leveraged institutions in speculative attacks? In recent theoretical work, large players may induce an attack by an early move, providing information to smaller agents. In contrast, many observers argue that large players are in the rear. We propose a model that allows both the large player to move early in order to induce speculation by small players, or wait so as to benefit from a high interest rate prior to the attack. Using data on net positions of "large" (foreigners) and "small" (locals) players, we find that large players moved last in three attacks on the Norwegian krone (NOK) during the 1990s: The ERM-crisis of 1992, the NOK-pressure in 1997, and after the Russian moratorium in 1998. In 1998 there was a contemporaneous attack on the Swedish krona (SEK) in which large players moved early. Interest rates did not increase in Sweden so there was little to gain by a delayed attack.

JEL Classifications: F31, F41, G15

Keywords: Speculative attacks, microstructure, international finance, large players

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1 Introduction

The problem of connecting currency crises to fundamentals has led to a discussion of possible manipulation of exchange rates. It has become a ritual among many politicians to denounce hedge funds and other highly leveraged institutions, especially foreign, for manipulating exchange rates during speculative pressure. In contrast, many observers have argued that both fundamentals and large players may play a role.

The different views are reflected in the development of the theory on currency crises. In the first generation model of Krugman (1979), the collapse of the exchange rate is inevitable due to deteriorating fundamentals. The second generation models, e.g. Obstfeld (1986), show that there may be a multiplicity of equilibria, leading to the possibility of self-fulfilling expectations of attack. If the market believes that an attact will be successful, everyone attacks, making it too costly for the central bank to defend the currency even with strong fundamentals. Hence, the initial belief is confirmed in the attack. These kinds of models cannot, however, explain the timing of the attack. Morris and Shin (1998) show that the multiplicity of equilibria is due to common knowledge of the fundamentals, and that only adding a small amount of noise to the players' signal on fundamentals results in a unique equilibrium where the timing of the attack can be determined.

Corsetti, Dasgupta, Morris, and Shin (2004) extend the model of Morris and Shin by introducing a single large player that might have superior information. By moving early the large player can signal his information to the small players, thereby inducing an attack. However, based on experiences from the ERM and Asia-crises, Tabellini (1994) and the IMF (1998) argue that large players move in the rear in currency crises because they benefit from positive interest rate differentials. We extend the Corsetti et al. model by allowing the large player to attack either before or after the small players. An early attack will provide a signal to the small players, just as in the Corsetti et al. model. On the other hand, by waiting to the last stages of the attack, the large player may profit from higher interest rates. The latter alternative is best if the attack is sufficiently likely so that an early signal is viewed as unnecessary.

To explore the model, we consider three cases of speculative pressure on the Norwegian krone (NOK), and one case for the Swedish krona (SEK). The Norwegian cases are: (*i*) The attack during the ERM-crisis in December 1992; (*ii*) the attack in January 1997; and (*iii*) the attack after the Russian moratorium in August 1998. The third crisis is also our Swedish case. In 1992 Norway had a fixed exchange rate, while the exchange rate was a managed float in 1997 and 1998. Sweden had officially a floating exchange rate regime in 1998, but had intervened on several occasions since the ERM-crisis in 1992–93. In these situations, speculators may take currency positions in the belief that monetary authorities will change the monetary regime, or at least allow for a considerable change in the exchange rate, in the near future.[1]

For Norway we have weekly data on currency trading by Norwegian banks with Norwegian customers and foreigners. The data differentiates between spot and forward trading and covers more than 90% of all trading in NOK. Anecdotal evidence from the Norwegian market suggests that the foreign investors are leveraged institutions, or "large players", while locals can be viewed as "small players". This seems particularly reasonable for periods of speculative pressure where foreigners can raise more funds than locals. In Sweden several banks, assigned as "primary dealers", report their buying and selling of spot and forward against locals and foreigners.

Our results suggest that the behavior of large and small players differs before and during speculative attacks. We find that large players moved last during the three attacks on the Norwegian krone (NOK). Our model predicts that if the probability of a successful attack is high, large players will choose to move late if there is some gain from waiting, e.g., a high interest rate differential. This is also suggested by Tabellini and the IMF. Regression analysis also indicates that the trading of large players is most important for triggering the actual attack. Furthermore, the sequence of the two groups during the attack period is different from the sequence during the non-attack period preceding the attack. During the attack on the Swedish krona (SEK) in 1998, it was the large players that moved early. However, interest rate differentials did not increase during the attack so there was little to gain for the large players by a delayed attack. The small players may be content with moving early during attacks due to less liquid portfolios, as in Tabellini, less ability to move quickly, a closer relationship to local authorities, or higher risk aversion.

To our knowledge only few papers exist on the topic of the role of large players. Wei and Kim (1997) study the importance of large players using the Treasury Bulletin reports. They find that trading by large players adds to the volatility of exchange rates, and argue that hedge funds act like "noise traders" in the Korean market. Corsetti, Pesenti, and Roubini (2002) use the same data, and compile more informal information about a number of speculative events. They find support for the role of large players and some indications of the presence of asymmetric information. Cai, Cheung, Lee, and Melvin (2001) also use the Treasury Bulletin data and find that the trading of large players contributes to volatility during the unwinding of the yen-carry trade in 1998.

The combination of long time series on trading that covers a number of relevant episodes, and information on disaggregated currency flows, makes our data set unique. Unlike the studies above, we have information on net positions of *both* large and small players in the periods around a speculative attack. Further, the source of our data covers almost the total market for the currencies under investigation. Finally, while the former studies have focused on the Asian markets we focus on two European

[1]See e.g. Calvo and Reinhart (2002) who argue that even if a country officially adopts a "flexible" exchange rate, they often tend to limit the fluctuations of the exchange rate.

economies. This adds a new dimension to the empirical findings in this field.

In section 2 we present the model and discuss some empirical implications. Section 3 contains a description of our data and the institutional framework of the exchange rate regime. Section 4 describes the empirical methodology and our results. Section 5 concludes.

2 The Model

Corsetti, Dasgupta, Morris and Shin (2004) (henceforth CDMS) analyze a model with a large player and a continuum of small players.[2] In their analysis of sequential trading CDMS only consider the alternative where the large player speculates first, so as to create a signal affecting the behavior of the small players. However, as mentioned by CDMS, the IMF, and Tabellini, there is anecdotal evidence indicating that large players are in the rear, rather than at the front. Here we extend the theoretical framework of CDMS by allowing the large player both to speculate early, so as to affect the behavior of the small players, and to speculate at a later stage in order to reap interest rate gains as well. Thus, the timing decision of the large player is endogenous.

Consider an economy where the central bank aims at keeping the exchange rate within a certain interval, either a well defined, publicly known, narrow target zone, or a less explicit "dirty float" policy. There is a single "large" player, and a continuum of "small" players indexed to $[0, 1]$. The players may attack the currency by short selling the currency, i.e. borrow domestic currency and sell it for dollars. The small players taken together have a combined limit to short selling the domestic currency normalized to 1. They decide independently and simultaneously whether or not to attack the currency. If they attack there is a cost $t > 0$ to engaging in short selling. This cost can be interpreted as trading costs and the interest rate differential between the domestic currency and dollars.[3] The costs are normalized so that the payoff to a successful attack on the currency, leading to a devaluation/depreciation of the currency, is given by 1, and the payoff from refraining from attack is 0. Thus, the net payoff for small players of a successful attack on the currency is $1 - t$, while the payoff to an unsuccessful attack is $-t$.

The large player has access to a large line of credit in the domestic currency, enabling him to take a short position up to the limit of $L > 0$. In contrast to CDMS, however, we assume a different action set and cost structure for the large player. The large player may trade at two different points in time, before and after the small players. Short selling before the action of the small players involves the cost t. Let λ denote the size of any early short selling of the large player, where $L \geq \lambda \geq 0$. However, if

[2] We use "player[s]" in the rest of the paper, instead of, e.g., trader[s].

[3] Hence, the exchange rate is sufficiently under pressure so that the interest rate differential has increased.

a massive speculative attack ensures that it is clear that a devaluation will take place, the large player has the opportunity to increase the speculative attack by using the rest of his credit at a later stage. This assumption is meant to capture the notion that larger players have better access to rapid information, and may react quicker in the market. Speculating at a late stage involves two advantages. First, there is less uncertainty as to the outcome of the attack, as there is no uncertainty as to the behavior of the smaller players. Second, the cost is smaller, as the costs associated with the interest rate differentials are incurred for a shorter period. To simplify the analysis, we shall assume that an attack by the large player at the late stage involves no uncertainty and no costs, implying a total gain to the large player of $L - t\lambda$ if a devaluation takes place.

Following CDMS, we let the strength of the economic fundamentals of the exchange rate regime be indexed by a random variable θ. This can be interpreted as a reduced form of the central bank reaction function, indicating how much reserves they are willing to use in the defense. If the fundamentals support the current regime, i.e. are strong, the central bank is willing to use more reserves in the defense. The strength of the speculative attack is measured by the amount used by the players attacking the currency. Whether the current exchange rate regime is viable depends on the strength of the economic fundamentals relative to the strength of the speculative attack. To keep the analysis simple, we assume that the large player only gets access to the credit at the late stage if it is already clear that the exchange rate falls. A possible justification for this assumption is that if creditors do not see that the early attack succeeds, they will not accept the risk involved in extending the rest of the credit ($L - \lambda$). Let ξ denote the mass of small players that speculate. Then the exchange rate will fall if and only if

$$\xi + \lambda \geq \theta. \tag{1}$$

If $\theta < 0$ the exchange rate will depreciate irrespective of whether a speculative attack takes place.

2.1 Information

The small players observe a private signal that yields information about the fundamentals as well as the amount of speculation of the larger player. A typical small player i observes

$$x_i = \theta - \lambda + \sigma\varepsilon_i, \tag{2}$$

where $\sigma > 0$ is a scaling-constant to the variance of the signal x. The individual specific noise ε_i is distributed according to a smooth symmetric and single-peaked density $f(\cdot)$ with mean zero, and $F(\cdot)$ as the associated c.d.f. The noise ε_i is assumed to be i.i.d. across players. Note that the small players cannot distinguish the information they obtain about the fundamentals from the information about the speculation of the larger player; they only observe a noisy signal of the difference between the two. This assumption simplifies the analysis considerably. It also captures an element of realism, as small players in reality cannot verifiably observe large players' moves in the FX market since there is no disclosure requirements in FX markets.

The larger player observes

$$y = \theta + \tau\eta, \tag{3}$$

where $\tau > 0$ is a scaling-constant to the variance of the signal, and the random term η is distributed according to a smooth symmetric and single-peaked density $g(\cdot)$ with mean zero. To obtain explicit solutions, we assume further that $g(\cdot)$ is strictly increasing for all negative arguments, and strictly decreasing for all positive arguments. $G(\cdot)$ is the associated c.d.f.

2.2 Analysis

We first consider the action of the small players, given the prior decision of the large player. We then consider the decision of the large player of whether to initiate an early attack.

Following CDMS, we will assume that the small players follow trigger strategies in which players attack the currency if the signal falls below a critical value x^*.[4] As in the analysis of CDMS, there is a unique equilibrium which can be characterized by two critical values, $(\theta - \lambda)^*$ and x^*, where the former captures that the currency will always collapse if the difference between the fundamental θ and the early speculation of the large player λ is below the critical value, while the latter is the critical value in the trigger strategy of the small players.

These critical values can be derived in the same way as in the analysis of the benchmark case in section 2.2.1 of CDMS. Given the trigger strategy, and that the true state is $\theta - \lambda$, the probability that a small player i will attack the currency is identical to the probability that the player's signal $x_i \leq x^*$, i.e.

$$\begin{aligned} prob\left[x_i \leq x^* | \theta - \lambda\right] &= prob\left[\theta - \lambda + \sigma\varepsilon_i \leq x^*\right] \\ &= prob\left[\varepsilon_i \leq \frac{x^* - (\theta - \lambda)}{\sigma}\right] = F\left(\frac{x^* - (\theta - \lambda)}{\sigma}\right). \end{aligned}$$

Since there is a continuum of small players, and their noise terms are independent, there is no aggregate uncertainty as to the behavior of the small players, so that the mass of small players attacking, ξ, is equal to this probability. As $F(.)$ is strictly increasing, it is apparent that the incidence of the speculative attack is greater, the weaker the strength of the economic fundamentals, less the early speculation of the large player $(\theta - \lambda)$.

[4] CDMS show that there are no other equilibria in more complex strategies.

A speculative attack will be successful if the mass of small players that speculate exceeds the strength of the economic fundamentals, less the early speculation of the large player, i.e. if

$$F\left(\frac{x^* - (\theta - \lambda)}{\sigma}\right) \geq \theta - \lambda.$$

Thus, the critical value $(\theta - \lambda)^*$, for which the mass of small players that attack is just sufficient to cause a devaluation, is given by the equality

$$F\left(\frac{x^* - (\theta - \lambda)^*}{\sigma}\right) = (\theta - \lambda)^*. \tag{4}$$

For lower values of $(\theta - \lambda)$, the incidence of speculation is larger, and the strength of the fixed exchange rate lower, implying that an attack will be successful if $\theta - \lambda \leq (\theta - \lambda)^*$.

Consider then the trigger strategies of the small players. A player observes a signal x_i, and, given this signal, the success-probability of an attack is given by

$$\begin{aligned} prob\left[\theta - \lambda \leq (\theta - \lambda)^* | x_i\right] &= prob\left[x_i - \sigma\varepsilon_i \leq (\theta - \lambda)^*\right] \\ &= prob\left[\varepsilon_i \geq \frac{x_i - (\theta - \lambda)^*}{\sigma}\right] = 1 - F\left(\frac{x_i - (\theta - \lambda)^*}{\sigma}\right) = F\left(\frac{(\theta - \lambda)^* - x_i}{\sigma}\right), \end{aligned}$$

where the last equality follows from the symmetry of $f(.)$, $F(\nu) = 1 - F(-\nu)$. The expected payoff of attacking the currency for player i, per unit of speculation, is thus

$$\begin{aligned} &(1-t)F\left(\frac{(\theta - \lambda)^* - x_i}{\sigma}\right) - t\left(1 - F\left(\frac{(\theta - \lambda)^* - x_i}{\sigma}\right)\right) \\ &\qquad = F\left(\frac{(\theta - \lambda)^* - x_i}{\sigma}\right) - t. \end{aligned}$$

For the marginal player, the expected payoff of attacking the currency must be zero, i.e. the optimal cutoff x^* in the trigger strategy is given by

$$F\left(\frac{(\theta - \lambda)^* - x^*}{\sigma}\right) = t. \tag{5}$$

To solve for the equilibrium, we rearrange (5) to obtain $(\theta - \lambda)^* = x^* + \sigma F^{-1}(t)$. Substituting into (4), we get

$$\begin{aligned} (\theta - \lambda)^* &= F\left(\frac{x^* - \left(x^* + \sigma F^{-1}(t)\right)}{\sigma}\right), \text{ or} \\ (\theta - \lambda)^* &= F\left(-F^{-1}(t)\right) \\ &= 1 - F\left(F^{-1}(t)\right) = 1 - t. \end{aligned}$$

Thus, the critical values are

$$(\theta - \lambda)^* = 1 - t, \text{ and} \tag{6a}$$
$$x^* = 1 - t - \sigma F^{-1}(t). \tag{6b}$$

These critical values correspond to the critical values in CDMS, the only novelty being the addition of the early speculation of the large player λ.

Before proceeding, let us briefly describe the economic outcome so far. As noted above, there is no aggregate uncertainty as to the behavior of the small players. All players observing a signal $x_i \leq x^*$ will attack. If $\theta - \lambda \leq (\theta - \lambda)^*$, the speculative attack will be successful. If $t < \frac{1}{2}$, then $F^{-1}(t) < 0$ (recall that as f has mean 0, so $F^{-1}\left(\frac{1}{2}\right) = 0$), so that $x^* > \theta - \lambda$. Thus, in this case a small player will attack even if he observes a signal $x_i \in (\theta - \lambda,\ x^*)$, i.e., even if he observes a signal that, if it were accurate, the attack would not be successful. This is because the gain from a successful attack in this case is greater than the loss from an unsuccessful one, so from equation (5) we see that the small player will accept a probability of success below $\frac{1}{2}$.

We then consider the decision of the large player of whether to speculate at an early stage, and if so, by how much. For a given probability of devaluation, it is clearly better to enter late so as to save speculation costs. However, as is apparent from (6a), a devaluation will take place if the fundamental $\theta \leq \theta^* \equiv 1 - t + \lambda$, implying that early speculation $\lambda > 0$ will increase the probability that a devaluation takes place. Thus, the large player will weigh the gain from increasing the probability of a devaluation by early speculation against the costs of doing so.

The expected payoff by attacking in the amount $\lambda \geq 0$ at an early stage is

$$E\pi = L \cdot prob\left[\theta \leq 1 - t + \lambda | y\right] - t\lambda = L \cdot G\left(\frac{1 - t + \lambda - y}{\tau}\right) - t\lambda,$$

where we again use the symmetry of the distribution.

The first order condition for an interior solution λ^* is

$$\frac{\partial E\pi}{\partial \lambda} = L \cdot g\left(\frac{1 - t + \lambda^* - y}{\tau}\right)\frac{1}{\tau} - t = 0. \tag{7}$$

Note first that if $Lg(0)\frac{1}{\tau} - t < 0$ (which is equivalent to $g(0) < \frac{\tau t}{L}$), then it is never optimal to speculate early, as this implies that $\frac{\partial E\pi}{\partial \lambda} < 0$ for all y and λ (recall that the density $g(.)$ has its maximum for the argument zero). The intuition is straightforward: if the gain from a successful speculative attack (L) is too small relative to the cost of speculation (t) and the effect of attempts to induce a speculative attack ($g(.)$ and τ), then it will never be profitable to try to induce a speculative attack. Or, if the "large" player is not particularly larger than the small he will not try to induce the small to speculate by early trading. In the sequel, we shall assume that $g(0) > \frac{\tau t}{L}$, implying that it will be profitable to induce a speculative attack under some circumstances, as will be discussed below.

The second order condition for an interior solution is

$$\frac{\partial^2 E\pi}{\partial\lambda^2} = L \cdot g'\left(\frac{1-t+\lambda^*-y}{\tau}\right)\frac{1}{\tau^2} < 0.$$

From the second order condition it follows that the optimal λ^* must satisfy $\frac{1-t+\lambda^*-y}{\tau} > 0$, so that $g'(.) < 0$.[5]

Restricting attention to the interval $\frac{1-t+\lambda-y}{\tau} > 0$, so that $g'(.) < 0$, and hence the inverse of $g(.)$ is defined, we can solve (7) for the optimal λ:

$$\frac{1-t+\lambda^*-y}{\tau} = g^{-1}\left(\frac{\tau t}{L}\right), \text{ or}$$
$$\lambda^* = y-(1-t)+\tau g^{-1}\left(\frac{\tau t}{L}\right). \tag{8}$$

Let y^{Lo} be the value of y for which the optimal early speculation λ^* is zero, i.e.

$$y^{Lo} = 1-t-\tau g^{-1}\left(\frac{\tau t}{L}\right).$$

Proposition 1 *Assume that $g(0) > \frac{\tau t}{L}$. Then there exist critical values y^{Hi} and y^{Lo} such that if the signal of the large player y is below or above these critical values, $y \leq y^{Lo}$ or $y \geq y^{Hi}$, then the optimal strategy is not to speculate early, i.e. set $\lambda = 0$. If $y \in (y^{Lo}, y^{Hi})$, the optimal strategy is to speculate early, setting $\lambda = \lambda^* > 0$, where λ^* is given by (8). A marginal change in the speculation costs t has an ambiguous effect on the optimal early speculation by the large, λ^*.*

The proof is in the appendix. The intuition behind the proposition is presented in Fig. 1, and can be explained as follows. The horizontal line $t\tau/L$ represents the marginal cost of speculating early, while the bell-shaped curve is the g-distribution. If the signal of the large player y is low (below y^{Lo}), indicating that the fundamental θ is likely to be low, the large player will view a devaluation as so likely that he will not find it profitable to incur the costs by early speculation, even if this would increase the probability of a devaluation. Nor will the large player find it profitable to speculate early if the signal of the large player y is high (above y^{Hi}), indicating that the fundamental θ is likely to be high, as in this case it will be too costly to raise the probability of a devaluation. However, for interior values of y, the gain from increasing the probability of a successful speculative attack by an early speculation of

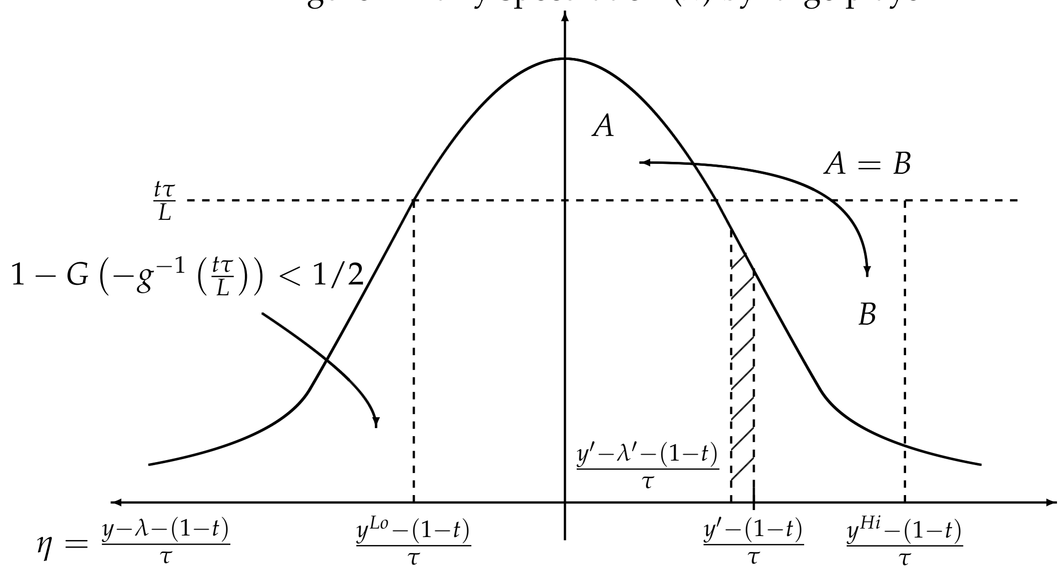
[5] For $\frac{1-t+\lambda-y}{\tau} < 0$, we have $g'(.) > 0$ implying that $\frac{\partial^2 E\pi}{\partial\lambda^2} > 0$, so that a solution to (7) would be a local profit minimum.

the large player is sufficiently large to outweigh the costs, and the large player will indeed speculate early.

For concreteness, let the large player receive a signal y'. By speculating in amount λ' he increases the probability of a successful attack by moving left along the g-curve. The increase from 0 to λ' is not profitable at the margin since $g\left(\frac{y'-\lambda'-(1-t)}{\tau}\right)$ is less than marginal cost $t\tau/L$. However, by increasing λ further, he enters the region where marginal benefits are higher than marginal costs (as indicated by area A in Fig. 1, and he will continue to increase λ until the point where $\frac{y'-\lambda-(1-t)}{\tau}$ equals $\frac{y^{Lo}-(1-t)}{\tau}$.

If the large player receives a signal y^{Hi}, he is indifferent between zero early speculation and a large early speculation down to the point where $\frac{y'-\lambda-(1-t)}{\tau}$ equals $\frac{y^{Lo}-(1-t)}{\tau}$. This is reflected in the area A (where marginal gain exceeds marginal costs) being equal to area B (where marginal gain is lower than marginal costs).

Figure 1: Early speculation (λ) by large player



Note: Marginal cost of early speculation $\left(\frac{t\tau}{L}\right)$ is given by the dotted horizontal line. The bell-shaped curve, $g(.)$, represents the marginal gain. For $y \in \left(y^{Lo}, y^{Hi}\right)$ the optimal strategy is to speculate early, setting $\lambda = \lambda^*$.

Hence, the optimal early speculation λ^* is strictly increasing in the interval $\left(y^{Lo}, y^{Hi}\right)$, starting at zero for y^{Lo} and reaching its maximum for y^{Hi}, and then falls to zero again for $y \geq y^{Hi}$.

The ambiguous effect of an increase in the speculation costs on the amount of early speculation reflects two opposing effects. On the one hand, higher speculation costs will reduce speculation by small players, inducing the large player to do more early speculation himself (cf. equation (8)). On the other hand, higher speculation costs make it more costly to speculate early, which has a dampening effect on early speculation.

3 Data and description of crises

3.1 Trading data

Norges Bank and Sveriges Riksbank collect data from market making banks on net spot and forward transactions with different counterparties. From Norges Bank we have weekly observations on Norwegian market making banks' trading with foreigners, locals, and the central bank.[6] Foreign participants are typically dominated by financial investors, especially in periods of turbulence. In the data set from Sveriges Riksbank we have weekly observations on market making banks' (both Swedish and foreign) trading with non-market making foreign banks and with Swedish non-bank customers. The first group represents financial investors (see Bjønnes, Rime, and Solheim, 2005). We will henceforth refer to locals as small players and foreigners as large players.

The Norwegian data distinguish between spot and forward. The Swedish data also contain swap and option volumes, in addition to purchases and sales of spot and forward contracts. For Norway we have observations from 1991, while the Swedish data set starts in 1993. Further information about the two data set will be given in the discussion of the three crises below.

3.2 Three crisis periods in Scandinavia

In this section we give a brief overview of the three crisis periods that we analyze: (*i*) the ERM-crisis and the depreciation of the Norwegian krone in December 1992; (*ii*) the appreciation of the Norwegian krone in January 1997; and (*iii*) the crisis in both Norway and Sweden following the Russian moratorium in August 1998. Fig. 2 shows the NOK/EUR and SEK/EUR exchange rates, together with the Norwegian sight deposit rate and the Swedish discount rate and the 3-month interest rate differential against Germany for the two countries, from the beginning of 1990 until the end of 2000.[7]

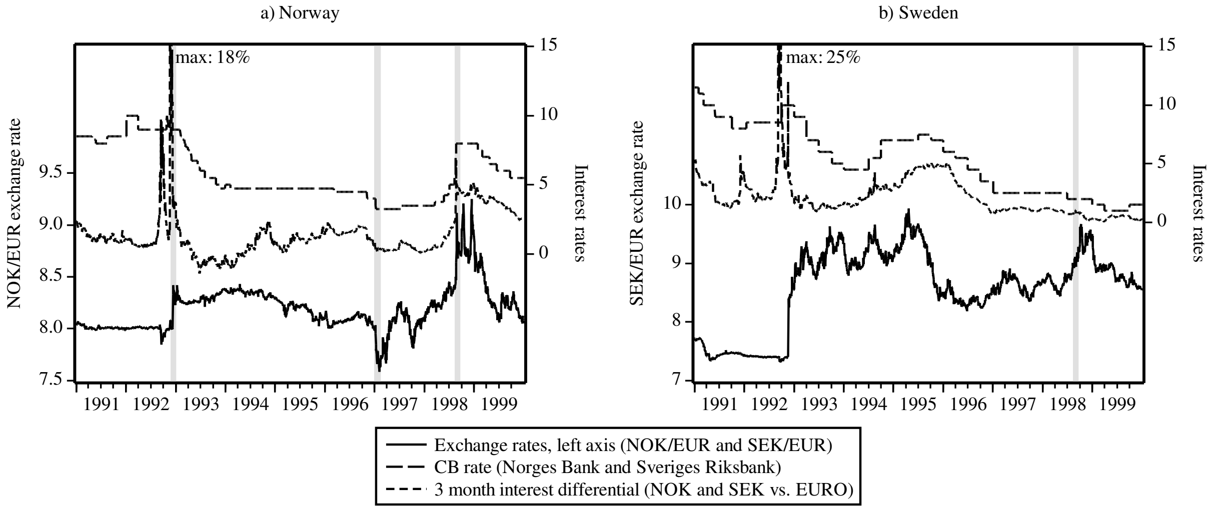
The key dates for the attacks can be identified e.g. from the financial press. In addition we have created the usual "crisis index" used to identify events with special pressure on the exchange rate (see e.g. Eichengreen, Rose, and Wyplosz, 1995, for a description). The crisis index, which take into account that speculative pressure may materialize through interest rate changes instead of exchange rate changes, also identifies these three periods. The index identifies several single events, but these three periods are the only clusters of events.[8]

[6]Foreigner and local are defined by their address.

[7]The euro was introduced Jan. 1, 1999. Using euro-rates implies that we use the NOK/DEM and SEK/DEM exchange rates adjusted for the DEM/EUR-conversion.

[8]The results for the crisis index are available upon request.

Figure 2: Exchange rate, Central bank rate, and 3-month interest rate differential: Norway and Sweden

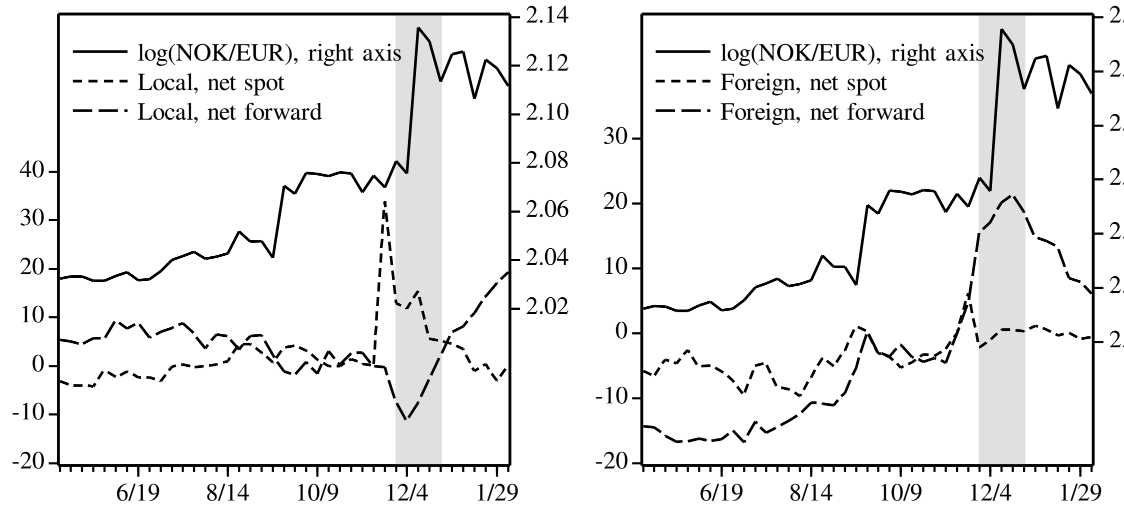


3.2.1 The ERM-crisis: 1992

The 1992-event has the features of a "traditional" currency crisis. Prior to 1992 both Norway and Sweden had pegged their exchange rates to the ECU, with a fluctuation band of $\pm$ 2.5% and $\pm$ 1.5% respectively. From Fig. 2 we see that during 1991 and until October 1992 the Norwegian exchange rate was stable (around a level of 7.65 against the ECU). In August first Finland and Italy, and later the UK, were forced to abandon their fixed pegs. Sweden withstood an attack in September, but chose to devalue in late November after increasing interest rates to 500%. Under the speculative pressure during the fall of 1992, Norges Bank repeatedly increased its key rate to reduce capital outflows. On December 10, 1992, Norges Bank was forced to abandon the fixed ECU-rate. The exchange rate stabilized in the interval between 8.3 and 8.4 against the ECU, implying a change of about 10% from middle rate to middle rate.

In Fig. 3 we see the levels of net positions in spot and forward for small (locals) and large (foreigners) players in the period from May 1992 to January 1993. One of the most striking features of this figure might be how stable these positions are throughout the first part of 1992. The only position that reveals a change is large players' (foreign) forward. Here we see a trend out of NOK-holdings from early August 1992. At this time the interest rate differential was very small. The holdings do, however, stabilize in October 1992. In November 1992 speculative activity emerges in two forms: Small players sold NOK spot and large players (foreigners) sold NOK forward. This is as one should expect. Small players (locals) have a larger part of their portfolio in NOK, and should therefore be able to sell NOK spot. Large players (foreigners) hold presumably a more limited amount spot.

Figure 3: The exchange rate and the level of net positions: Norway during the ERM-crisis.



Note: A negative number indicates a net holding of NOK. Exchange rates measured along the right axis and flows on the left axis.

3.2.2 The Norwegian crisis: 1997

In the aftermath of the ERM-crisis Norway and Sweden chose different monetary policy regimes. Sweden adopted a formal inflation target of 2% in 1993. Norway, on the other hand, chose a managed float regime. Norges Bank had an obligation to stabilize the exchange rate, but only in a medium-term sense. Extreme measures to hold the exchange rate within bounds in the short term were not to be used.[9]

In January 1997 there was speculation inducing an appreciation of the Norwegian krone. The cost of a DEM in NOK fell by more than 5% over a period of 14 days with the largest changes on Jan. 8th – 10th, while the SEK/DEM was largely unaffected. Pressure against NOK had been building for some time prior to this. A number of newspaper reports referred to the role of foreigners speculating in a Norwegian appreciation during the fall of 1996. For instance, on November 5, 1996, the leading business newspaper in Norway (Dagens Næringsliv) reported that foreign analysts "believe in stronger NOK".[10] Already on the next day, Norges Bank lowered its key rate. According to newspapers, Kjell Storvik (the governor of the central bank) hoped that this would reduce the interest in NOK among foreign investors.[11] On November 29, 1996, Dagens Næringsliv states that

> [f]oreigners have again thrown themselves over the Norwegian krone.

[9]The monetary policy regulation from May 6, 1994, stated: "... monetary policy instruments will be oriented with a view to returning the exchange rate over time to its *initial range*. No fluctuation margins are established, nor is there an appurtenant obligation on Norges Bank to intervene in the foreign exchange market." Emphasis added. Norway officially introduced an inflation target of 2.5% in March 2001.

[10]Mathiassen (1996).

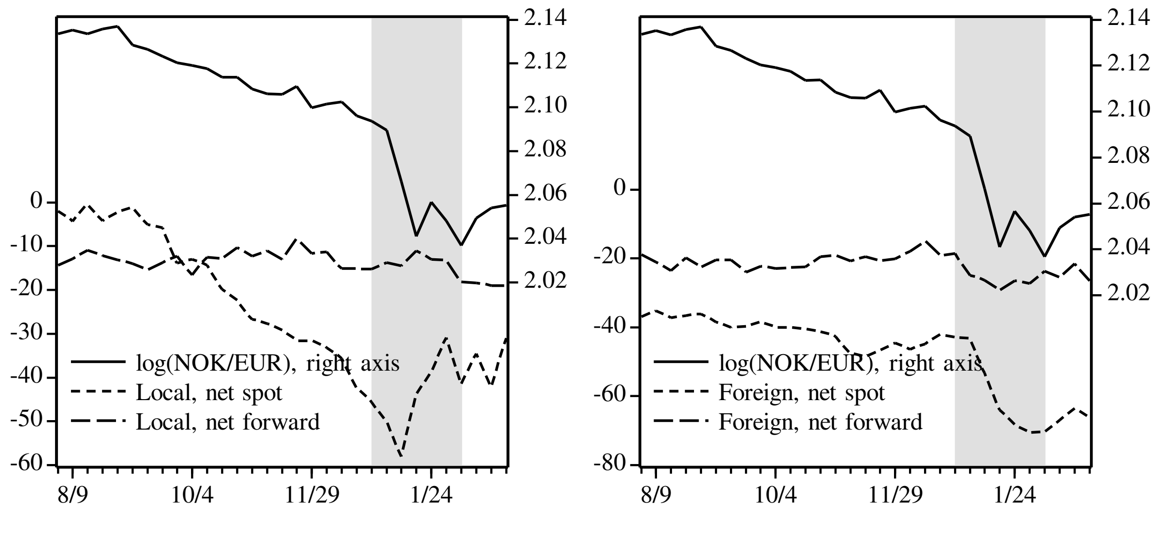
[11]Dagens Næringsliv (1996).

> [...] People in the market [...] believe that the strengthening is a result of foreign investors now believing NOK is so cheap that it is a good buy.[12]

The speculators believed that a strong Norwegian economy and emerging inflationary pressure would force the Norwegian government to change from a managed float to an inflation targeting regime. Inflation targeting would allow Norges Bank to set interest rates higher to fight inflation and dampen a potential boom, with little regard for a potentially steep appreciation of the NOK. Norges Bank instead defended the exchange rate by lowering its key rate.

Fig. 4 shows the NOK/DEM exchange rate and the level of net positions during the period from August 1996 to February 1997. First, note that there is no movement in the forward positions over this period. Second, we see that the exchange rate was trending down from early September 1996. In the period from September to December small players (locals) accumulated spot foreign currency positions as the exchange rate was appreciating. Large players (foreigners) did not change their net positions. During the speculative attack in the first weeks of 1997, the central dates were January 6-7, 1997, large players (foreigners) were buying NOK spot. At this time small players (locals) were selling NOK spot.

Figure 4: The exchange rate and the level of net positions: The Norwegian 1997-crisis.



Note: A negative number indicates a net holding of NOK. Exchange rates measured along the right axis and flows on the left axis.

3.2.3 The Russian moratorium crisis: August 1998

The 1998-crisis in Norway and Sweden took place at the same time as Russia declared a debt moratorium, which was the starting point of a period with substantial international financial turbulence and uncertainty. Russia experienced a boom during the

[12]Haug (1996).

mid-1990's, not least due to high oil prices. However, in June 1998 Russia began to experience balance-of-payment problems as oil prices had fallen substantially through the year.[13] Russia turned to negotiations with the IMF and international creditors, and, after severe problems, an agreement was reached on the evening of Sunday, July 12. In the ten days prior to this agreement the central bank of Russia had sold USD 1.6 billion in attempts to stabilize the exchange rate. During August the crisis reemerged, and on August 17 the Russian president Boris Jeltsin announced a reform package including a possible devaluation of the rouble. The result was a meltdown of international confidence. On August 24 Russia declared a moratorium on all debt payments. This event triggered massive international uncertainty. Investors withdrew money from small currencies, including the NOK and SEK, and countries with a high share of raw material exports were hit especially hard.

In Norway the largest changes in the exchange rate came on the 24th and the days immediately following. Market participants had for some time expected a change in the monetary regime, from a managed float to inflation targeting. During the spring of 1998 Norway experienced a slowdown in growth, and many argued for monetary and fiscal stimulus in order to spur growth.[14] A change to inflation targeting was expected to have resulted in lower short-term interest rates in order to stimulate growth, and thus a weaker currency.

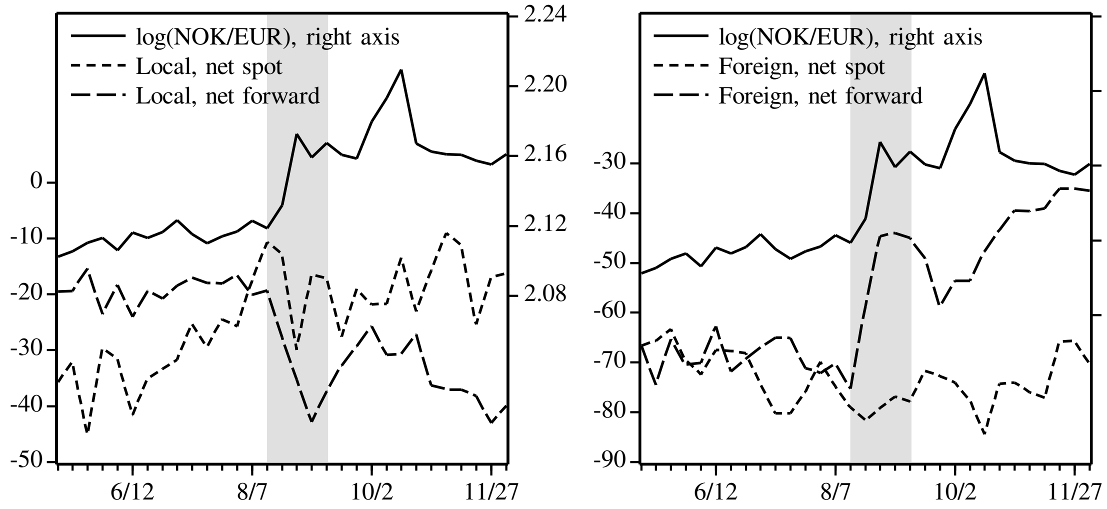
The reaction functions of Norges Bank and Sveriges Riksbank are partly revealed when we look at Fig. 2. We see that while Norges Bank increased its key rate as the NOK/DEM depreciated in July and August, Sveriges Riksbank did not adjust its key rate in response to changes in the exchange rate during this period. This is a clear indication of two very different monetary policy regimes. A key implication is that in Norway delayed speculation would involve a benefit from the interest rate differential. In contrast, in Sweden, there was no increase in the interest rate and thus no reason to postpone speculation.

Figs. 5(a) and 5(b) show NOK/DEM and SEK/DEM exchange rates and the level of net positions during the period from May 1996 to December 1998. Again we see that in Norway small players (locals) were accumulating foreign currency spot during the summer. When the large players (foreigners) attacked in August they did so in the forward market. This sale of NOK was matched by small players (locals) buying NOK forward. In Sweden the large players (foreigners) were selling SEK in July and August, with a peak around the Russian moratorium. Small players (locals), on the other hand, were buying SEK forward.

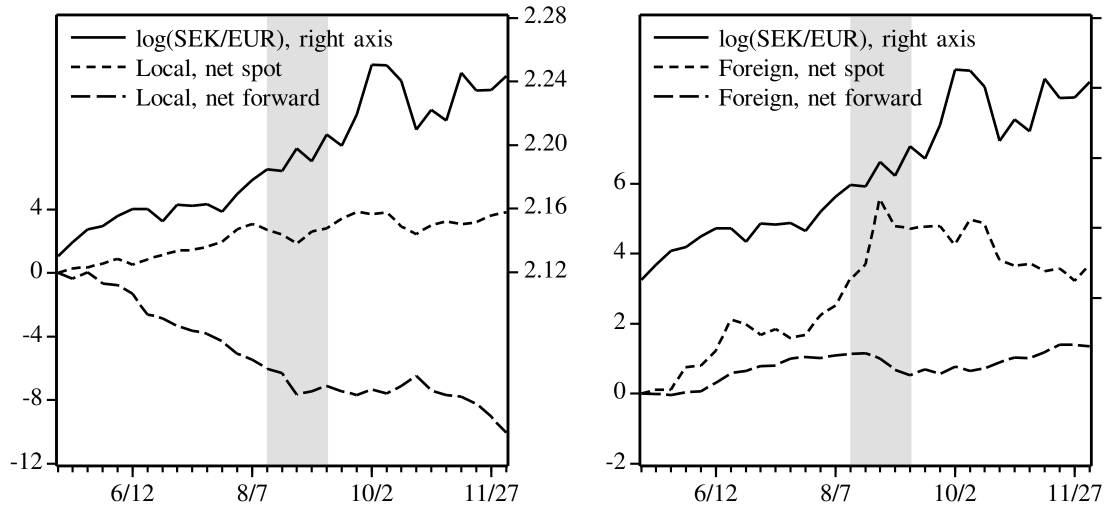
[13]Oil prices fell from USD 17 at the beginning of 1998 to an average price of USD 12.50 in the period June-October 1998.

[14]Norway's leading indicator peaked in December 1997, and decreased during 1998.

Figure 5: The exchange rate and the level of net positions: The 1998 Russian moratorium crisis in Norway and Sweden.



(a) Norway



(b) Sweden

Note: A negative number indicates a net holding of NOK. Exchange rates measured along the right axis and flows on the left axis.

4 Results

Ideally, we would want to test the model by exploring to what extent the value of the signal to the large player could explain the trading behavior and the effect on the exchange rate. However, the signal is not observable to us. Our observable variables are caused by the fundamentals as well as the action of the players. Thus, our test will focus on variables we can observe, along two lines: (*i*) The sequence of move of the large and small players, and (*ii*) which players trigger the actual change in the exchange rate. Let us repeat: If fundamentals are weak, i.e., a successful attack is very likely, large players will move in the rear in order to reap the interest rate benefit (if any), while small players will move early. If fundamentals are stronger, or the interest rate benefit is small, large players may move early as well in order to induce small players to join in on the attack. Only in the case where large players *only* speculate early will we see that only small players trigger the exchange rate change. Further, we have identified four specific events, three in Norway and one in Sweden, for which we will test these hypotheses. Since foreigners can raise more funds on short notice we will treat foreigners as large players.

To test for the sequence in the speculative attacks we will use the statistical concept of Granger causality. Granger causality is not an economic definition of causality, but might be useful to distinguish between which group of players move first or last.

There is *absence* of Granger causality from x to y if estimation of a variable y on lagged values of y and lagged values of x are equivalent to an estimation of y on only lagged values of y. This can be expressed as

$$y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i y_{t-i} + \sum_{i=1}^{k} \beta_i x_{t-i} + \varepsilon_t, \tag{9}$$

where the variable x *does not* Granger cause y if the joint hypothesis of $\beta_1 = \ldots = \beta_k = 0$ is not rejected.

When choosing the sample for the Granger causality test we take the crisis dates as our starting point. We end the samples as soon as there are any signs that the exchange rate has stabilized, i.e. when the crisis is over. The beginning of the sample is determined similarly, and in addition adding observations in the beginning to ensure that the sample is sufficiently long for statistical analysis. This balances the need for a sufficient number of observations without mixing crisis periods and calm periods.

The results from the Granger causality tests are shown in Table 1. We regress the first-difference of the net position used in the attack, as seen from the graphs of Figs. 3 to 5, on the first lag of smalls (locals) flows and larges (foreigners) flows. We use dummies to differentiate between crisis period and pre-crisis period, and p-values are in parenthesis. In the appendix we present a summary of other results for the crisis

Table 1: Granger causality test for flows: Crisis and pre-crisis

Note: Difference of net-position (flows) used for speculation by large and small players estimated within a system on lagged flows of large and small players, with dummies for pre-crisis period and crisis period. p-values in parenthesis. All equations use one lag, except for Norway in 1998 where we use two lags of small's spot trading in the large-specification during the crisis-period, based on Swarchz criterion. In Norway, small players (locals) always speculate in spot, while Large players (foreign) speculate with spot in 1997 and with forward in 1992 and 1998. For the Swedish 1998 crisis we estimate using difference of total position. ** and * indicates significance at the 1% and 5%-level, respectively.

	Norway						Sweden	
	1992		1997		1998		1998	
	Large	Small	Large	Small	Large	Small	Large	Small
Constant	0.352	0.177	-0.305	-1.092	-0.441	0.789	-0.009	-0.520
	*(0.09)	(0.44)	(0.13)	*(0.07)	(0.33)	(0.14)	(0.64)	**(0.00)
Crisis: Large, lagged	0.357	0.098	0.573	-0.721	0.030	-0.009	0.899	-1.318
	**(0.02)	(0.71)	**(0.00)	(0.11)	(0.91)	(0.98)	**(0.00)	**(0.00)
Crisis: Small, lagged	0.208	-0.420	0.184	-0.401	0.341	-0.379	0.016	-0.412
	**(0.00)	**(0.00)	**(0.04)	**(0.03)	**(0.00)	**(0.00)	(0.80)	**(0.02)
Pre-crisis: Large, lagged	-0.208	-0.021	-0.268	-0.136	-0.080	0.017	0.824	-0.816
	**(0.01)	(0.82)	**(0.00)	(0.33)	(0.39)	(0.94)	**(0.00)	**(0.00)
Pre-crisis: Small, lagged	0.014	-0.124	0.077	-0.315	0.141	-0.403	-0.041	-0.154
	(0.91)	(0.22)	**(0.03)	**(0.00)	(0.34)	**(0.00)	(0.71)	(0.40)
adj.R^2	0.23	0.13	0.21	0.12	0.03	0.11	0.85	0.57
Durbin-Watson	2.17	2.23	1.91	1.80	1.88	2.29	2.83	1.51
Observations	81		70		71		71	
Crisis-observations	41		30		31		31	
Crisis period	May 1, 1992 – Feb 2, 1993		Aug 9, 1996 – Feb 28, 1997		May 8, 1998 – Dec 4, 1998		May 8, 1998 – Dec 4, 1998	

and pre-crisis periods, for different lag-structures and VAR-formulations, that indicate that the results are rather robust.

For the three Norwegian crises we see that lagged speculation of small players has a significant positive effect on the speculation of large players, while the lagged speculation of large players has no significant effect on the small players' speculation. Thus, small players Granger cause large players. This is in line with the model since in all three cases interest rate differentials changed in such a way to make it more costly to speculate early, implying that large players might gain from delaying the attack.

For the Swedish 1998-crisis there is some evidence that large players Granger cause small players, as lagged speculation of large players is significant in the small player regression. This result is also consistent with the model since large players (foreigners) did not have a gain from waiting as Sveriges Riksbank did not increase interest rates; hence risk-adjusted gains by moving late were lower. In Sweden, no change in monetary policy was expected, indicating a higher fundamental θ, and a higher signal y. On the other hand, lower Swedish interest rates meant that speculation costs were lower, i.e. lower t. For small players, low θ and low t have opposing effects, leaving the impact on speculation indeterminate. For large players, however, it follows directly from (8) and the proof of the Proposition in the appendix, that, keeping the sum of the signal and the speculation costs, $y + t$, constant, an increase in speculation costs leads to less early speculation by the large player. In other words, in the speculative attack in Sweden, where interest rates were low, we would expect more early speculation by the large player.

Finally, a comparison of the pre-crisis and crisis part of Table 1 (and Table 6 in the appendix) we see that the pattern discussed above is not representative for the pre-crisis periods. This is consistent with the idea of the model that trading sequences during an attack are different from non-crisis periods.

The second question is to identify which group was most active during the actual crisis. To investigate this question we use the following strategy. We regress changes in the exchange rate on contemporaneous changes in flows and macro variables. Due to problems of multicollinearity we run separate regressions for small (locals) and large (foreigners) players.

The sample is selected in the same way as in the GC-analysis. We use the same observations as above, but since we also estimate flow effects outside of the actual crisis we merge these three periods. The focus is on what happens during the actual speculative attack. Hence, for each crisis we create dummies that equal one the week before the actual attack and the largest changes around the official date, and zero otherwise. This gives us three crisis-observations (dummy equals one) for 1992 and 1998, and four for 1997. Tables 2 and 3 report the regressions for Norway and Sweden respectively.

Table 2: NOK-regressions

	dlog(NOK/DEM)			
	on Foreign flows		on Local flows	
Constant	-0.00013		0.00046	
	(-0.17)		(0.50)	
Interest rate diff	-0.00062		-0.00240	
	(-1.07)		(-3.77)	**
Oil price	-0.02894		-0.03162	
	(-1.45)		(-1.47)	
92-crisis, spot	0.00839		-0.00147	
	(3.75)	**	(-1.39)	
92-crisis, forward	0.00687		0.00432	
	(4.29)	**	(1.68)	
97-crisis, spot	0.00226		0.00088	
	(3.31)	**	(1.10)	
97-crisis, forward	0.00034		-0.00903	
	(0.23)		(-2.50)	*
98-crisis, spot	0.00238		-0.00183	
	(1.15)		(-4.01)	**
98-crisis, forward	0.00167		-0.00152	
	(4.44)	**	(-2.20)	*
Spot	-0.00053		0.00056	
	(-1.76)		(3.00)	**
Forward	0.00026		-0.00007	
	(0.82)		(-0.20)	
AR(1)	-0.22184		-0.06703	
	(-2.06)	*	(-0.59)	
adj.R^2	0.41		0.35	
DW	2.11		2.04	

Table 3: SEK-regressions

	dlog(SEK/DEM)			
	on Large's flows		on Small's flows	
Constant	0.0005		-0.0001	
	(1.02)		(-0.20)	
Interest rate diff.	0.0174		0.0189	
	(5.24)	**	(5.56)	**
Oil price	-0.0175		-0.0180	
	(-1.99)	*	(-2.01)	*
98-crisis, Spot	0.0033		0.0027	
	(0.66)		(0.18)	
98-crisis, Forward	-0.0078		-0.0070	
	(-0.29)		(-0.71)	
Spot	0.0079		-0.0058	
	(5.82)	**	(-4.18)	**
Forward	0.0067		-0.0037	
	(5.59)	**	(-2.70)	**
AR(1)	-0.1829		-0.1513	
	(-4.11)	**	(-3.41)	**
adj.R^2	0.14		0.12	
DW-stat.	2.00		1.99	

In the regressions we include the 3-month interest rate differential against Germany and the log-differenced oil price as macroeconomic variables. The rows labeled "Spot" and "Forward" report the coefficients and t-values for flows outside the actual crisis, while the other rows are the effect of flow in the different crisis. For Sweden we only consider the 1998-crisis.

From the informal discussion as well as the GC-analysis above, we would expect that large players (foreigners) were instrumental in the three Norwegian crises. This should be reflected in significant and positive coefficients, as players buy currency (positive flow) when speculating on a depreciation (positive change in the exchange rate), and sell when speculating on an appreciation. In the 1992- and 1998- crises, foreigners speculated forward (as they have less spot available), while they used spot in the 1997- appreciation crisis.

We would also expect that the small players (locals) flow is insignificant in all three crisis in the case of Norway, and at least not positive. From Table 2 we see that these expectations are largely borne through. In addition, the large players' (foreigners) spot flow is significant and positive for the 1992-crisis, and some of the small players' (locals) flows are significant and negative for the 1997 and 1998-crises. Negative coefficients imply that the small players (locals) are providing liquidity to the large players (foreigners) during the actual attack.

For Sweden we do not find any significant effects during the 1998-crisis. Given the evidence that large players (foreigners) Granger caused small players (locals) we would expect that at least the small players (locals) were positive and significant. However, Fig. 5 seems to suggest that it is the large players that are most active in the crisis week, and that the period when the SEK actually jumped was somewhat later.

For Norway, we see that the strength of the correlation differs somewhat between the three events. For the 1992-case we find a size effect of forward flow is 0.69% per billion NOK sold, or about 5% per 1 billion USD equivalent.[15] For the 1997-event we find the spot-effect to be about 1.6% per 1 billion USD equivalent. For the 1998-event we find the effect of forward to be approximately 1.2% per 1 billion USD equivalent. As a comparison Evans and Lyons (2002) report an effect from order flow to the DEM/USD exchange rate of about 0.5% per 1 billion USD equivalent. The larger effect of given currency trade on the exchange rate that we find seems reasonable given that the NOK/DEM market is much smaller than the DEM/USD market. The lower numbers for 1997 and 1998 might be due to increased liquidity, less rigid monetary regimes, and possibly that external events were more important than changes in currency positions during these events.

5 Conclusion

We study the dynamics of speculative attacks. The problem of connecting currency crises to fundamentals has led to a discussion of possible manipulation of exchange rates, especially by large foreign players like hedge funds and other highly leveraged institutions. To analyze this we extend the model of Corsetti et al. (2004) to allow large players to move both prior and after small players during a speculative attack. The model of Corsetti et al. (2004) predicts that large players may move early in an attack in order to induce small players to attack. It has, however, been argued by Tabellini (1994) and the IMF that large players move in the rear in currency crises because they benefit from higher interest rate differentials. In our model the large players may choose to speculate early, at the same cost as small players, or later at a lower cost. The lower cost is due to benefits of higher interest rate differentials. The small players are not able to speculate late because in that case one must be able to move quickly in order to not be *too* late. The predictions of the model are the following: If there is no gain from speculating late, the large player will speculate early. If there are gains from speculating late, the strategy of the large player depends on his signal of fundamentals. If fundamentals are very weak, large players will do all their speculation late as there is no gain from inducing the small players to join in the attack. If fundamentals are stronger, the large players may choose to speculate early with some of their funds. Unless the large players' signal on fundamentals is so strong that they choose to do all their speculation early, the change in position of the large players will be the one that

[15] The average NOK/USD rate over the period 1992-2000 was 7.4.

triggers the attack.

The implications of the model are then tested using data on net positions of large (foreigners) and small (locals) players in Norway and Sweden for the following four speculative attacks during the 1990s: The ERM-attack in 1992 on the Norwegian krone; the 1997 apprectionary crisis in Norway; and the August 1998 crisis following the Russian moratorium. In the latter case we can also compare with Sweden, using similar data, which also experienced speculative pressure but followed a different strategy than the central bank of Norway. The sequence of trading is tested with Granger causality tests, while the triggering of the attacks is tested with regression analysis. We find that small players lead the large players in all cases except the 1998-crisis in Sweden. This is in line with the model since the Norwegian central bank used interest rates to defend the krone in all cases, while the Swedish central bank did not change its interest rate during the depreciation crisis in 1998. Hence, while there was a gain for the large players by delaying the attack in Norway, there was no gain by delaying the attack for large players in Sweden. The regression analysis shows that it was the large players that triggered the attack in all cases. We can not condition on the signal of the players in the regressions. The fact that all attacks were successful may, however, indicate that fundamentals in Norway in all three cases were in the region where large players preferred to move in the rear.

This paper is to the best of our knowledge the first that is able to study speculative attacks with data on the positions of both large (foreign) and small (local) players.

A Proof of Proposition

For later use, note that the expected payoff given an early speculation λ^* is given by

$$E\pi^* = L \cdot G\left(\frac{1-t+\lambda^*-y}{\tau}\right) - t\lambda^* =$$

$$L \cdot G\left(g^{-1}\left(\frac{\tau t}{L}\right)\right) - t\left(y-(1-t)+\tau g^{-1}\left(\frac{\tau t}{L}\right)\right), \quad (10)$$

where we use equation (8) to substitute for λ^*.

The expected payoff from not speculating early, yet entering at a late stage in the amount L (at zero cost), is

$$E\pi^0 = L \cdot G\left(\frac{1-t-y}{\tau}\right). \quad (11)$$

Proof. Consider first the interval $y < y^{Lo}$. In this interval we know that $\frac{\partial E\pi}{\partial \lambda} = L \cdot g\left(\frac{1-t+\lambda-y}{\tau}\right)\frac{1}{\tau} - t < 0$, as it follows from the derivation above that

1. $\frac{\partial E\pi}{\partial \lambda} = 0$ for $y = y^{Lo}$ and $\lambda = 0$.

2. $g'(.) < 0$ for all $y < y^{Lo}$ (as $g(.)$ is strictly decreasing for all positive arguments, and $\frac{1-t-y^{Lo}}{\tau} > 0$)

It follows that in this interval the optimal early speculation is zero, $\lambda = 0$ (as we do not allow negative speculation)

We then restrict attention to $y > y^{Lo}$. Define the difference between the profit under optimal early speculation and the profit with no early speculation $W(y) \equiv E\pi^* - E\pi^0$. Using (10) and (11), we obtain

$$W(y) = L \cdot G\left(g^{-1}\left(\frac{\tau t}{L}\right)\right) - t\left(y - (1-t) + \tau g^{-1}\left(\frac{\tau t}{L}\right)\right) - L \cdot G\left(\frac{1-t-y}{\tau}\right).$$

We have that $W(y^{Lo}) = 0$, as it is optimal to set the early speculation at zero for $y = y^{Lo}$. Furthermore, note that the derivative of W in the point $y = y^{Lo}$ is also zero, i.e.,

$$\frac{\partial W(y^{Lo})}{\partial y} = -t + L \cdot g\left(\frac{1-t-y^{Lo}}{\tau}\right)\frac{1}{\tau}$$
$$= -t + L \cdot g\left(\frac{1-t-\left(1-t-\tau g^{-1}\left(\frac{\tau t}{L}\right)\right)}{\tau}\right)\frac{1}{\tau} = -t + L\frac{\tau t}{L}\frac{1}{\tau} = 0.$$

Consider first the interval for y satisfying $\frac{1-t-y^{Lo}}{\tau} > \frac{1-t-y}{\tau} \geq 0$. It is clear that in this interval $\frac{\partial W}{\partial y} > 0$, since $g(.)$ is strictly decreasing for positive arguments, implying that $g(.)$ is greater for smaller arguments (i.e., for $y \geq y^{Lo}$). It follows that $W(y) > 0$ in this interval; this implies that it is profitable to speculate early in a quantity $\lambda^* > 0$ in this interval.

Then consider all y satisfying $\frac{1-t-y}{\tau} < 0$. We have

$$\frac{\partial^2 W}{\partial y^2} = -L \cdot g'\left(\frac{1-t-y}{\tau}\right)\frac{1}{\tau^2} < 0,$$

implying that W is strictly concave. As W clearly goes to minus infinity as y converges to infinity, there is a unique value y^{Hi} for which $W(y^{Hi}) = 0$. Thus, for $y > y^{Hi}$, then $W(y) < 0$, implying that early speculation is not profitable, i.e. set $\lambda = 0$. However, in the interval $y \in \left(y^{Lo}, y^{Hi}\right)$, $W(y) > 0$, implying that early speculation is profitable, in the amount λ^*. ■

B Tables

Table 4: Summary of bivariate Granger causality tests for flows during crisis: Norway, 1992, 1997 and 1998 crises
Note: Table shows all significant (5% -level, 10% -level if marked with *) bivariate Granger causality relationships for the crisis-periods defined above, for lag 1 to 4. Relationships in bold confirm our previous results.

		Lags=1	Lags=2	Lags=3	Lags=4
1992	Levels		**Ss⇒Ls**	**Ss⇒Ls**	**Ss⇒Ls**
		Ss⇒Lf	Ss⇔Lf	**Ss⇒Lf**	**Ss⇒Lf**
		St⇒Ls	**St⇒Ls**		
		St⇒Lf	**St⇒Lf**	**St⇒Lf**	**St⇒Lf**
			Lt⇒Ss		
		Sf⇔Lf	Lf⇒Sf	Lf⇒Sf	Lf⇒Sf
		Lt⇒Sf	Lt⇒Sf	Lt⇒Sf	Lt⇒Sf
	Differences	**Ss⇒Ls**	**Ss⇒Ls**	**Ss⇒Ls**	**Ss⇒Ls**
		Ss⇒Lf	**Ss⇒Lf**	**Ss⇒Lf**	**Ss⇒Lf**
		St⇒Ls	**St⇒Ls**	**(St⇒Ls)***	
		St⇒Lf	**St⇒Lf**	**St⇒Lf**	**St⇒Lf**
					Lf⇒Sf
1997	Levels	**Ss⇒Ls**	Ss⇔Ls		
			Ss⇔Lf		
		St⇒Ls	St⇔Ls	**St⇒Ls**	
			St⇒Lf		**St⇒Lf**
		Ss⇒Lt	**Ss⇒Lt**	**Ss⇒Lt**	**Ss⇒Lt**
		St⇒Lt	**St⇒Lt**	**St⇒Lt**	**St⇒Lt**
			Lt⇒Sf	Lt⇒Sf	
			Ls⇒Sf	Ls⇒Sf	
		Sf⇒Lf	Sf⇒Lf	Sf⇒Lf	Sf⇒Lf
	Differences	Ls⇒Ss	Ls⇒Ss		
		Ss⇒Lf	**Ss⇒Lf**	**Ss⇒Lf**	
		Ls⇒St	Ls⇒St		
		St⇒Lf	**St⇒Lf**	**St⇒Lf**	St⇔Lf
		Ss⇒Lt	Ss⇔Lt	**Ss⇒Lt**	**Ss⇒Lt**
		St⇒Lt	St⇔Lt	**St⇒Lt**	**St⇒Lt**
1998	Levels	**Ss⇒Lf**	**Ss⇒Lf**	**Ss⇒Lf**	**Ss⇒Lf**
		St⇒Lf	**St⇒Lf**	**St⇒Lf**	
		Ss⇒Lt	**Ss⇒Lt**	**Ss⇒Lt**	
		St⇒Lt	**St⇒Lt**	**St⇒Lt**	**St⇒Lt**
		Lf⇒Sf	Lf⇒Sf	Sf⇒Lf	Lf⇒Sf
		Sf⇒Lt	Lt⇒Sf	Sf⇔Lt	Lt⇒Sf
	Differences		**Ss⇒Lf**	**(Ss⇒Lf)***	**(Ss⇒Lf)***
		Lf⇒Sf	Lf⇒Sf	Lf⇒Sf	Lf⇒Sf
		Lt⇒Sf	Sf⇔Lt	Lt⇔Sf	

Table 5: Summary of bivariate Granger causality tests for flows during crisis: Sweden, 1998-crisis

Note: Table shows all significant (5% -level, 10% -level if marked with *) bivariate Granger causality relationships for the crisis-periods defined above, for lag 1 to 4. Relationships in bold confirm our previous results.

		Lags=1	Lags=2	Lags=3	Lags=4
Swe 1998	Levels	**Lf⇒Sf**	**Lf⇒Sf**	**Lf⇒Sf**	**Lf⇒Sf**
		Lf⇒St	**Lf⇒St**		**Lf⇒Ss**
		Ls⇒Sf	**Ls⇒Sf**		**Ls⇒Sf**
	Differences	**Lf⇒Sf**	Lf⇔Sf	**Lf⇒Sf**	
			Ss⇒Lf	Ss⇒Lf	

Table 6: Bivariate Granger Causality tests for non-crises period

Note: Table shows all significant (5% -level, 10% -level if marked with *) bivariate Granger causality relationships for the periods prior to the crisis-periods defined above, for lag 1 to 4.

		Lags=1	Lags=2	Lags=3	Lags=4
Nor 1992	Levels	Ss⇔Ls	Ss⇔Ls	Ls⇔Ss	Ls⇒Ss
		Lf⇒Ss	Lf⇒Ss	Lf⇒Ss	Lf⇒Ss
		Lt⇔Ss	Lt⇒Ss	Lt⇒Ss	Lt⇒Ss
		Sf⇒Ls			
		Ls⇔St	Ls⇒St		
		St⇔Lt	Lt⇒St		
	Differences			Ls⇒Ss	
		Lt⇒Ss		Lt⇒Ss	
Nor 1997	Levels	Ss⇒Lt			
		Ls⇒St			
			Ss⇒Lt	Ss⇒Lt	Ss⇒Lt
		St⇒Lt	St⇒Lt		
	Differences		Lf⇒Sf	Lf⇒Sf	
Nor 1998	Levels	Lf⇒Ls	Ss⇔Ls	Ls⇒Ss	Ls⇔Ss
			Ls⇔St	Lf⇒Ss	Ls⇒St
				Ls⇒St	Lf⇒St (Lf⇔St)*
				Lf⇒St	Lf⇔Ls
	Differences	Ls⇔Ss	Ls⇒Ss	Ls⇒Ss	Ls⇔Ss
		Ls⇔St	Lf⇒Ss	Lf⇒Ss	Lf⇒Ss
			Lf⇒St	Ls⇒St	Lf⇔St
				Lf⇔St	Lf⇔Ls
Swe 1998	Levels	Ls⇒Lf	Ls⇒Lf	Ls⇒Lf	
		Sf⇒Lf	Sf⇒Lf	Sf⇒Lf	Sf⇒Lf
		Ss⇒Lf	Ss⇒Lf	Ss⇒Lf	Ss⇒Lf
		St⇒Lf			
		Sf⇔Ls	Sf⇔Ls	Sf⇔Ls	Sf⇔Ls
		Ss⇒Ls	Ss⇒Ls		
		Lt⇔Sf	Lt⇔Sf	Lt⇔Sf	Lt⇔Sf
		Ss⇒Lt			Ss⇒Lt
	Differences			None	

Table 7: Summary of Granger causality test for flows during crises: Alternative specifications

Note: Bivar. GC is GC-tests within a bivariate VAR, Trivar. GC is GC-tests within a trivariate VAR, and All Flows refer to a VAR with all four flows included. In the "Large spec. trivariate VAR" we include the flow variable the Large player (foreign) used for speculation and the two flows of the Small players (locals), and vice versa in the "Small spec. trivariate VAR". Small players (locals) always speculate in spot, while Large players (foreign) speculate with spot in 1997 and with forward in 1992 and 1998. All tests performed at the 5%-level or better, and only significant ones are reported. We investigate formulations with 1 to 4 lags. Numbers in parenthesis indicate which lag the Granger causality is valid for, unless it is valid for all specifications. We use the following two-letter abbreviations for flows: First letter indicates large (L) or small (S). Second letter indicates spot (s), or forward (f), or sum of spot and forward (t).

	Bivar. GC	Trivar. GC		All flows
		Foreign spec.	Small spec.	
1992	**Ss⇒Lf**	**Ss⇒Lf**	**Ss⇒Lf**	**Ss⇒Lf**
Nor.	St⇒Lf	Lf⇒Sf	Lf⇒Ls	Lf⇒Ls
	Lf⇔Sf	Ss⇔Ls (1)	Ss⇒Ls	Ss⇒Ls
	St⇒Ls	Ss⇒Ls (2)		Lf⇒Sf
				Ss⇒Sf
1997	**Ss⇒Ls (1)**	**Ss⇒Ls (1)**	**Ss⇒Ls**	**Ss⇒Ls**
Nor.	Ss⇒Lt	Ls⇒Sf	Lf⇒Ls	Sf⇒Lf
	St⇒Lt	*Ss⇔Ls* (2,3)	Ss⇒Lf (2)	Lf⇒Ls
	St⇒Ls (1)			Ls⇒Sf (1)
	Lt⇒Sf			
	Ls⇒Sf (1)			
	Sf⇒Lt (1)			
	St⇒Lf (1)			
1998	**Ss⇒Lf**	**Ss⇒Lf**	**Ss⇒Lf**	**Ss⇒Lf**
Nor.	St⇒Lf	Lf⇒Sf (1)	Ls⇒Lf (3,4)	Lf⇒Sf (1)
	Ss⇒Lt	Ss⇒Sf (2)		Ls⇒Lf (3,4)
	Lf⇒Sf			Ss⇒Sf (3,4)
	Sf⇒Lt (1)			
	St⇒Lt (3)			
	Lt⇒Sf (4)			
1998	**Ls⇒Ss**	Sf⇒Ls (1)	**Ls⇒Ss**	**Ls⇒Ss** (4)
Swe.	Ls⇒Sf (4)	Sf⇔Ls (4)	Lf⇒Ls (1)	Lf⇒Ss
	Lt⇒St	Ss⇒Sf (4)	Lf⇔Ls (4)	Ls⇒Sf (4)
	Lt⇒Ss			
	Lf⇒St (1)			
	Lf⇔St (4)			

References

Bjønnes G.H., Rime D., Solheim H.O.A., 2005. Liquidity provision in the overnight foreign exchange market. Journal of International Money and Finance 24, 177–198.

Cai J., Cheung Y.L., Lee R.S.K., Melvin M., 2001. 'Once-in-a-generation' yen volatility in 1998: Fundamentals, intervention, and order flow. Journal of International Money and Finance 20, 327–347.

Calvo G.A., Reinhart C.M., 2002. Fear of floating. Quarterly Journal of Economics 117, 379–408.

Corsetti G., Dasgupta A., Morris S., Shin H.S., 2004. Does one Soros make a difference? a theory of currency crises with large and small traders. Review of Economic Studies 71, 87–114.

Corsetti G., Pesenti P., Roubini N., 2002. The role of large players in currency crises. In: S. Edwards, J.A. Frankel (Eds.), Preventing Currency Crises in Emerging Markets, University of Chicago Press, chap. 5.

Dagens Næringsliv, 1996. Nytt press på den Norske kronen (*Renewed Pressure on the Norwegian krone*). Dagens Næringsliv November 6.

Eichengreen B., Rose A.K., Wyplosz C., 1995. Exchange market mayhem. Economic Policy , 251–312.

Evans M.D.D., Lyons R.K., 2002. Order flow and exchange rate dynamics. Journal of Political Economy 110, 170–180.

Haug A.K., 1996. Nytt press på den Norske kronen (*Renewed Pressure on the Norwegian krone*). Dagens Næringsliv November 29.

IMF, 1998. Hedge funds and financial market dynamics. IMF Occasional Paper 166, International Monetary Fund.

Krugman P.R., 1979. A model of Balance-of-Payments crises. Journal of Money, Credit and Banking 11, 311–325.

Mathiassen S., 1996. Stor tro på kronen utenlands (*Great confidence in the krone abroad*). Dagens Næringsliv November 5.

Morris S., Shin H.S., 1998. Unique equilibrium in a model of self-fulfilling currency attacks. American Economic Review 88, 587–597.

Obstfeld M., 1986. Rational and Self-Fulfilling Balance-of-Payments crises. American Economic Review 82, 72–81.

Tabellini G., 1994. Comments: 'European exchange rate credibility before the fall' by A.K. Rose and L.E.O. Svensson. European Economic Review 38, 1221–1223.

Wei S.J., Kim J., 1997. The big players in the foreign exchange market: Do they trade on information or noise. Working Paper 6256, NBER.

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