Speculative Attacks on

Nordic Exchange-Rates, 1971-1992

August 27, 2005

Licentiate Thesis

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Abstract

This paper analyzes the relationship between economic fundamentals and balance-of-payments crises for the three Nordic countries, Norway, Sweden, and Finland, during 1971-1992.

To identify periods of balance-of-payments crisis a method first introduced by Eichengreen, Rose, and Wyplosz (1996) was used. They did not report specific results for the three Nordic countries, but compared a group of ERM countries with a control-group of non-ERM countries (including Norway, Sweden and Finland) during 1967-1992. The results here verify theirs more generally, in that the three Nordic non-ERM countries in particular also followed the so-called first-generation of balance-of-payments-crisis models (Paul Krugman, 1979).

A second finding was that balance-of-payments crises for the three Nordic countries mainly took place during recessions, typically when governments tried to stimulate their way out by holding government spending constant in spite of decreased tax revenues, which led to budget deficits and speculative attacks. This result is consistent with Krugman's first-generation model, based on constant revenue and increased spending, which led to the same result.

Keywords: Balance of Payments Crisis; Nordic; Exchange rates; Speculative Attacks

JEL-Codes: F31; F32

Acknowledgments

I would like to thank Professor Clas Wihlborg for suggesting this as a possible dissertation topic, as well as Assistant Professor Ali Tasarin and Almas Hesmati who were very helpful at the beginning of the work. Eugeniy Nivorozhkin encouraged me throughout, together with Thomas Eriksson, who provided many helpful comments. Rick Wicks has provided language corrections, editorial suggestions, and many other useful comments.

Not least I would like to thank Stiftelsen Kapitalmarknadsgruppen (the Capital Market Group Foundation) for generously providing a grant for this work.

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1. Introduction

1.1 Background

The purpose of this paper is to examine the relationship between balance-of-payments crises and economic fundamentals for the three Nordic countries, Norway, Sweden, and Finland, during 1971-1992. There are three different generations of models that compete to explain the relationship; this study was designed to evaluate them empirically in the Nordic context. Once the relationship between balance-of-payments crises and economic fundamentals is understood, increased awareness might help governments make better policy-decisions and thereby perhaps avoid currency-crises.

The models are the so-called *first*-generation balance-of-payments-crisis models, by Krugman (1979) and Flood and Garber (1984a), which are characterized by a rather direct link between economic fundamentals and balance-of-payments crises. This gives a tendency to put the blame on the government for crises because the government is thought to have financed increased spending through increased money-supply, and thereby to have caused the crisis.

Then comes the so-called *second*-generation balance-of-payments-crisis models (Obstfeldt, 1986), which add to the first type by allowing for self-fulfilling speculative attacks. In other words, speculative attacks, and thereby balance-of-payments crises, could occur even though foreign reserves were large enough to handle "normal" balance-of-payments deficits. If not broken, the link between economic fundamentals and speculative attacks thereby becomes at least very much reduced, and one would thus no longer expect any clear correlation between economic fundamentals and crises. Several empirical studies have supported this model.

Finally, the *third* type of model, developed under the collective heading "*second* generation of currency-crisis *literature*", again emphasizes the role of government, which now is able to evaluate the costs and benefits of keeping the exchange-rate fixed. Thus there could again be a correlation between economic fundamentals and crises, but possibly a stepwise relation, since the government might postpone the crisis, leading to possible multiple equilibriums.

A difficulty when empirically testing the relationship between balance-of-payments crises and economic fundamentals has to do with locating crisis-periods in time. Therefore a

method proposed by Eichengreen, Rose, and Wyplosz (hereafter referred to as ERW) (1996a) was used here. ERW used speculative attacks to identify crises, because speculative attacks may cause crises (in second-generation models), or they may be provoked by economic fundamentals (in first-generation models, as well as in "second-generation literature"). Speculative attacks were in turn identified with the help of an index of speculative pressure, since speculative attacks themselves are seldom openly announced or even admitted. Centered on each such speculative attack, a "period of crisis" of five quarters of a year was defined, for which data on economic fundamentals was then tested, comparing periods of crisis and non-crisis.

Before constructing the index of speculative pressure and identifying speculative attacks and periods of crisis, however, the three time-series of macroeconomic variables that make up the index (exchange-rate, foreign reserves, and interest-rates) had to be analyzed to make sure that they did not bias the results through autocorrelation or heteroscedasticity. This analysis (and correction, if necessary) was done with the help of univariate time-series analysis.

This study confirms the results by ERW (1996a), who found that a group of non-ERM countries (including Norway, Sweden, and Finland) generally followed the first-generation models during the period of study. The results here, however, show constant government-spending combined with decreasing revenue, instead of constant revenue with increased spending as in Krugman's model. This becomes visible through a falling trend in fiscal ratios and trade-balances, showing that crises among the three Nordic countries usually occurred during recessions. The governments – trying to stimulate their way out of recession – managed to increase money-supply without affecting interest-rates, credit-growth, or inflation, as the data shows, but they did not avoid speculative attack.

The study of the Nordic countries covers the period from the abandonment of the Bretton Woods Agreement in 1971 to the abandonment of the fixed exchange-rate in 1992. It is thus a bit shorter than the study by ERW, which included more countries, some of which for instance Germany, left Bretton Woods even earlier.

Section 1.2 elaborates a bit more on the three different types of balance-of-payments-crisis models; section 1.3 then describes other empirical studies that have also made use of the index of speculative pressure, and their results. Section 1.4 describes the present study more fully, and section 1.5 the index of speculative pressure. Chapter 2 describes, for each country successively, the preparation through univariate time-series analysis of the three

macroeconomic time-series that make up the index of speculative pressure. Chapter 3 presents the identified periods of crises together with histograms with all three countries pooled together, showing how fundamental variables differed between periods of crisis and non-crisis. Chapter 4 presents the results of the final analysis of the comparison between fundamentals and balance-of-payments crises (again, pooled data). Chapter 5 summarizes and presents conclusions. Appendix A presents a common list of identified speculative attacks for all three countries together. Appendix B lists the exchange-rate regimes in the three Nordic countries as they have changed over time, while Appendix C shows their devaluations and revaluations. Appendix D shows F-tests of periods, and Appendix E shows normal-probability plots of the indices of speculative pressure.

1.2 Theoretical models of balance-of-payments crises

The balance-of-payments account is a summary statement of the flow of international transactions between the residents of a nation and the rest of the world for a particular period of time, usually one quarter or one year (Cumby and Levich, 1998). A nation can develop balance-of-payments problems through either long-lasting surpluses or deficits, so it is considered healthy when payments are in equilibrium, i.e., when the current account, the capital-account, and changes in foreign reserves sum up to zero for some period of time. (The current account reflects trade in goods and services, while the capital-account reflects investments and transactions.) If a country with a fixed exchange-rate runs into balance-of-payments problems (because, say, it is importing too much and exporting too little, and not enough investment is coming in to maintain balance), then at minimum its GDP must include a sufficient surplus to pay the interest on the loans that it will need to keep up its foreign reserves; otherwise it will eventually run out of reserves, and have to let its currency float. However, before the reserves are fully depleted, a balance-of-payments crisis will occur, and this has in its turn generally been preceded by speculative attacks.

Krugman (1979) was the first to model balance-of-payments crises including speculative attacks, inspired to some extent by Salant and Henderson's (1978) attempt to explain fluctuating gold prices in the beginning of the 1970s. This happened after several governments had started to sell off their gold reserves and the abandonment of the Bretton Woods Agreement, and the US dollar as well as most other currencies had become non-convertible in terms of gold. The fluctuating gold prices was a puzzle since the market threatened to be flooded with gold, at the same time there was an acknowledgment that gold was a finite natural resource and that the alternative use was in industry which in its turn

would demand more and more gold and eventually deplete this resource. In more general terms, Salant and Henderson model describes a "supplier", selling a finite natural resource at some pegged price. At the beginning this price will be higher than the natural (supply and demand) price, but as the resource becomes depleted the natural price will rise above the pegged price. Speculators will recognize this and try to obtain what remains of the resource. The model predicts that they will do so suddenly, in an almost violent way, and at a specific threshold in time.

Krugman (1979) assumes a small open economy with fixed exchange-rate, and residents with rational expectations that allow them to foresee the consequences of a government expansion of domestic credit on the foreign reserves. Krugman also assumes no currency-controls, allowing domestic residents to buy foreign bonds. If domestic residents do not absorb domestic credit as fast as the government increases the money-supply (negatively affecting the value of the domestic money), but if they instead exchange this extra money for foreign bonds, then the government will eventually end up in a balance-of-payments crisis. There will be a run on the currency (speculative attack) by holders of domestic currency anticipating that the pegged exchange-rate will be abandoned, trying to acquire what remains of the foreign reserves "cheaply" before the government lets the currency float (and devalue).

Flood and Garber (1984b) linearized Krugman's model, making it possible to pinpoint when a speculative attack would occur. It must occur far enough before the peg has collapsed to have some remaining reserves to speculate on, but close enough to the devaluation to make this effort meaningful. (Speculative attacks often consist of many small individual decisions spread out over a period of time and may also occur a repeated number of times.) The larger the foreign reserves are, the easier it will be for the government to defend the peg and fight off a speculative attack; low credit-expansion will also help deter an attack.

Many papers have been written expanding on the first generation of balance-of-payments-crisis models. Wyplosz (1986), for instance, points out that currency controls may postpone speculative attacks, but cannot prevent them.

Obstfeld (1986) provides an alternative explanation, initiating the *second* generation of balance-of-payments-crisis models. He also assumes a small open economy with profit-maximizing asset-holders carrying perfect foresight. But now speculative attacks can also be self-fulfilling, i.e., they may occur even though the level of foreign reserves, R_t, seems sufficiently large to handle "normal" balance-of-payments problems. This becomes

possibility since the domestic credit (D_t, in the money-supply equation: $M^s_t = R_t + D_t$) now also contains a stochastic disturbance-term, υ_t , so that

$$D_t = \overline{D} + \upsilon_t \tag{1}$$

where υ_t follows a covariance-stationary autoregressive process of order one,

$$\upsilon_t = \rho\, \upsilon_{t-1} + \varepsilon_t \qquad (0 \leq \rho < 1,\ E_{t-1}[\varepsilon_t] = 0) \tag{2}$$

It is then inevitable that the country will sooner or later experience a balance-of-payments crisis. Until this happens the government has maintained a fixed exchange-rate, but when foreign reserves are exhausted the central bank withdraws from the currency market and let the exchange-rate float. The floating exchange-rate in its turn allows the government to desert its old credit growth policy (i.e., it switches policy), and begin to increase domestic credit, which in turn results in inflation and currency-depreciation. Without the expectation of a potential depreciation (exchange-rate adjustment), there would be no spur to carry out speculative attacks. With the same tools as Krugman, the second generation models explains how come sometimes governments falls pray for speculative attacks even though they used to keep a sound credit growth policy.

Governments often stabilize a pegged exchange-rate on the world market by buying and selling foreign reserves to keep the rate inside some upper and lower (percentage) bound. Obstfeld argued that speculative attacks could be launched against foreign reserves whenever the fixed exchange-rate approaches its upper bound, which could happen randomly even if the fundamentals were sound. Speculative attacks could therefore occur without a linear trend in the fundamentals, making it impossible to attribute them to inappropriate domestic policies. Several empirical papers during the 1990s (e.g., Rose and Svensson 1994) have in fact been unable to tie speculative attacks to development of the fundamentals.

Obstfeld's model allows for multiple equilibriums, where speculators can launch attacks repeatedly. If the government succeeds in fighting off an attack, everything may go back to normal, since the fundamentals were never affected. But if speculative attacks can be launched repeatedly, the government may eventually be forced to give up the fixed exchange-rate and let the currency depreciate.

As noted earlier, a new (*third*) line of theoretical crisis-models has emerged recently, under the collective heading of "*second*-generation of currency crisis *literature*". Rangvid (2001) surveys this literature, which further elucidates the role of government. There is an inconsistency in believing that a government will try to maintain a fixed exchange-rate if it is

conducting a policy that it knows must ultimately lead to a currency-crisis. The government must be smarter than earlier assumed and thus itself be aware of the contradiction. In these new models, governments thus take into account the costs and benefits associated with maintenance of fixed exchange-rates, via a cost-function or loss-function. They then decide whether it is better to resist a speculative attack, for instance by borrowing foreign reserves on the international financial markets, or to give in and allow the exchange-rate to float. The spectrum of modeled government-alternatives has thereby increased considerably.

The fact that the government can often borrow enough on international financial markets to withstand an attack on its foreign reserves lessens the first-generation-models' emphasis on the role of the foreign reserves. Central banks can in principle always resist a speculative attack, if they are willing to pay the price. Besides borrowing foreign reserves, they can absorb domestic credit and thereby raise interest rates to levels that make position-taking against the domestic currency unprofitable (Obstfeld and Rogoff, 1995).

The possibility of a government deliberately postponing a balance-of-payments crisis gives a second explanation for multiple equilibriums, in addition to arbitrarily launched speculative attacks, as above. As noted earlier, it also means that the relationship between fundamentals and crises might become stepwise. Even if the fundamentals seem to indicate a crisis, the government might try to postpone it, hoping it might blow over, but the crisis might reappear if the government is unable to solve the problem with the fundamentals.

To sum up, all three types of models recognize the role of speculative attacks in balance-of-payments crises. The first- and second-generation models build on a similar set of stylized assumptions, while the third type of models also take a government cost-function into account. Each type leads to different practical results. The first predicts a linear relationship between fundamentals and crises; the second predicts no relationship at all; and the third predicts a possible stepwise relationship.

1.3 Previous empirical results using the index of speculative pressure

This section describes four empirical studies that have used the index of speculative pressure to identify balance-of-payments crises, two of them by ERW (1996a and 1996b).

1.3.1 The main study by ERW

ERW (1996a) covered 22 OECD countries over 25 years, 1967-1992, comparing the development of ERM (exchange-rate mechanism) countries with non-ERM countries, and

searching for differences in economic fundamentals between the two groups in periods of crisis and non-crisis.[1]

For the non-ERM countries, ERW found discernible (i.e., statistically significant) differences between periods of crisis and non-crisis in budget-deficits, credit-growth, inflation-rates, and trade-balances. In line with the first-generation models, they interpreted these differences as causing the subsequent attacks.

ERW did not find the same kinds of differences for the ERM countries, perhaps because their central banks had obligations to intervene collectively to help each other during attacks and crises, which might have blurred relationships between fundamentals, currency speculation, and exchange-rate movements. The only case where ERW found that ERM-country fundamentals followed the pattern predicted by first-generation models was for changes in foreign reserves and interest-rates, but this was to be expected since the index used to define speculative attacks (and thus crises) contained these variables. Money-growth and inflation also changed, but the directions of change were opposite those predicted.

ERW also found that when ERM countries underwent exchange-rate realignments they showed significantly higher inflation, interest-rates, money-growth, credit-growth, and budget-deficits, and their trade-balances were also weaker. None of these were true for exchange-rate realignments by the non-ERM countries, including at the collapse of the Bretton Woods Agreement, the Smithsonian Agreement, or during the narrow-margin regimes of pegged exchange-rates.

1.3.2 More uses of the index of speculative pressure

ERW (1996b) discussed "contagious" currency-crises and examined two possible transmission-links between countries, via trade or via macroeconomics. Countries may trade with the same markets or trade with each other. If one country falls prey to a speculative attack that forces it to devalue, this changes its competitive position, weakening its competitors and turning them into potential victims for new speculative attacks. Or suppose that, under certain macroeconomic conditions (not necessarily the same as "fundamentals"), that a random speculative attack has been successful in one country; speculators might look for other countries with similar conditions, interpreting them as a sign of vulnerability, and

[1] As noted earlier, since speculative attacks are not usually announced or acknowledged, and do not always result in exchange-rate realignment, ERW constructed an index of speculative pressure (on which more below) to identify speculative attacks, then defined five quarters centering on that point as a period of crisis.

thus attack there too. ERW (1996b) in fact found evidence that speculative attacks were contagious, and that the link was probably via trade.

Sachs, Tornell, and Velasco (1996) studied the Mexican-peso crisis in December 1994 and the resulting so-called "Tequila effect" on 20 other developing countries. They used a reduced index of speculative pressure containing only changes in exchange-rates and foreign reserves, but not interest-rates, because many of the countries in their study had laws regulating short-term interest-rates, making them more-or-less fixed. Their interpretation is that Mexico became subject to a self-fulfilling (i.e., random, second-generation model) speculative attack. Panic then spread among investors to several other less developed countries, including Argentina, Brazil, and the Philippines, which had previously also suffered from weak fundamentals, with large appreciation of the real exchange-rate; problems in the banking system; and low foreign reserves. These countries then also succumbed to contagious attacks, though without the original random attack on Mexico they might not have.

Glick and Rose (1998) also used the index of speculative pressure, together with data from five well-known currency-crises (1971, 1973, 1992, 1994, and 1997), to estimate to what degree each crisis was transmitted from one country to another, even if subsequent attacks didn't lead to devaluation. The index thus gave a more thorough picture of what had really happened. They pointed out that many of the currency-crises were transmitted regionally, perhaps because of the trade-related reasons mentioned above. The crisis in 1992, which started in Finland, was very regional, mostly affecting EFTA and the EMS countries. The Mexican crisis in 1994 had its most severe effect among other Latin American countries, though Thailand, Hong Kong, the Philippines, Hungary, and others were also affected. In the "Asian flu" that began with continuous speculative attacks on Thailand in the late spring of 1997, Malaysia, the Philippines, and Indonesia were attacked soon after Thailand let the Baht float. Later the crisis spread to still other Asian countries, and still later to Chile and Brazil. Glick and Rose noted that although trade seemed to be an important link for transmitting these attacks and crises, not all countries were attacked, which might mean that macroeconomic fundamentals were not unimportant.

1.4 Purpose, data, and method of the present study

1.4.1 The purpose

The relationship between economic fundamentals and balance-of-payments crises was studied for, Norway, Sweden, and Finland, to see whether they had followed any of the models discussed above. ERW (1996a) found discernible differences in fundamentals during crisis-periods in a large group of non-ERM countries, and interpreted the result as support for the first-generation models. Norway, Sweden, and Finland were included among the non-ERM countries they studied, but no results were specific to them, so a separate investigation of the three Nordic countries seemed appropriate.

1.4.2 Why Norway, Sweden, and Finland?

An advantage of studying the Nordic non-ERM countries like Norway, Sweden, and Finland (Denmark was an ERM country), relative to the larger group of non-ERM countries studied by ERW is the similarity in economic policies of the Nordic countries, which all followed either a Keynesian policy (Norway and Sweden) or an even more interventionist policy (Finland). This might yield more clear-cut answers to the questions studied.

The first policy-similarity – begun immediately after World War II (and even earlier in Sweden) and lasting until the end of the 1970s (and even later in Finland) – was the so-called "low-interest-rate" monetary policy, which involved extensive interest-regulation and currency-controls. It also required use of fiscal and credit instruments instead of monetary instruments for stabilization. This tendency to rely on political means to govern the economy increased when Bretton Woods was abandoned in 1971, culminating with the "bridging-over" policy that the three countries adopted to combat the 1975 recession, caused by the oil-shocks of 1973. Another policy-similarity was the substantial liberalization of financial markets undertaken by all three countries after that.

But there are also disadvantages in studying the three Nordic non-ERM countries. All three lagged in the development of their financial markets during the study-period, and were thus forced to undergo frequent policy-changes, including changes in legislation affecting policy-instruments, development of new markets, and inclusion of new market participants. However, they all developed similarly, with changes more or less synchronized across countries, making the changes somewhat easier to follow.

1.4.3 The German time-series as a benchmark

ERW (1996a) used the corresponding German time-series as a benchmark to separate the individual developments of various macroeconomic variables of the studied ERM and non-ERM countries from those of the rest of the world. To maintain comparability, the present study did the same. Thus the corresponding German time-series was subtracted from each variable used for the index of speculative pressure, as well as from the various fundamentals.

1.4.4 The data

Information concerning national monetary policies and financial markets was mainly collected from official publications of each country's central bank, but also from other official sources, such as *Statens Offentliga Utredningar* (*SOU*, or State Public Investigations) for Sweden, as well as other economic periodicals and publications.

When constructing the indices of speculative pressure and testing for correlations between economic fundamentals and periods of crisis, the same macroeconomic variables were used as ERW. All time-series were taken from the CD-ROM version (June 1995 and June 2000) of the International Monetary Fund's International Financial Statistics (IFS).

In computing the indices of speculative pressure, monthly data was used. For short-term money-market *interest-rates*, IFS line *60b* was used. For *foreign reserves*, international reserves (line *11*) corrected for international liabilities (line *16c*) was used wherever possible (available). And for *exchange-rates*, IFS line *ae* was used.

The time-series for fundamentals mostly consist of quarterly data, and consequently the analysis was also quarterly. For the *fiscal ratio*, the ratio of the central-government budget-position (line *80*) to nominal GDP (typically line *99a*) was used; the real effective exchange-rate was measured by normalized unit-labor-costs (line *reu*, available only since 1975); for the *ratio of exports to imports*, the ratio of line *70* to line *71* was used, expressed as a seven-month centered moving-average to eliminate excessive noise. For *credit-growth*, domestic credit (line *32*) was used. For *money-growth*, narrow money (line *34i*) normalized for the rate of growth of international reserves was used. Finally, CPI inflation (line *64*) was used for the *inflation-differential*.

1.4.5 Methods

The analysis was divided into two parts. The first, reported in detail in chapter 2 but described preliminarily below, consisted of preparatory time-series analysis of the variables

used to make up the indices of speculative pressure, done separately for each country. The second part, the final analysis of the relationships between fundamentals and balance-of-payments crises, is reported in chapters 3 and 4; for this part the data from all three countries was pooled in a common analysis.

Preparatory analysis

First, each time-series used in the speculative-pressure indices was turned into percentage-changes by taking logarithms and then subtracting the first lag. This procedure also made the time-series stationary. Similar transformations were also done for the time-series of fundamental variables.

After having transformed all the time-series in this way, it was checked whether the three included in the speculative-pressure indices were free from heteroscedasticity, i.e., that their variances were stable, which was necessary before applying ordinary univariate time-series-analysis. One reason why some macroeconomic time-series are heteroscedastic is because of changes in economic policies, which can lead to changes in economic agents' expectations (Lucas, 1976) and thus to systematic changes in the parameters of the time-series model. A preliminary test of heteroscedasticity was made (although not presented here) using Portmanteau Q-tests and the Engels Lagrange-Multiplier (LM) test.

Any time-series that showed signs of being heteroscedastic was split up into homogenous parts. It was not obvious, however, where the cuts should be made. In chapter 2 we will therefore review the relevant political developments and other changes that took place in each country during the study-period. Segments separated accordingly were tested again, using F-tests, and later also checked that they did not contain any altering autoregressive processes, since, as noted above, heteroscedasticity and altering autoregressive processes often coincide, which implies that a shift in variance might also mark a shift in autoregressive parameters.

After time-series analysis was completed, cf. ch. 2, the observations were divided by the standard deviations of the respective time-periods in order to standardize the variables and create unit-variance. Then, as noted above, the corresponding German time-series, representing the "rest of the world", was subtracted, and finally the parts were linked together again into new time-series. (This apply to the time-series for foreign reserves and interest-rate, while for the exchange-rate the German counterpart was subtracted on beforehand, before the time-series analysis.)

Then the time-series of the three macroeconomic variables were combined to construct the speculative-pressure indices. It was possible at this point to weight the variables making up the indices, if one believed that one carried more information about speculative attacks than another. ERW compared various types of weight-schemes, but only a linear combination with equal weights for each variable was utilized in this study, because each time-series had already been standardized to give them unit-variance, and had thereby in a way been made equally informative.

Final analysis

With the index of speculative pressure, speculative attacks were identified through a test of hypotheses at two different levels of confidence: one capturing more severe cases, at a 95% confidence-level, and another capturing a broader spectrum of speculative attacks (including the more severe cases) at 90% confidence-level. The reason for identifying speculative attacks at two different confidence-levels was that this made it possible to compare data in a sensitivity-test (through changed *p*-values) to see how crises developed as fundamentals worsened – or improved. ERW, however, identified speculative attacks only at the broader 90% level. The null hypothesis when testing the indices, H_0, was that each observation came from a group with a mean of zero or lower; i.e., H_0: $\theta \leq 0$, and the alternative hypothesis, H_1: $\theta > 0$, that the observation belonged to a group of observations with a mean larger then zero. Those with mean larger than zero were considered indicative of speculative attack.

Finally the indices of speculative pressure were turned into qualitative time-series, where all observations identified as attacks were converted to 1's, and all remaining observations were turned into 0's.

The normal-probability plots in Appendix E give an idea at what levels, measured by the index of speculative pressure, the Nordic central banks started to defend themselves against speculative attacks. In the plot for Finland it is possible to distinguish a bend in the observations where the right tail turns upward. Had the observations been distributed perfectly normally, these observations would instead form a straight line, connecting (matching) observed and expected data. A similar bend is not equally clear for Sweden and Norway, instead the right tails for these two countries turn upwards somewhat earlier and the bend is smoother, or vaguer. Since data is in percentage-change, a positive observation is often followed by a negative; therefore the southwest quadrant of the plot more or less

mirrors the northeast quadrant, and does not carry much information of its own. This also explains the use of one-sided hypothesis tests when sorting out speculative attacks.

Around the calendar-quarter of each such speculative attack a "period of crisis" was constructed, consisting of two quarters before and two after, thus five quarters in total. Chapter 3 reports the identification of these crisis-periods with the help of the indices. ERW made tests to refine the analysis of fundamentals by adjusting the length of the "periods of crisis", and seem to have found that a period of five quarters was optimal for tracing the relationships studied.

Having identified periods of crisis and non-crisis, the observations of fundamental variables were then divided into two corresponding sub-samples, pooled for all three countries, and histograms were built for each. Chapter 3 reports how the fundamentals were distributed during periods of crisis and non-crisis.

Finally, again following ERW, tests were conducted to identify differences in the empirical distributions of the fundamental variables between periods of crisis and non-crisis. The Wilcoxon test, an equivalent two-sample version of the Kruskal-Wallis test used by ERW, was used, as well as the Kolmogorov-Smirnov test and a common t-test.

1.5 The index of speculative pressure

1.5.1 The origins and characteristics of the index

The origin of the speculative-pressure index can be traced back to Girton and Roper (1977), who used it to measure exchange-market pressure in an attempt to estimate the volume of intervention necessary for the Canadian central bank to achieve desired exchange-rate targets.

One benefit of using the index to identify balance-of-payments crises (as did ERW, and here) is that it discloses both successful and unsuccessful speculative attacks. If only successful attacks were registered, they might belong to some specific time-period when the central bank was weak, or when it had already endured a long period of balance-of-payments crises, which would bias the sample and lead to spurious correlations.

According to ERW, the ideal situation would be to have an accepted theory with fixed relationships between fundamentals and exchange-rate adjustments. According to the classical reference (Meese and Rogoff, 1983), who made repeated tests on models out of sample (i.e., with fresh data-sets), there is no such theory. But if one nevertheless creates a

model based on fixed relationships – as in Girton and Roper (1977), or the index of speculative pressure used here – it will only be relevant under very specific conditions. ERW observe that the Girton and Roper model gives parameters that are possible to estimate, but that the values of those parameters are easily changed by adding or subtracting terms on either side of the model. ERW therefore chose not to focus on any specific model, but instead tried sensitivity-analysis to optimize their parameter-estimates (testing different weights of the time-series making up the index, as well as the length of the crisis-periods).

In any case, if findings are general enough, such as that crises have a tendency to occur during recessions, it seems likely that they will apply to the future as well.

1.5.2 The model of speculative pressure

The model for the speculative-pressure index can be developed out of an ordinary money-demand function and the equilibrium-condition that money-supply equals money-demand.

Base-money supply consists of the foreign reserves and money created through domestic credit-expansion. The exponential money-demand function can then be written as

$$H_i = F_i + D_i = P_i Y_i^{\beta i} \exp(-\alpha_i \rho_i) \qquad (3)$$

where H_i = supply of base-money issued by the central bank of country i;

F_i = base-money created through the purchase of foreign reserves;

D_i = base-money created by domestic credit-expansion;

P_i = the price-level;

Y_i = real income;

β_i = income-elasticity > 0;

α_i = the interest-rate coefficient > 0; and

ρ_i = an index of interest-rates.

Rewriting (3) in logarithmic form and differentiating with respect to time yields

$$h_i = r_i + d_i = p_i + \beta_i y_i - \alpha_i \rho'_i \qquad (4)$$

where $h_i = H'_i / H_i$ $\qquad r_i = F'_i / H_i$

$d_i = D'_i / H_i$ $\qquad p_i = P'_i / P_i$

$y_i = Y'_i / Y_i$ $\qquad \rho'_i(t) = d\rho_i / dt$

ERW wished to compare changes in the variables with the same variables in the rest of the world (marked with an asterisk). Suppressing the country-index *i*, equation (4) can then be rewritten as

$$(r\text{-}r^*) + (d\text{-}d^*) = (p\text{-}p^*) + \beta(y\text{-}y^*) - \alpha(\rho'\text{-}\rho'^*) \qquad (4')$$

Using purchasing-power parity to substitute the rate of depreciation for the inflation-differential, and rearranging terms, ERW derived

$$e + (\rho'\text{-}\rho'^*) - (r\text{-}r^*) = (d\text{-}d^*) - \beta(y\text{-}y^*) + (1 + \alpha)(\rho\text{-}\rho^*) \qquad (5)$$

where e = percentage-change in the exchange-rate;

ρ' = percentage-change in the interest rate;

r = percentage-change of foreign reserves;

d = percentage-change of domestic credit-expansion;

β = the income semi-elasticity for money-demand;

y = percentage-change of income; and

α = the interest-rate semi-elasticity for money-demand.

The left-hand side in (5) can now be interpreted as the index of speculative pressure. It says that pressure will increase if the exchange-rate (or the log of the exchange-rate, e) or interest rates (ρ') rise, or if foreign reserves (r) decline.

Additional macro-economic *fundamentals* like the trade-ratio can be derived out of the income-variable (y), which could also be expanded into several new macroeconomic variables.

2. Preparation of the index of speculative pressure

Using univariate time-series analysis, all systematic components (recurring effects) were removed from the time-series that make up the index of speculative pressure for each country, leaving only white noise (normally distributed residuals). The resulting time-series might still contain signs of specific events, however, such as occasionally increased interest-rates, which might indicate possible increased speculative pressure.

Unfortunately, the Box-Jenkins procedure used here for time-series analysis is sensitive to heteroscedasticity (changing or unstable variance), so the data had to be checked carefully first, both in levels and after the time-series had been made stationary; F-tests were used to check whether the time-series was free from heteroscedasticity.

In the following Box-Jenkins procedure, an autoregressive model was specified to describe and remove any systematic components, also checking whether any auto-correlated processes changed over time. (This could be done, for instance, by dividing the time-series into smaller parts and checking that the specified model applied to each part; or in a more refined way, through Chow-tests.)

Both heteroscedasticity and changing auto-correlation processes could result from political or economic change (see section 1.4.5). If they were found, the chosen remedy was to cut up the time-series into shorter homogeneous parts that were then analyzed again separately.

After the univariate Box-Jenkins time-series analysis was finished, a Ljung-Box Q-test was used to check that the model chosen yielded normally distributed residuals. These residuals (time-series observations freed from recurring effects, like auto-correlation) were then standardized by dividing through by the standard deviation for each part to create unit-variance, and were then linked together again to create a new time-series, replacing the old one, which was then used in the index of speculative pressure.

Political changes in the three Nordic countries often paralleled each other, so that, after beginning in one country, they would soon appear in the other two. For instance, Norway was first to introduce a free interest-rate market, while Finland was first to tie its exchange-rate to a basket of currencies. Discussions about these issues are therefore tied primarily to the country where they first appeared, even though the others soon followed.

2.1 Norway

2.1.1 Norwegian exchange-rates

First the krone/dollar exchange-rate was logged and the first lag subtracted, to make the time-series stationary (described in section 1.4.5), and the same for the mark/dollar exchange-rate. Then the two time-series were subtracted from each other, as shown in Equation (2.1.1) below, which gave the percentage-change differences in the exchange-rate between the Norwegian krone and the German mark.

$$e_{Norway} = [\ln(NOK/USD)_t - \ln(NOK/USD)_{t-1}] - [\ln(DEM/USD)_t - \ln(DEM/USD)_{t-1}] \quad (2.1.1)$$

After that any differences in variance between parts of the time-series were analyzed. As one might expect, variance was larger when Norway's and Germany's exchange-rate regimes were independent of each other, such as the period December 1978 – September

1990, during which the krone was pegged to a basket of currencies in which the US dollar played a major role, while the German mark was floating (the Norwegian and German exchange-rate regimes are shown in Table A.1, Appendix A). Similarly, variance was smaller when the krone was tied either directly or indirectly to the mark, as when (under the Smithsonian Agreement) both were pegged to the dollar, or when the two countries applied similar exchange-rate strategies, as when both currencies were floating (September – November 1971).

The differences in variance between these periods gave rise to heteroscedasticity. As a result the time-series was divided into parts, as follows:

Period 1: September 1971– November 1978

This was a period of rather low variance. As noted, during the first three months the krone and the mark were both floating; then both Norway and Germany entered the Smithsonian Agreement, a continuation of the Bretton Woods Agreement,[2] with exchange-rates pegged bilaterally to the dollar after it had been devalued and reduced its gold content. Finally both countries joined the Snake Agreement,[3] first during the so-called Snake in the Tunnel, and later as the Snake floated against the dollar.

Period 2: December 1978 – September 1990

When Norway abandoned the Snake in December 1978, the krone was instead pegged to a basket of currencies including the dollar. The connection to the mark was thereby weakened, and the variance of the time-series increased 190%, making it necessary to analyze this period separately from the first.

Period 3: October 1990 – December 1992

Norway now tied the krone to the ecu, and thus it became closely related to the mark once more. Variance decreased to about what it had been in the first period.

[2] For an account of the Bretton Woods Agreement and the Smithsonian (or Washington) Agreement, see for instance Kenen (1998).

[3] Giovannini (1998) gives a good account of the Snake Agreement.

F-tests

The time-series for the krone/mark exchange-rate was thus split into three parts; the differences in variance were confirmed with the help of F-tests (Tables D.1.1.1 and D.1.1.2 in Appendix D.1.).[4]

Time-series analysis of the krone/mark exchange-rate

Each of the three periods was then analyzed separately, resulting in three final time-series models (see Table 1 below), each containing only an intercept, a_0, plus an error-term, indicating white noise from the beginning. Thus no further manipulation was required.

Table 1. Autoregressive models of the difference in percentage-change for the exchange-rate between the Norwegian krone and the German mark

	Period 1: 9/71-11/78	Period 2: 12/78-9/90	Period 3: 10/90-12/92
a_0 [a)]	0.003 (1.87)	0.003 (1.92)	0.004 (1.56)
DW	1.806	1.804	1.634
AIC	-477.73	-760.52	-158.56
SBC	-477.53	-760.52	-158.56
Est. var.	0.00024	0.00027	0.00016
N	87	142	27
Time-dummies	No dummies used	No dummies used	No dummies used
Q(6) [b)]	8.82 (0.18)	6.74 (0.35)	1.45 (0.96)
Q(12)	18.85 (0.09)	10.18 (0.60)	- -
Q(18)	23.31 (0.18)	11.61 (0.87)	- -
Q(24)	- -	20.77 (0.65)	- -

Notes:

[a)] The parameters were denoted by a_i, where i=0,1,2,...k stands for the order of the lag-structure of the model (standard deviations in parentheses). In all three cases here the final model consisted of only an intercept, a_0, and an error-term, e_t; that is, $y_t = a_0 + e_t$.

DW = Durban-Watson statistic, a test of first-order autocorrelation.

AIC = Akaike's information-criterion.

SBC = Schwartz information-criterion.

(AIC and SBC are helpful in judging the efficiency of a model and in choosing the most parsimonious candidate.)

Est. var. = estimated variance after the model was implemented.

N = the number of observations.

[b)] Ljung-Box Q-statistics for the residuals (*p*-values in parentheses).

As explained above, the observations in each part were then standardized by dividing through by the standard deviation for that period to create unit-variance, and the three parts were then linked together again into a new time-series that was then included in the index of speculative pressure for Norway.

[4] Variances presented in the F-tests sometimes differ from those presented in the final time-series analysis since they originated from different stages of the calculations.

2.1.2 Norwegian foreign reserves

To obtain a time-series of the difference in percentage-changes between Norwegian and German foreign reserves, both were logged and made stationary by subtracting their first lags. However, while a separate analysis of autoregressive processes in German reserves showed only white noise, there was reason to suspect a unique AR-pattern for Norway (as well as for Sweden and Finland), because of different customary organizations of the reserves. Therefore the Norwegian (and later the Swedish and Finnish) time-series were first analyzed separately, before their German counterpart was subtracted.

Economic development, exchange-rate regimes, and monetary policies are all known to affect foreign reserves. Taking those and other factors into account, the Norwegian time-series of reserves was divided into four parts, as follows:

Period 1: September 1971 – March 1975

As noted above, the krone was floating for the first three months of this period, reducing the need for large foreign reserves. Nevertheless, foreign reserves continued to grow during this period, and variance grew even faster, giving a cone-shape that made the time-series heteroscedastic. During unruly 1971 (during the breakdown of the Bretton Woods Agreement), the central bank absorbed a lot of foreign exchange from the banking sector, as well as from the gray-lending sector, as private firms chose to hedge against exchange rate-changes by reducing their dollar-assets and by forward-selling future dollar-earnings. In 1972 a positive balance of payments contributed to growing reserves. Devaluation of the dollar in March 1973, and revaluation of the krone in November 1973, gave further incentive to increase reserves to restore their former value measured in kroner. In 1974 and 1975 the reserves continued to grow because the dollar strengthened (the reserves were 85% in dollars), but also as a result of interventions in the money-market inside the Snake.

Period 2 (partial): April 1975 – April 1980

This was the period of the so-called "bridging-over" policy that had its roots in the first OPEC oil-crisis of 1973 and the severe recession that followed. The fourfold increase in oil-prices led to severe repercussions on the balance of payments of most industrialized countries.[5] However, Norway had gradually started to explore its oil resources in the North

[5] The rising oil-prices led to large currency-outflows that exacerbated conditions due to already tight monetary policies. To stop this contraction, the Group of 20, meeting in Rome in January 1974, recommended keeping up production and employment through more expansive economic policies, but readiness to implement such

Sea during the 1970s, which led to increased income at the end of this period, which also affected reserves.

The business-cycle in most Nordic countries lagged the rest of the world somewhat at this time, and the recession in Norway did not reach bottom until late 1974 or early 1975. The government then counter-cyclically encouraged both private and public sectors to borrow from abroad to stimulate domestic demand.[6] The resulting influx of foreign capital made reserves grow. From 1978 on, the central government successively cut back on its own borrowing from abroad and instead encouraged municipalities and the private sector to take over as main borrowers. This counter-cyclic policy fit well into overall industrial development, as the North Sea oil-sector, which had high potential profits, needed investment. By 1979 this counter-cyclic policy was being phased out, however.

Three specific policy-changes also affected foreign reserves during this period:

(1) In 1978 a new currency-control law was introduced to make it easier for municipalities and firms to borrow from abroad (Beretning og Regnskap, 1978, p. 74). The focus changed from maintaining an upper limit for individual borrowers to regulating the total volume of foreign exchange coming into the country as a whole. However, private firms still needed a special license to borrow abroad, unless they were in the oil-sector, shipping, or shipyards. The system of licenses, remained in place into the early 1980s, though by then its purpose had been changed from helping to defend the peg to just helping the central bank control liquidity and stabilize the business-cycle.

(2) In 1978 Norway abandoned the Snake Agreement (the central bank thereby stood more or less alone in protecting the peg), thus necessitating larger foreign reserves, although the official argument was that the fluctuating price of Norwegian exportables, especially oil, required larger foreign reserves in order not to affect the import of goods and services.

(3) In 1979 another softening of the currency-controls (Beretning og Regnskap, 1979, p. 52) made it somewhat easier for foreigners to buy Norwegian stocks and bonds. It also made it easier for Norwegian firms to make bank-deposits abroad, though they still needed approval.

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policies varied among countries. Germany, which had earlier mostly fought inflation, moved to an expansive economic policy in 1974, but soon turned more restrictive again. Most willing to maintain expansive policy were some of the smaller countries, including Norway (and Sweden).

[6] Brinch (1977, pp. 290-98) discusses the conditions in which borrowing from abroad was allowed.

Period 2 (continued): May 1980 – August 1985

In 1980 the government once more started to pay down its foreign debt as incomes from the oil industry made foreign reserves grow rapidly, as did large interventions on the exchange-market by the central bank, and high earnings on the foreign reserves because of high international interest-rates (about 15%). Reserves continued to grow during the beginning of 1982 because of an expected appreciation of the krone due to large oil exports. But instead the krone was devalued twice, in August and again in September (Table C1 in Appendix C), to strengthen the competitiveness of Norwegian industry. Swedish devaluation in October resulted in expectations of a third Norwegian devaluation and unwanted downward pressure on the krone, causing the central bank instead to buy kroner. The situation turned around again in 1983 because of renewed expectations of an appreciation of the krone because of large export-surpluses, resulting in an inflow of dollars ending up in the foreign reserves. The central bank continued to intervene on the exchange-market during 1984, buying foreign currencies to stabilize the value of the krone.

Period 3: September1985 – August 1992

The government now decided to split its foreign reserves into three categories (Beretning og Regnskap, 1985, p. 26): "reserves" proper, "other foreign assets", and "foreign-currency deposits with Norwegian banks"; in accordance with international standards, the latter would henceforth not be considered reserves. "Reserves" (proper) would be held sufficient to cover about four months of imports of goods and services, plus interest and possible exchange-market interventions. Concerning "other foreign assets", it was decided that more weight should be placed on the gains.

F-tests

There was no statistically significant difference in variance between the two parts of period 2 (see Tables D.1.2.1 and D.1.2.2 in Appendix D.1.) so they were combined into a single period from April 1975 to August 1985. The variances before and after this were statistically different, however, so the time-series of Norwegian foreign reserves was divided into three periods for time-series analysis.

Time-series analysis of Norwegian foreign reserves

The observations for September, October, and November 1971, when the krone was floating against the dollar, had a lower variance than the rest of period 1, but because of the

low number of observations no time-series analysis was possible; instead these observations were included in the index of speculative pressure without further manipulation. As noted earlier, the rest of the observations in period 1 were heteroscedastic with cone-shaped variance. The growth of variance was estimated using the Box-Cox procedure, on the basis of which a square-root transformation of all the observations was made; the values of two outliers, October and December 1974, were first reduced to +/- 2 STD, so as not to interfere with the regressions in the Box-Cox procedure. The results from the time-series analyses of the three periods are shown in Table 2 (below).

Table 2. Autoregressive models of the differences in percentage-change in Norwegian foreign reserves

	Period 1:[c] 12/71-3/75	Period 2: 4/75-8/85	Period 3: 9/85-8/92
a_0 [a]	0.009 (0.34)	0.021 (3.10)	-0.002 (-0.40)
a_1	0.290 (1.98)	0.025 (0.31)	
a_2	0.035 (0.22)	0.039 (0.49)	
a_3	-0.375 (-2.45)	-0.232 (-2.88)	
a_{11}			0.316 (2.70)
a_{12}		0.361 (4.39)	
DW	1.398	1.901	1.859
AIC	-26.959	-331.773	-309.918
SBC	-19.914	-317.632	-297.764
Est. Var.	0.02836	0.00390	0.00136
N	43	125	84
Time-dummies	10-1974 [d] 12-1974 [d]	No dummies used	06-1986 03-1990 04-1990
Q(6) [b]	5.38 (0.15)	4.17 (0.13)	8.53 (0.13)
Q(12)	7.83 (0.55)	7.17 (0.52)	11.54 (0.40)
Q(18)	- -	9.43 (0.80)	13.30 (0.72)
Q(24)	- -	10.28 (0.96)	- -

Notes (other notes and abbreviations as in Table 1):
[c] Square-root transformed.
[d] Observation reduced to +/-2 STD.

The observations in each part were then standardized by dividing through by the standard deviation for that period to create unit-variance, and the three parts were then linked together again into a new time-series before the German counterpart was subtracted; the resulting time-series was then included in the index of speculative pressure for Norway.

2.1.3 Norwegian short-term interest-rates

The time-series of Norwegian short-term interest-rates was affected mainly by changing interest-rate legislation, as policy-emphasis shifted from a low interest-rate to full liberalization, accompanied by introduction of new capital-markets as well as deregulation of

remaining currency-controls. From the 1950s to the late 1970s Norway had tried to keep interest-rates low and stable in order to stimulate and stabilize investment and bring about a more egalitarian income-distribution; it was chiefly left with fiscal policy to affect liquidity and stabilize the economy. To keep interest-rates low it had used: interest-rate regulations and controls; segmentation of bank customers with the help of a number of special public banks and savings-banks; currency-controls; and control of the right to issue bonds and bond-investment obligations.[7]

The low interest-rate policy was dropped in the late 1970s as it was found to be incompatible with a restrictive monetary policy. Low interest-rates had made it difficult for the banking sector to efficiently allocate credit, instead leading to a general rationing of credit. A gray-lending sector had been authorized by the government to help supply credit to large private enterprises and municipalities with special needs, but it had started to outgrow its boundaries and capture new market-share. A transition to market-adjusted interest-rates thus began in 1977.

September 1985 – December 1992

By mid-1985 Norway had new legislation and a modern financial system able to handle the demand for liquidity. The central bank had invested in a screen-based information-system at the Oslo Stock Exchange, making possible daily secondary-market trade of bonds and medium-term bearer-certificates. In September banks and other financial institutions as well as companies were also given the right to issue loan-certificates, making the interest-markets compatible. The central bank was now able to affect liquidity as well as interest-rates via the volume it offered in trade. Interest-rates were thus fully market-adjusted, yielding useful information for the index of speculative pressure. Because interest-rates didn't contain much information earlier, only this part of the time-series was used.

Time-series analysis of Norwegian short-term interest-rates

The time-series consisted only of white noise (see Table 3 below), so no further manipulation was necessary. Instead the observations were simply standardized by dividing through by the standard deviation to create unit-variance, after which the German counterpart

[7] Eide and Forsbak (1977) review Norwegian interest-rate policies; see also Norges Banks Skriftserie Nr. 15 (1985).

was subtracted and the new time-series was included in the index of speculative pressure for Norway. [8]

Table 3. Autoregressive model of the differences in percentage-change in Norwegian short-term interest-rates

	Period 1: 9/85-10/92
a_0 [a)]	-0.017 (-0.41)
DW	1.813
AIC	71.796
SBC	86.381
Est. Var.	0.129
N	84
Time-dummies	05-1986
	06-1986
	01-1987
	02-1987
	12-1988
Q(6) [b)]	6.71 (0.35)
Q(12)	12.58 (0.40)
Q(18)	20.83 (0.29)

Notes and abbreviations as in Table 1.

2.2 Sweden

The three time-series used to construct the index of speculative pressure for Sweden were prepared in the same way.

2.2.1 Swedish exchange-rates

Just as for Norway, the difference in percentage-changes for the exchange-rate between the Swedish krona and the German mark were calculated as

$$e_{Sweden} = [\ln(SEK/USD)_t - \ln(SEK/USD)_{t-1}] - [\ln(DEM/USD)_t - \ln(DEM/USD)_{t-1}] \quad (2.2.1)$$

And again it was the exchange-rate regimes of the two countries that had the most influence on the time-series (Swedish exchange-rate regimes are shown in Table B2, Appendix B). Because of shifts in variance, the time-series was again divided into three parts, roughly corresponding to those for Norway.

Period 1 (later reduced): September 1971 – August 1977

This was a period of rather low variance that can, in turn, be divided into four shorter periods, based on changes in the Swedish and German exchange-rate regimes. When Sweden

[8] As with foreign reserves, the German time-series was found to contain only white noise, and is therefore not reported here.

left the Bretton Woods Agreement in August 1971 the Swedish krona was initially allowed to float through November (subperiod 1.1). The German mark was also floating. In December both Sweden and Germany entered the Smithsonian Agreement (subperiod 1.2). Then in April 1972 the six European Community (EC) members—Germany, France, Italy, the Netherlands, Belgium, and Luxembourg—introduced the so-called Snake in the Tunnel Agreement, while Sweden remained in the Smithsonian Agreement (subperiod 1.3). In March 1973 Sweden finally entered the Snake as it started to float against the dollar and changed its nickname from "Snake in the Tunnel" to just "the Snake" (subperiod 1.4). Sweden abandoned the Snake in August 1977.[9]

Period 2: September 1977 – April 1991

The krona was now pegged to a trade-related currency-basket representing Sweden's fifteen most important trading partners (Sveriges Riksbanks Förvaltningsberättelse 1977, p. 12), which reduced the influence of the mark. At first the dollar was given double-weight in the basket on grounds that a large share of world trade was carried out in dollars, but this was reduced to single-weight in the middle of 1985.

Period 3: May 1991 – November 1992

In December 1990 parliament decided that Sweden would apply for membership in the European Community. In May 1991 the krona was thus pegged to the ecu and again became closely related to the mark. At the end of the period the krona was allowed to float independently, while the mark remained in the (also floating) ecu.

F-tests

F-tests (see Table D.2.1.1 in Appendix D) showed significant differences in variance between several of the four subperiods of period 1: higher in subperiod 1 and 4 than in 2 and 3.[10] The estimated variance of period 2 was about 40% higher than that during the Snake era (period 1.4), so it also was treated separately. Variance during period 3 was again considerably lower (Table D.2.1.2 in Appendix D shows the F-tests substantiating these differences).

[9] The Snake itself lasted until December 1978, when the European Monetary System replaced it and the European Currency Unit, the ecu—in which the mark weighed heavily—was created.

[10] During subperiod 1 the mark contributed to the higher variance, while during subperiod 4 the krona and the mark both exhibited high but unsynchronized variance against the dollar.

Time-series analysis of the krona/mark exchange-rate

Time-series analysis (Table 4 below) showed that period 1.4 consisted of only white noise subperiods 1-3 were dropped from the analysis because each contained too few observations. Period 2 also contained white noise, but period 3 contained too few observations to make for a proper time-series analysis. The Durban-Watson statistic indicates an AR(1)-process, but the Ljung-Box Q-statistic gives no evidence of any significant AR-process, so it seems most likely that this period also consisted of white noise.

Table 4. Autoregressive models of the difference in percentage-change for the exchange-rate between the Swedish krona and the German mark

	Period 1.4: 3/73-8/77	Period 2: 9/77-4/91	Period 3: 5/91-11/92
a_0 [a)]	0.002 (1.17)	0.003 (2.10)	0.001 (1.24)
DW	2.051	1.836	1.307
AIC	-335.756	-873.633	-149.356
SBC	-327.800	-861.233	-146.522
Est. var.	0.0001087	0.0002777	0.0000195
N	54	164	19
Time-dummies	06-1973	09-1981	09-1992
	04-1977	10-1982	11-1992
	08-1977	03-1991	
Q(6) [b)]	3.53 (0.74)	3.85 (0.70)	5.30 (0.506)
Q(12)	9.41 (0.67)	8.09 (0.78)	- -
Q(18)	- -	12.30 (0.83)	- -
Q(24)	- -	25.45 (0.38)	- -

Notes and abbreviations as in Table 1.

The observations in each part were then standardized by dividing through by the standard deviation for that period to create unit-variance, and the three parts were then linked together again into a new time-series that was then included in the index of speculative pressure for Sweden.

2.2.2 Swedish foreign reserves

As with Norway, Swedish foreign reserves were analyzed separately from the German time-series before they were subtracted from each other. Reserves had been kept moderate in the 1950s,[11] reflecting the stability of the Bretton Woods Agreement and the strict currency-exchange regulations of the time. Reserves started to grow somewhat during the 1960s, partly because of the increased integration of international capital-markets, but also because of the

[11] See "En effektivare kreditpolitik - Betänkande av kreditpolitiska utredningen," SOU 1982:52, Diagram 2.6: "Valutareserven 1945-82," p. 47.

strong postwar international economic upswing that lasted more or less up to the first oil-crisis in mid-1973.

Period 1: September 1971 – March 1973

Even though the Swedish economy was weak in 1971, the foreign reserves continue to grow during subperiods 1.1, 1.2, and 1.3 described above under exchange-rates.

Period 2: April 1973 – August 1977

This period corresponds to subperiod 1.4 above, when Sweden was a member of the Snake. The international upswing that started in 1972 reached its peak in the spring of 1973, deteriorated somewhat, and then quickly turned into recession with the October war in the Middle East and the following OPEC oil-crisis. This in turn affected the Swedish economy with some delay, leading to large currency-outflows in the beginning of 1974. In April the Swedish central bank tried to halt the outflow by increasing the discount-rate, which also forced the penalty-rate to rise. To keep up liquidity and stimulate the economy, an active "bridging over" policy (like Norway's) was introduced in June. To free capital on the Swedish capital market for this purpose the government relaxed the prevailing currency-controls and encouraged firms and municipalities to borrow abroad instead. Swedish foreign reserves grew not as a consequence of a surplus in the current account, but because of loans from abroad.[12]

Period 3: September 1977 – September 1982

This period starts as Sweden abandoned the Snake and pegged the krona to a trade-related basket of currencies. Economic activity was now rather moderate, which also affected the growth of foreign reserves. After two devaluations in 1977 the price-competitiveness of Swedish industry improved considerably, but still the utilization of industrial capacity remained low. The economy continued weak into the early 1980s, largely due to a second oil-crisis that hit in 1979-80 and led to a second round of bridging-over policy, under which the government took over as main borrower from abroad.

[12] Business-cycles in the US and Japan began to turn up at the end of 1976, but the Swedish current account nevertheless continued to show deficits all the way from 1974 to 1989, the only exceptions being 1984 and 1986. Thus the bridging-over policy led to increased borrowing, rapid growth of liquidity, and instability in external affairs that lasted through the middle of the 1980s (SOU 1985:52, p. 208).

Period 4: October 1982 – June 1989

This period started with a devaluation of the krona, after which reserves began to grow more rapidly, partly because of strong improvements in exports, resulting in positive current-account balances in 1984 and 1986. The introduction of new financial instruments for borrowing probably also contributed to more rapid growth, paving the way for a more market-oriented monetary policy, with growing financial activity and a larger domestic capital-market.[13, 14] The trade-balance continued positive throughout the remainder of the 1980s, partly because of low oil-prices, despite growing domestic costs from 1985.

Period 5: July 1989 – July 1992

The last currency-controls were now removed, and turnover on the currency-markets increased, with mostly foreigners buying bonds denominated in kronor, but also domestic residents borrowing in foreign currencies. Thus the division between domestic and foreign capital-markets became less clear. Because the size of the capital-markets had increased and a large amount of trade was denominated in foreign currencies, there was need for larger Swedish foreign reserves, which grew quickly, with increased variance.

Observations from August 1992 were excluded as outliers due to high volatility before the krona was allowed to float in December 1992.

F-tests

F-tests (Table D2.2.1 in Appendix D) showed no significant differences in variance between the subperiods of period 1, but there was a significant difference (Table D2.2.2) between periods 1 and 2, so they were treated separately. F-tests showed no significant difference between periods 2, 3, and 4 however (also Table D2.2.2). Nevertheless Chow-tests (Tables D.2.2.3 and D.2.2.4) indicated structural changes with different AR-processes, so

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[13] Up to the end of the 1970s, credit for the private sector had been channeled primarily through the banking sector, while the government, together with housing-credit institutions, dominated the bond-market. It was not until the introduction of Certificates of Deposit (CD's or *Bankcertifikat*) in 1980 that a well-functioning secondary bond-market serving firms and municipalities was established. The trade in CD's did not become really active until after the upturn of the economy in 1982, however. In July 1982 the government also introduced a new treasury bill (*Statsskuldväxeln*), a short-term government bond sold outside the banking sector through special brokers. In 1983, treasury notes (*Riksobligationer*) were introduced. Both these types of bonds allowed the government to raise money on the Swedish market.

[14] How can a larger number of financial instruments for firms and municipalities influence foreign reserves? One explanation is the connection between currency-flows and the capital-account (Kredit- och Valutaöversikt 1984:2, p.16). A more developed credit-market leads to larger currency-flows and thereby calls for larger reserves. In support of this view is some empirical evidence showing that Swedish reserves from 1950 to 1989 by and large followed changes in imports. In 1990 there was a shift to a somewhat higher level, however (Wihlborg 1993, p.258).

they were also treated separately. F-tests (again Table D2.2.2) showed a significant difference between periods 4 and 5.

Time-series analysis of Swedish foreign reserves

Period 1 contained too few observations (19) to allow for proper time-series analysis (Table 5, below): The Durban-Watson test showed a rather low value (0.95) indicating an AR(1)-process, but Q-tests indicated no significant deviation from normal distribution, so no further manipulation was made. Period 2 contained an AR(1)-process, while period 3 was only white noise. Period 4 contained an AR(2)-process, while period 5 had an AR(5)-process.

After having adjusted the observations for each part according to the respective AR-processes, they where standardized by dividing through by the standard deviation for that period to create unit-variance, and the parts were then linked together again into a new time-series before the German counterpart was subtracted; the resulting time-series was then included in the index of speculative pressure for Sweden.

Table 5. Autoregressive models of the difference in percentage-change in Swedish foreign reserves

	Period 1: 9/71 – 3/73	Period 2: 4/73 – 8/77	Period 3: 9/77 – 9/82	Period 4: 10/82 – 6/89	Period 5: 7/89 – 7/92
a_0	0.034 (3.97)	-0.001 (-0.08)	-0.005 (-0.90)	0.006 (1.38)	0.033 (3.93)
a_1		0.461 (3.48)		-0.223 (-2.00)	0.228 (1.36)
a_2				-0.284 (-2.52)	-0.234 (-1.36)
a_3					-0.157 (-0.90)
a_4					-0.109 (-0.63)
a_5					-0.403 (-2.39)
DW	0.95	1.094	2.104	2.305	1.30
AIC	-69.863	-144.159	-215.286	-225.774	-76.843
SBC	-68.919	-134.307	-198.399	-213.801	65.566
Est. var.	0.00141	0.00351	0.00152	0.00339	0.00597
N	19	53	61	81	37
Time-dummies	No dummies used	10-1976 04-1977 05-1977	09-1977 10-1977 11-1977 06-1980 01-1981 02-1981 09-1981	10-1982 06-1985	11-1991
Q(6)	8.83 (0.19)	1.94 (0.86)	4.55 (0.60)	0.94 (0.92)	2.62 (0.11)
Q(12)	15.98 (0.19)	4.08 (0.97)	11.85 (0.46)	3.3 (0.97)	8.28 (0.31)
Q(18)	- -	- -	- -	7.83 (0.95)	- -

Notes and abbreviations as in Table 1.

2.2.4 Swedish short-term interest-rates

The introduction of new capital-markets and capital-market instruments in the early 1980s also affected Swedish short-term interest-rates. A low interest-rate policy had been introduced in the early 1930s, and was maintained until the mid-1980s, which meant that Swedish short-term interest-rates had been administrated by the central bank during the 1970s and up to the end of 1985. So again, it was first after rates became flexible that they could be used for the index of speculative pressure.

November 1985 – December 1992

In November 1985 a progressive penalty-rate was also introduced, which meant that the cost for private banks to borrow from the central bank increased stepwise, depending on how much was already borrowed. This in turn led to a difference in bank-costs for raising capital, so that a free inter-bank short-term interest-rate could be introduced. This induced the banks in 1986 to create an inter-bank or deposit-market for short-term loans, through which they could level out their liquidity.

A lending-ceiling on all credit-institutions was also dropped in November 1985. Earlier in the autumn of 1985 two new types of bonds had been introduced to allow for forward notation on treasury bills and treasury notes. In March 1986 buying and selling of interest-rate options based on bonds began. Then in the autumn of 1986 the requirement for life insurance companies and general pension funds (*Allmänna pensionsfonden*, or *AP fonden*) to hold bonds was canceled.

In 1988 the Stockholm Stock Exchange introduced a computerized trading system (SAX), though most bond-trading continued to take place outside of the exchange.

During the spring 1990 there was a downturn in the international business cycle. In Sweden, both the current account and the government budget rapidly deteriorated, leading to higher interest-rates immediately to offset currency-speculation, and again in October. After an increase of overnight interest-rates by 5%, currency-flows reversed.

In 1991 the Stockholm Stock Exchange introduced the Stockholm Bond Exchange (SOX), as well as an electronic system for small-scale bond-trading.

Time-series analysis of Swedish short-term interest-rates

As with Norway, the model contained only an intercept plus an error-term (Table 6, below), showing that the time-series consisted of only white noise, so no further manipulation

was necessary. The observations were simply standardized by dividing through by the standard deviation to create unit-variance; then the German counterpart was subtracted and the resulting time-series was included in the index of speculative pressure for Sweden.

Table 6. Autoregressive model of the differences in percentage-change in Swedish short-term interest-rates

	Period 1: 11/85-12/92
a_0 [a)]	-0.004 (-0.41)
DW	2.092
AIC	-163.367
SBC	-156.039
Est. var.	0.0083
N	85
Time-dummies	09-1992 10-1992
Q(6) [b)]	3.13 (0.79)
Q(12)	9.55 (0.66)
Q(18)	11.28 (0.88)

Notes and abbreviations as in Table 1.

2.3 Finland

The three time-series used to construct the index of speculative pressure for Finland were prepared in the same way.

2.3.1 Finnish exchange-rates

The difference in percentage-changes for the exchange-rate between the Finnish markka and the German mark was calculated as

$$e_{Finland} = [\ln(FIM/USD)_t - \ln(FIM/USD)_{t-1}] - [\ln(DEM/USD)_t - \ln(DEM/USD)_{t-1}] \quad (2.3.1)$$

Just as for Norway and Sweden, the variance of this time-series was primarily affected by changes in the exchange-rate regime (Table B.3 in Appendix B, shows the Finnish exchange-rate regimes). However, Finland never joined the Snake Agreement, as did Norway and Sweden. Instead Finland changed directly to a trade-related currency-basket in 1973 (Puro 1978, p. 20). Still there were three different periods.

Period 1: September 1971 – October 1977

Finland abandoned the Bretton Woods Agreement in September 1971 and thereafter let the markka float against the dollar for three months before joining the Smithsonian

Agreement in December. In June 1973 Finland secretly pegged the markka to a trade-related currency-basket from 16 countries, including several from Eastern Europe.

Period 2: November 1977 – May 1991

In November 1977 Finland made the peg to the currency-basket public. In the middle of 1985 Finland changed from a "competitiveness-oriented" to "price-stability-oriented" exchange-rate policy. Before that the central bank had intervened on the capital-market whenever necessary to stabilize the exchange-rate, but a general liberalization of currency-controls that started in 1984 and lasted to 1991 made it harder to adjust the exchange-rate. Instead the interest-rate differential became the main instrument for affecting the exchange-rate, while the exchange-rate was reduced to an "intermediate" objective (Lehmussaari 1991, pp. 3-8).

Period 3: June 1991 – August 1992

Finland (like Norway and Sweden) now pegged its currency to the ecu, and thus the markka was again more closely related to the German mark.

F-tests

F-tests (Table D3.1.1 in Appendix D) showed no significant differences in variance between when the markka was floating against the dollar and when it was bilaterally pegged to the dollar in the Smithsonian Agreement, or when it was secretly pegged to the currency-basket. But variance fell to half during period 2, showing that the Finnish central bank gave high priority to a stable exchange-rate. The turn from daily intervention to an interest-rate differential in mid-1985 implied somewhat less control, visible through greater exchange-rate volatility. However, the difference in variance between these two sub-periods (November 1977 to May 1985, and June 1985 to May 1991) was not big enough to justify a division into two separate periods (see Table D3.1.1 in Appendix D). But variance increased significantly again during period 3.

Time-series analysis of the markka/mark exchange-rate

As before, each of the three periods was then analyzed separately (see Table 7, below). For periods 1 and 2 the autoregressive processes consisted of only white noise, while period 3 contained too few observations to allow a proper time-series analysis. However, neither the Durban-Watson statistic nor the Q-tests showed any significant deviation from normal distribution, so white noise was also assumed here.

Table 7. Autoregressive models of the difference in percentage-change for the exchange-rate between the Finnish markka and the German mark

	Period 1: 9/71-10/77	Period 2: 11/77-5/91	Period 3: [e] 6/91-8/92
a_0 [a]	0.00548 (2.52)	0.00077 (0.76)	0.0098 (1.45)
DW	1.718	1.985	2.010
AIC	-377.927	-954.250	-65.858
SBC	-375.623	-941.875	-65.150
Est. var.	0.000350	0.000164	0.000681
N	74	163	15
Time-dummies	No dummies used	02-1978 03-1980 10-1982	11-1991
Q(6) [b]	3.40 (0.75)	0.91 (0.99)	2.39 (0.88)
Q(12)	10.02 (0.61)	7.23 (0.84)	- -
Q(18)	11.60 (0.87)	10.30 (0.92)	- -
Q(24)	- -	18.30 (0.79)	- -

Notes: (other notes and abbreviations as in Table 1.)
[e] No time-series analysis.

The observations in each part were then standardized by dividing through by the standard deviation for that period to create unit-variance, and the three parts were then linked together again into a new time-series that was included in the index of speculative pressure for Finland.

2.3.2 Finnish foreign reserves

Finnish foreign reserves were mainly affected by changes in economic development, exchange-rate regimes, currency-controls, and similar factors, just as for Norway and Sweden. The Finnish economy grew during the 1970s and 1980s, passing OECD average GDP-per-capita in the mid-1980s. Nevertheless, the Finnish current account showed a deficit during most of the 1970s and 1980s, the only exceptions being 1977, 1978, and 1984.

Period 1: September 1971 – May 1973

This period covers the first months after the Bretton Woods Agreement when the markka was floating, as well as when the markka was bilaterally pegged to the dollar under the Smithsonian Agreement.

Period 2: June 1973 – October 1977

Finnish foreign reserves remained more or less constant from 1971 to 1977. However, variance increased after mid-1973, possibly because the markka was secretly pegged to a trade-related currency-basket reflecting the daily administration of the exchange-rate peg.

Period 3: November 1977 – May 1985

When the peg to the currency-basket was made public, the Finnish central bank became more exposed, standing alone protecting the peg. The central bank therefore needed larger foreign reserves, which started to grow at a steady rate although with constant variance, making the time-series heteroscedastic in percentage-change.

Period 4: June 1985 – June 1991

Reserves continued to grow after Finland announced the shift from a "competitive-oriented exchange-rate policy" to a "price-stability-oriented policy" in mid-1985. The interest-rate differential that was introduced to help maintain the exchange-rate without constant intervention affected capital-flows and thereby also foreign reserves (Suvanto 1991, pp. 29-35).

The elimination of currency controls also affected convertibility between the markka and many Eastern European currencies, for which most of the bilateral agreements were abandoned in the mid-1980s.

Period 5: July 1991 – August 1992

Finland had now shifted its peg from a broader currency-basket to the ecu, before letting the markka float in September 1992. Foreign reserves basically leveled out after 1991, though volatility remained high. The Finnish economy had started to become unbalanced, partly because trade with the Soviet Union fell from almost 25% to about 12% of Finnish trade in 1991. Another reason was that the public sector expanded quickly during the 1980s, contributing to a shortage of labor that caused wages to rise, increasing domestic demand. Financial deregulation also increased the possibilities for private loans, affecting liquidity. Eventually there was a serious crisis and Finland was forced to give up the fixed exchange-rate and allow the markka to float. This in turn led to a wave of speculative attacks against currencies all over Europe. Norway and Sweden were soon forced to let their currencies float as well (Glick and Rose, 1998).

F-tests

F-tests (Table D.3.2.1 in Appendix D) showed no significant difference in variance for the period when the exchange rate was floating compared to when Finland was in the Smithsonian Agreement, so they were combined as one period. Variance was significantly

higher during period 2. Period 3 was heteroscedastic so was also treated separately. Variance during periods 4 and 5 was also significantly different from each other.

Time-series analysis of Finnish foreign reserves

Table 8 below shows the results of time-series analysis for the five periods. The last period contained too few observations for a proper time-series analysis. However, neither the Durbin-Watson statistic (DW) nor the Q-tests of the period indicate any deviation from normal distribution.

Table 8. Autoregressive models of the differences in percentage-change in Finnish foreign reserves

	Period 1: 9/71–5/73	Period 2: 6/73–10/77	Period 3 [f]: 11/77–5/85	Period 4: 6/85–6/91	Period 5 [g]: 7/91–8/92
a_0 [a]	0.006(0.29)	-0.003 (-0.21)	0.037 (2.49)	0.016 (1.20)	-0.034 (-0.54)
a_1	0.456(2.23)		0.197 (1.96)	0.339 (2.79)	
a_2			-0.066 (-0.65)		
a_3			-0.237 (-2.31)		
a_{12}			0.349 (3.37)		
DW	1.041	2.346	1.447	1.335	1.886
AIC	-63.726	-87.539	-127.479	-166.279	-
SBC	-61.637	-83.599	-112.894	-157.118	-
Est. Var.	0.0025	0.0108	0.0117	0.0057	0.0539
N	21	54	84	73	14
Time-dummies	No dummies used	09-1976	11-1979	08-1986 05-1991	No dummies used
Q(6) [b]	4.85 (0.43)	4.64 (0.59)	1.86 (0.40)	2.05 (0.84)	2.41 (0.88)
Q(12)	- -	6.86 (0.87)	3.83 (0.87)	8.13 (0.70)	- -
Q(18)	- -	- -	10.15 (0.75)	10.87 (0.86)	- -

Notes (other notes and abbreviations as in Table 1):
[f] This period was heteroscedastic with a rather high variance in the beginning, then falling; it was therefore transformed by raising all observations to the power of 0.86. The first six observations from November 1977 to May 1978 were considered outliers, so the actual time-series analysis did not start until June 1978.
[g] No time-series analysis.

The observations in each part were then standardized by dividing through by the standard deviation for that period to create unit-variance, and the parts were then linked together again into a new time-series before the German counterpart was subtracted; the resulting time-series was then included in the index of speculative pressure for Finland.

2.3.3 Finnish short-term interest-rates

Finnish interest-rate policy was similar to Norwegian and Swedish policies from the 1950s through the 1970s: They all had the same goal, to keep a low and stable interest-rate.

The Finnish call-money interest-rate was more or less administrated up to the end of 1985. Thus Finland maintained controlled interest-rates a bit longer than did Norway and Sweden.

Period 1: January 1986 – May 1989

Finally in early 1986 the Finnish central bank cautiously started to develop a market-adjusted call-money rate.[15] A spread was introduced to encourage banks to open up a separate overnight interbank market with market-adjusted interest-rates. During this period admittance to the call-money market was still based on individual base-quotas.

Period 2: June 1989 – August 1992

Finland now abolished bank-specific quotas for call-money credit from the central bank. The call-money market thereby became open to new participants.

F-tests

F-tests (Table D3.3.1 in Appendix D) showed no significant difference in variance between periods 1 and 2. However, since conditions changed in June 1989, with new participants in the call-money market, the time-series was cut in two.

Time-series analysis of the Finnish short-term interest-rate

Period 1 consisted of only white noise (Table 9, below). Period 2 showed a more complex AR-process, than Norway and Sweden, when interest-rates were allowed to move more freely.

[15] For an overview of the financial reform in Finland during the late 1970s and 1980s, see for instance Abrams (1989, pp. 6-19).

Table 9. Autoregressive model of the difference in percentage-change in Finnish short-term interest-rates

	Period 1: 1/86–5/89		Period 2: 6/89–8/92	
a_0 [a)]	0.006	(0.66)	0.005	(0.92)
a_1			0.349	(2.07)
a_2			-0.071	(-0.41)
a_3			-0.201	(-1.17)
a_4			-0.398	(-2.12)
a_8			-0.438	(-2.56)
DW	1.920		1.212	
AIC	-115.416		-112.056	
SBC	-110.275		-100.411	
Est. var.	0.00327		0.00262	
N	39		39	
Time-dummies	06-1986 10-1986		05-1991	
Q(6) [b)]	3.76	(0.71)	0.44	(0.51)

Notes and abbreviations as in Table 1.

The observations in each part were then standardized by dividing through by the standard deviation for that period to create unit-variance and the parts were then linked together again into a new time-series; then the German counterpart was subtracted and the resulting time-series was included in the index of speculative pressure for Finland.

3. Speculative attacks, periods of crisis, and fundamental variables

3.1 Speculative attacks

Section 1.2 discussed three various theoretical models of balance-of-payments crises; characteristic for these models were that crisis by definition culminated in speculative attacks which, if successful, would force the government to let the exchange-rate float. Speculative attacks can thus be used to identify balance-of-payments crises, but first the attacks themselves have to be identified with the help of an index of speculative pressure.

In section 1.4.5 it was described how the index of speculative pressure was put together from individual time-series, and how speculative attacks were identified at both 95% and 90% confidence levels.

Finally, in Appendix A a list is presented of the speculative attacks identified, in chronological order, for all the three Nordic countries together. The list shows the size, and structure of each attack; that is, how strong the reaction by the central bank was, and what

instrument the central bank depended on the most to defend itself, the exchange-rate, the interest-rate, or the foreign reserves.

3.2 Periods of crisis

From the speculative attacks, periods of crisis were constructed. (As noted earlier quarters were used because the fiscal and macroeconomic variables were given in quarterly data.) Around each attack a window was built covering a period of five quarters, or a little more than a year. Several windows could of course overlap or succeed each other, making a period of crisis last longer than five quarters. Table 11 (below) shows the periods of crisis for each country separately, for speculative attacks selected both at 95% (the more severe cases) and at 90% confidence-levels (altogether).

Table 11. Periods of crisis, constructed around speculative attacks selected at 95% and 90% confidence levels, for Norway, Sweden, and Finland

95% confidence level (severe cases)		90% confidence level (altogether)	
Attacks	Period of crisis	Attacks	Period of crisis
Norway		**Norway**	
1973:1, 1973:2, 1974:1	1972:3 – 1974:3	1973:1, 1973:2, 1973:3, 1974:1	1972:3 – 1974:3
1977:4, 1978:1	1977:2 – 1978:3	1977:4, 1978:1, 1978:4, 1979:2, 1979:3	1977:2 – 1980:1
1981:3, 1982:4	1981:1 – 1983:2	1981:3, 1982:4, 1983:1, 1983:2, 1984:1	1981:1 – 1984:3
1986:2, 1987:1, 1987:4	1985:4 – 1988:2	1986:2, 1987:1, 1987:4	1985:4 – 1988:2
1992:3, 1992:4	1992:1 – 1992:4	1992:3, 1992:4	1992:1 – 1992:4
Sweden		**Sweden**	
1973:1, 1973:2, 1973:3	1972:3 – 1974:1	1973:1, 1973:2, 1973:3, 1974:1	1972:3 – 1974:3
1977:2, 1977:3, 1977:4, 1978:4, 1979:3	1976:4 – 1980:1	1977:2, 1977:3, 1977:4, 1978:4, 1979:3	1976:4 – 1980:1
1981:3, 1982:4	1981:1 – 1983:2	1981:3, 1982:4	1981:1 – 1983:2
		1985:4	1985:2 – 1986:2
1992:3, 1992:4	1992:1 – 1992:4	1991:4, 1992:3, 1992:4	1991:2 – 1992:4
Finland		**Finland**	
1973:1, 1973:2	1972:3 – 1973:4	1973:1, 1973:2, 1973:3	1972:3 – 1974:1
		1975:1	1974:3 – 1975:3
1976:3, 1977:2, 1977:4, 1978:4, 1979:3	1976:1 – 1980:1	1976:3, 1977:2, 1974:4, 1978:3, 1978:4, 1979:3	1976:1 – 1980:1
1982:4	1982:2 – 1983:2	1982:4	1982:2 – 1983:2
1986:3	1986:1 – 1987:1	1986:3	1986:1 – 1987:1
1992:3	1992:1 – 1992:4	1991:4, 1992:3, 1992:4	1991:2 – 1992:4

Figure 1 (below) shows the periods of crisis selected at 90% (gray) and 95% (black) confidence levels stacked above each other for comparison across countries. The figure also shows a clear correspondence of speculative attacks and periods of crisis across countries, indicating an international component in the periods of crisis.

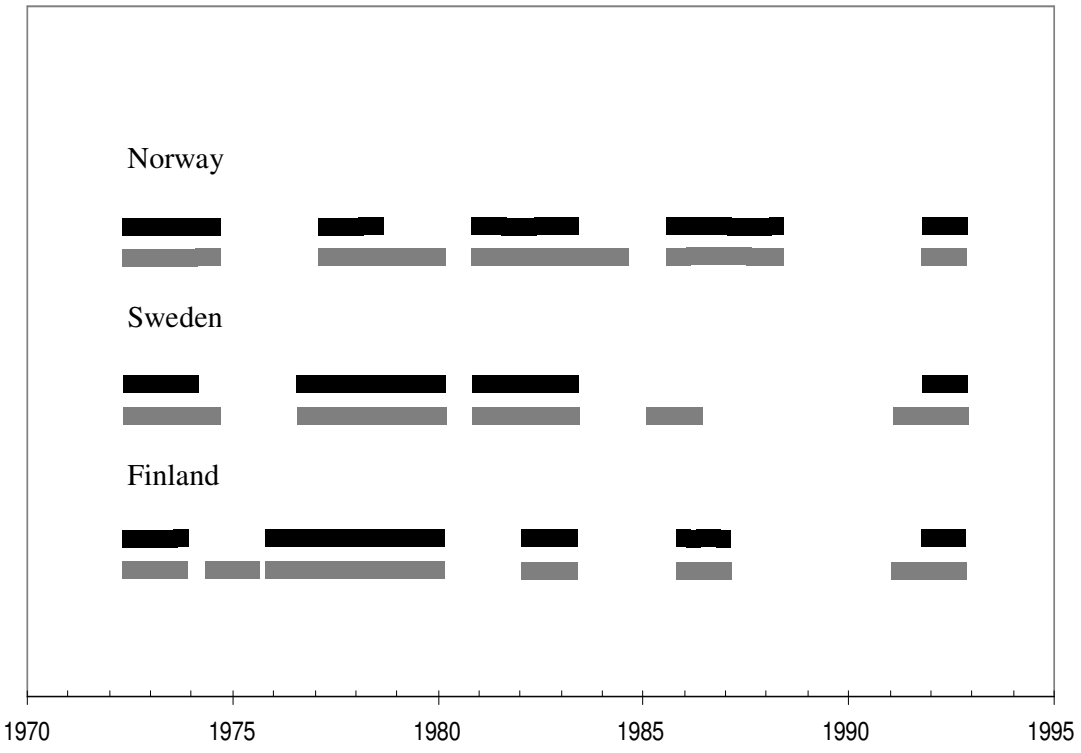


Figure 1: Periods of crises, selected at 90% (gray) and 95% (black) confidence levels for Norway, Sweden, and Finland, 1971-1992.

3.3 The "fundamental" variables

The eight fiscal and macro-economic variables considered as "fundamentals" were each pooled for all countries and then classified by quarter at both 90% and 95% confidence level as belonging to either a period of crisis or non-crisis. Figure 2.1, and 2.2, (below) shows these classes of observations for the various variables in separate histograms after they have been standardized and with the spread displayed in number of standard deviations.

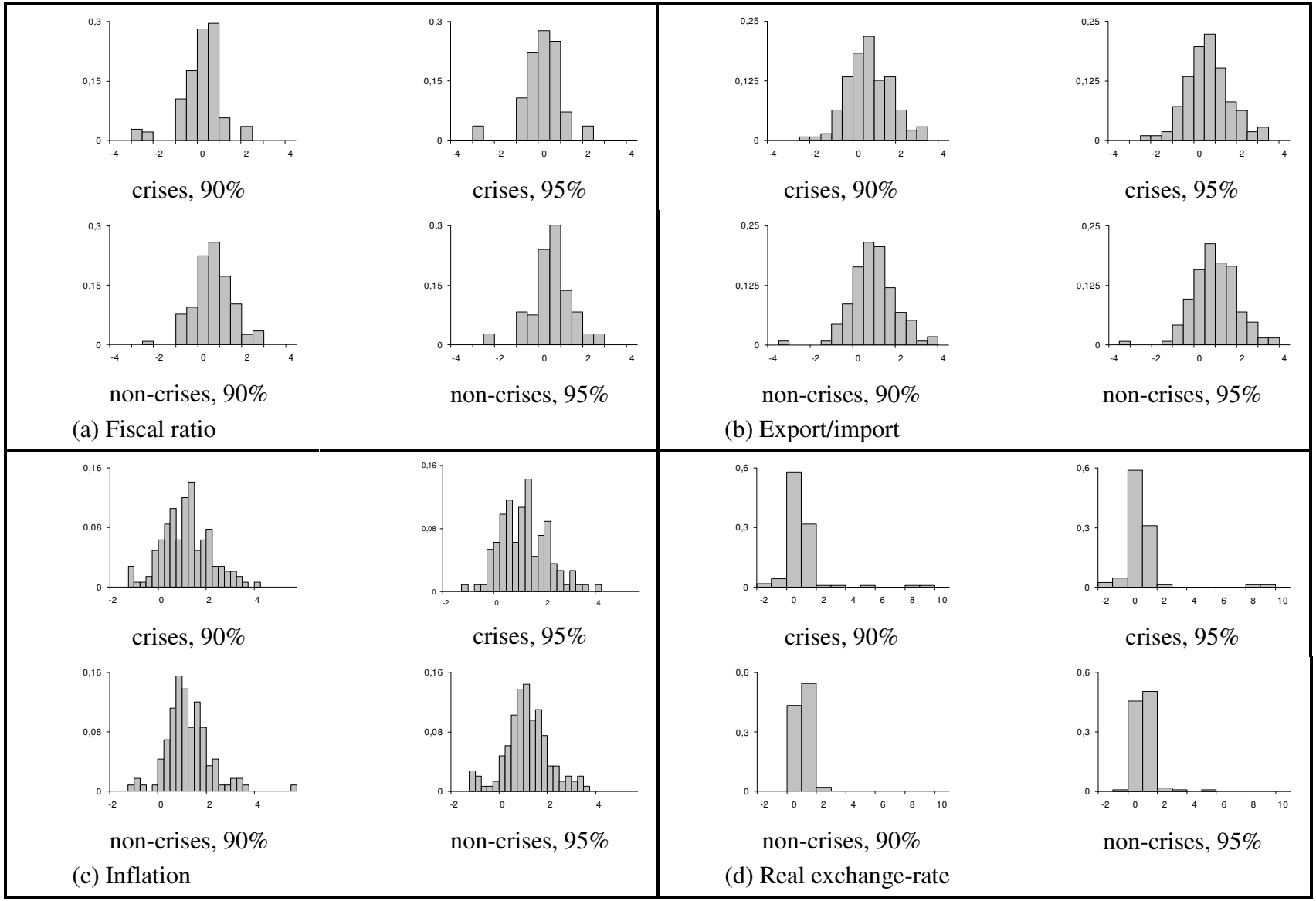


Figure 2.1 Histograms of "fundamental" fiscal and macroeconomic variables, classified by quarters, and belonging to periods of crises and non-crises selected at both 90% and 95% confidence level.

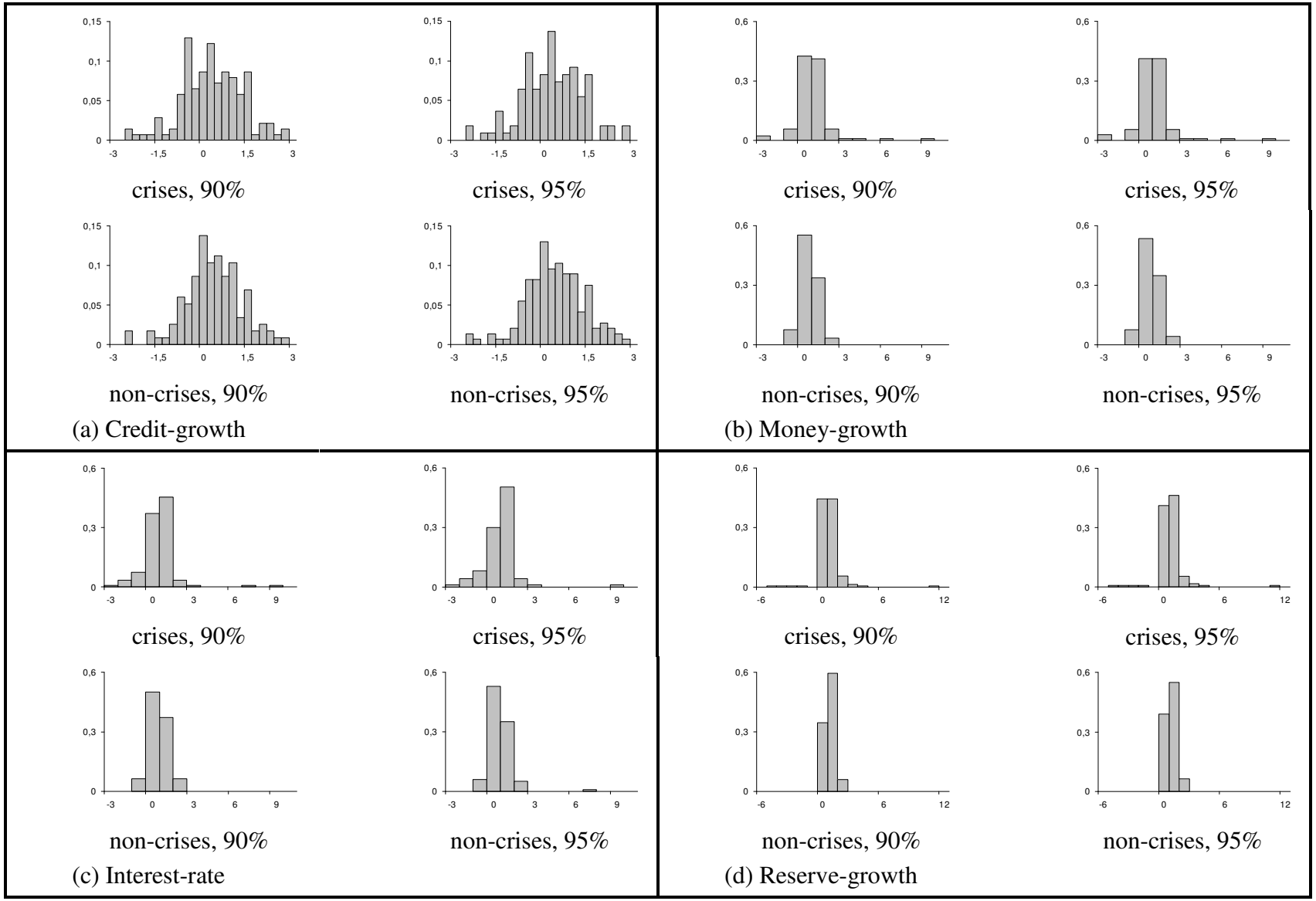


Figure 2.2 Histograms of "fundamental" fiscal and macroeconomic variables, classified by quarters, and belonging to periods of crises and non-crises selected at both 90% and 95% confidence levels.

4. Results

The eight fiscal and macroeconomic variables were then analyzed statistically to identify correlations between the variables and periods of crisis to see that what had caused the balance of payments problems.

4.1 Statistical tests

To preserve comparability, the same set of three statistical tests as ERW used was used again: the Kolmogorov-Smirnov (K-S) test, the Kruskal-Wallis (K-W) test, and the common t-test. However, instead of the Kruskal-Wallis test itself, which is used for testing several samples together, an equivalent used for two-sample cases, the Wilcoxon (W) test, was used (since the crisis and non-crisis data for all three countries were pooled, there were only two samples).

The K-S test and the W test are both non-parametric: The K-S test is used to identify differences in empirical cumulative distribution functions, and the W test to identify differences in medians. The t-test, on the other hand, is parametric, used to identify differences in means. For the K-S test, the null hypothesis was that there were no statistically significant differences between the empirical cumulative distribution functions for the periods of crisis and non-crisis, but instead that both samples originated from the same distribution function. For the W test and the t-test, the null hypotheses were that there were no such differences for medians and means between periods of crisis and non-crisis, and the alternative hypotheses that the medians and the means respectively were either significantly bigger or smaller.

Table 12 (below) shows the results. The periods of crisis and non-crisis are as presented in Table 11 and Figure 1 above; the variables are the same as in the histograms in Figure 2 above.

Table 12. Kolmogorov-Smirnov (K-S), Wilcoxon (W), and common t-tests for the eight fiscal and macroeconomic variables selected at 90% and 95% confidence-levels

	p-values		t-values (*p*-values)
	K-S test	W test [1]	common *t*-test [2]
Periods of crisis identified at 95% confidence-level (more severe):			
Fiscal ratio (yearly data)	**<0.00**	**<0.00**	**-3.96** **(<0.00)**
Real exchange-rate	**0.00**	**0.00**	-1.23 (0.22)
Inflation	0.70	0.88	0.34 (0.73)
Export/import ratio	**0.02**	**0.01**	**-2.54** **(0.01)**
Credit-growth	0.83	0.41	-0.86 (0.39)
Money-growth	0.07	0.12	1.71 (0.09)
Interest-rate	0.11	0.23	0.25 (0.80)
Reserve-growth	0.07	0.20	-0.58 (0.57)
Periods of crisis identified at 90% confidence level (includes less severe):			
Fiscal ratio (yearly data)	**0.00**	**<0.00**	**-4.76** **(<0.00)**
Real exchange-rate	**0.00**	**0.00**	-1.09 (0.28)
Inflation	0.37	0.61	-0.62 (0.54)
Export/import ratio	0.09	0.06	-1.71 (0.09)
Credit-growth	0.65	0.72	-0.33 (0.75)
Money-growth	**0.04**	**0.04**	**1.97** **(0.05)**
Interest-rate	0.41	0.61	0.46 (0.65)
Reserve-growth	**0.03**	0.08	-0.85 (0.39)

Note: Bold indicates statistical significance at the 5% level.
[1] Two-sided Wilcoxon test, *p*-value = Pr > |z|.
[2] Two-sided, without assuming equal variance, *p*-value = Pr > |t|.

4.2 Results by test method and sample

For more-severe periods of crisis identified at the 95% confidence-level, the K-S tests of three variables were statistically significant (having p-values less then or equal to 0.05): the fiscal-ratio, real exchange-rate, and export/import ratio (money-growth and reserve-growth were close). The W-tests were equally statistically significant for the same three variables, while the *t*-tests were only statistically significant for the fiscal-ratio and the export/import ratio, both of which were negative during periods of crisis compared to non-crisis (money-growth was close, and positive).

For the periods of crisis identified at the 90% confidence-level (including also less-severe crises), the K-S tests of four variables were statistically significant: the fiscal-ratio, real exchange-rate, money-growth, and reserve-growth (the export/import ratio was close). The W-tests were statistically significant for three of the same variables (fiscal-ratio, real exchange-rate, and money-growth), while the export/import ratio was again close, as was reserve-growth. Again the *t*-tests were statistically significant for two variables, the fiscal

ratio (again negative during crises) and money-growth (positive during crises), while the export-import ratio was close.

Comparing the results for the two samples (selected at 90% and 95% confidence-levels) suggests that governments may have had more freedom to act in the sample including also the less severe crises. That the degree of crisis also reflected different economic conditions becomes clear from the export/import ratio, which was significant in severe crisis but otherwise only close, meaning that the trade-balance was more normal in less severe crises. Governments apparently utilized this freedom to stimulate their economies, since money-growth was significant in the sample including less-severe crises, but only close in the more-severe sample.

4.3 Results by variable

The fiscal ratio was statistically significant in all three tests of both samples and with negative t-values in both cases, indicating potential fiscal deficits as governments either increased their spending or maintained spending and received too little in tax revenues during crises. In addition to this, the export/import ratio was statistically significant in all three tests of more-sever crises, –and close in the other sample–and in both cases negative. These results indicate that periods of crisis often took place during recessions.

Several other results seem to indicate that governments tried to stimulate their economies out of recessions during periods of crisis. For example, money-growth was close to significant for more-severe crises, significant for all three tests of the sample including less-severe crises, and positive in both cases. Credit-growth, on the other hand, seems to have remained essentially unchanged during periods of crisis and non-crisis, also showing that governments tried to stimulate their economies out of recession with a slack credit-policy; otherwise, credit-growth would have fallen, as did the export/import ratio, because of a downturn in the economy.

Inflation remained unaffected in both samples, indicating that governments managed to neutralize the inflationary effects of economic stimulus. This also supports the hypothesis that crises often occurred during recessions; otherwise, stimulation of the economy and low inflation wouldn't go together.

The real exchange-rate was statistically significant in both samples for the K-S and W tests, though not for the t-tests. The real exchange rate was measured with respect to unit-labor costs, and therefore primarily tells us something about wage levels. An appreciation of

the domestic currencies—as here, shown by the negative t-test values, and by the histograms—indicates that wages increased more slowly in the Nordic countries during crises then in the rest of the world at the same time periods. Low inflation and appreciating (decreasing) real exchange-rates are thus consistent with each other. The histograms show a somewhat larger spread during crises compared to non-crises for the real exchange rate, however, indicating that wage increases were sometimes also high, which might explain why the t-tests was never significant.

Reserve-growth was of course part of the index of speculative pressure, so it's no surprise that it occasionally turns up significant, or close. Finally, the interest-rate was nowhere significant, possibly reflecting interest-rate regulations that prevailed up to the mid-1980s.

4.4 Conclusions

It appears then, that periods of crisis among the Nordic countries occurred primarily during recessions, indicated by the negative fiscal and export/import ratios. Positive money-growth and unaffected credit-growth show that governments tried to stimulate their economies during periods of crisis. But governments were successful in neutralizing the inflationary effects of these stimuli, since inflation remained low and the real exchange-rate with respect to labor-costs appreciated.

So why were there speculative attacks and periods of crisis when the governments seem to have handled the situation so well, both stimulating their economies and yet successfully keeping inflation under control? Krugman (1979) and the first generation of balance-of-payments-crisis models described something similar. However, it was not growing inflation that induced speculative attacks among the Nordic countries, as in those models. Instead it seems to have been the combination of reduced national income and tax revenues through falling export/import ratios (trade balance) and growing fiscal deficits (due to increased or maintained spending), which threats to lead to exchange rate adjustments, that triggers speculative attacks. Thus, it seems like speculators (residents, having rational expectations, in the model world) can foresee the consequences of falling trade balance in combination with growing fiscal deficits on the foreign reserves in the same way as they do with inflation, this in turn leads to the same type of "linear" relationship between the fundamental variables and periods of crisis as in the model by Krugman (1979).

Thus, even though theory predicts that speculative attacks primarily occur because of inflation, governments cannot permit large budget deficits when stimulating their economies, even if they are able to keep inflation low.

4.5 Comparison of results with ERW (1996a)

The study by ERW compared the European Monetary System (ERM) countries with a group of 22 OECD countries (including Norway, Sweden, and Finland). The fact that Norway, Sweden, and Finland constitute a much smaller and more homogeneous group, both politically and economically, than the larger group of OECD countries might explain the different results found here. Table 13 (below) compares ERW's OECD (non-ERM) results with those found here for periods of crisis identified at the 90% confidence level, the only level used by ERW.

Table 13. Comparison of ERW OECD (non-ERM) results and the three Nordic countries

	ERW (non-ERM countries) [1]			Norway, Sweden, and Finland		
	K-S	W	t-test	K-S	W	t-test
Periods of crisis identified at 90% confidence-level						
Fiscal ratio	**.00**	**.01**	-1.93	**.00**	**.00**	**-4.76**
Real exchange-rate	.35	.53	0.60	**.00**	**.00**	-1.09
Inflation	**.02**	**.01**	**2.28**	.37	.61	-0.62
Export/import	**.00**	**.00**	**-3.14**	.09	.06	-1.71
Credit-growth	.09	.07	**-1.99**	.65	.72	-0.33
Money-growth	.12	.28	1.19	**.04**	**.04**	**1.97**
Interest-rate	.34	.37	1.20	.41	.61	0.46
Reserve-growth	**.00**	.07	**-2.32**	**.03**	.08	-0.85

Note: Bold indicates statistical significance.
[1] Source: Eichengreen, Barry. Rose, Andrew K. and Wyplosz, Charles. (1996a)

The fiscal-ratio was negative in both studies, in the end leading to fiscal deficits in periods of crisis. ERW also found a significant negative export/import ratio during periods of crisis; this was also negative for the Nordic countries, although significant only in the sample of more-severe crises (in this sample it was close). Reserve growth was also negative in both studies, as would be expected.

On the other hand, ERW found significant negative credit growth during periods of crisis, while no significant change was found here. ERW also found unchanged money growth during crises, while the Nordic countries showed positive money-growth. Thus, compared to the Nordic countries the larger group of OECD (non-ERM) countries seem to have been more restrictive in how they stimulated their economies during periods of crisis.

A similar difference can be seen for inflation, which ERW found to be significant and positive during periods of crisis, whereas inflation remained unchanged for the three Nordic countries. ERW also found no significant change for the real exchange rate, meaning that the larger group of OECD (non-ERM) countries showed no relative change in wage-increases during periods of crisis, whereas the Nordic countries became more competitive during crises.

To sum up, it looks like periods of crisis also occurred primarily during recessions for the larger group of OECD (non-ERM) countries, as well as for the smaller group of Nordic countries. This is indicated by ERW's negative fiscal ratio, together with negative export/import ratio and negative credit-growth (low economic activity). It appears, however, that the governments of the larger group of OECD (non-ERM) countries were somewhat less active in response to crises, compared to the Nordic countries; thus the OECD (non-ERM) countries did not reduce wage-increases and inflation as much as the Nordic countries did. Still they were not completely passive: They kept money-growth unchanged (it could also have turned downward as the economies went into recession), thereby possibly contributing to a somewhat higher inflation.

The sheer presence of correlations for several of the variables shows that the results of both studies are consistent with the first generation of balance-of-payments-crisis models. Especially, the study by ERW shows a significant difference in inflation between periods of crisis and non-crisis, following Krugman (1979). While in the case of the Nordic countries there is a growing gap between national income (negative export/imports ratio) and government expenditure (increased fiscal deficits) that speculators (or, in the model world, residents with rational expectations) easily can foresee eventually must lead to an exchange rate adjustment.

5. Summary

The purpose of this paper was to study the relationship between balance-of-payment-crises and economic fundamentals for the three Nordic countries, Norway, Sweden and Finland, for the period 1971 to 1992, and to compare the results to an earlier, well-known study on a wider group of countries.

There are three types of models that compete to explain this relationship: the first- and second-generations of balance-of-payments-crisis models, plus a model described in "the

second generation of currency-crisis literature". Each model has its own characteristics and implications.

A method introduced by Eichengreen, Rose, and Wyplosz (1996a) (hereafter referred to as ERW) was used. The first step, with the help of an index of speculative pressure, was to identify speculative attacks against the Nordic currencies. Positive outliers were regarded as speculative attacks. Each such attack is by definition also thought to denote the peak of a balance-of-payments crisis, so periods of crisis were thus identified. Eight different fiscal and macro economic variables were then tested to see how they differed in distribution between periods of crisis and non-crisis.

Prior to construction of the index of speculative pressure, however, the three time series' used in it (exchange-rate, foreign reserves, and interest-rate) had to be prepared to make sure that autocorrelation and heteroscedasticity, as well as shifts in the autoregressive parameters, did not bias the results. A univariate time-series analysis was thus done for each of the original time-series before they were combined into the index of speculative pressure.

To allow for a sensitivity test, the speculative attacks were furthermore identified at two different levels of confidence, one picking up only more-severe crises and another including also less-severe crises. The resulting speculative attacks are listed in Appendix A; the corresponding periods of crisis are listed in Table 11, Chapter 3.

For the three Nordic countries studied here, the fiscal ratio was negative in periods of crisis, indicating fiscal deficit. Together with a negative export/import ratio, this was interpreted as a sign that crisis-periods often occurred during economic recessions. In addition it appears that the governments often tried to stimulate their economies out of recession, primarily indicated by increased money-growth during periods of crisis, along with unchanged credit-growth. Stimulus was stronger in the sample including less-severe crises.

Inflation remained more or less unchanged during periods of crisis, while the real-exchange rate with respect to labor costs showed signs of appreciating, indicating that domestic wages increased more slowly than in the rest of the world. Thus governments were successful in maintaining low inflation during periods of crisis, despite economic stimulus.

So why were there then speculative attacks and periods of crisis, when the governments seem to have handled the situation so well, both stimulating their economies and yet maintaining successful anti-inflationary policies in periods of crisis? The situation is somewhat similar to that described by Krugman (1979) and the first generation of balance-of-payments-crisis models, with correlation between several of the fundamental variables and

periods of crisis. A difference, however, is that it does not seem to have been rising inflation that induced speculative attacks among the Nordic countries. Instead it seems to have been the combination of recession (with reduced tax revenues) and growing fiscal deficits (indicating increased or maintained spending) that in the end threatened to lead to exchange-rate adjustment, which in turn triggered speculative attacks. Potential exchange-rate adjustment caused a "linear" relationship between fundamental variables and periods of crisis.

Even though theory predicts that speculative attacks primarily occurs because of inflation. The speculative attacks that occurred in the Nordic countries show that governments cannot permit large budget deficits when stimulating their economies, even if they are able to keep inflation low.

The three Nordic countries, as a group, were thus found to follow a variation of the first generation model by Krugman (1979), just as had the larger group of OECD (non-ERM) countries studied by ERW. Periods of crisis in both samples seem to have occurred during recessions. However, the Nordic countries seem to have stimulated their economies more, yet they were also more successful in keeping inflation low. As we saw, however, this did not prevent speculative attacks and periods of crisis.

Appendix A: Nordic speculative attacks in chronological order, 1971-1992

Table A1. Speculative attacks, identified at 90% level, for Norway, Sweden, and Finland, in chronological order

Country	Date	*p*-value Pr <= z	Exchange-rate change: %Δ(e-e*)	Interest-rate change: %Δ(i-i*)	Foreign-reserve change: %Δ(r-r*)
Norway	1973.02	0.017	1.078	.	-1.782
Sweden	1973.02	0.022	2.520	.	0.276
Finland	1973.02	0.018	1.974	.	-0.800
Norway	1973.06	0.001	3.696	.	-0.416
Sweden	1973.06	0.005	2.866	.	-0.032
Finland	1973.06	0.001	3.311	.	-0.925
Norway	1973.07	0.071	1.876	.	-0.105
Sweden	1973.07	0.023	1.379	.	-0.858
Finland	1973.07	0.099	1.221	.	-0.483
Finland	1973.09	0.065	1.350	.	-0.650
Norway	1974.03	0.029	1.385	.	-1.173
Sweden	1974.03	0.066	0.222	.	-1.462
Finland	1975.02	0.085	0.700	.	-1.114
Finland	1976.09	0.002	1.485	.	-2.333
Finland	1977.04	0.008	3.726	.	0.548
Sweden	1977.06	0.036	0.741	.	-1.270
Sweden	1977.07	0.017	0.491	.	-1.869
Sweden	1977.08	0.000	4.623	.	0.641
Norway	1977.10	0.059	1.199	.	-0.910
Norway	1977.11	0.017	-0.134	.	-2.988
Finland	1977.11	0.000	1.174	.	-4.399
Sweden	1977.12	0.049	1.344	.	-0.506
Finland	1977.12	0.013	0.662	.	-2.303
Norway	1978.02	0.000	4.419	.	-2.319
Finland	1978.09	0.098	0.326	.	-1.389
Norway	1978.10	0.057	0.679	.	-1.445
Sweden	1978.10	0.008	1.607	.	-1.102
Finland	1978.10	0.011	2.054	.	-0.982
Norway	1979.06	0.095	0.909	.	-0.856
Norway	1979.09	0.092	1.400	.	-0.390
Sweden	1979.09	0.007	1.393	.	-1.343
Finland	1979.09	0.028	0.716	.	-1.811
Norway	1981.09	0.009	1.975	.	-1.210
Sweden	1981.09	0.000	5.719	.	1.745
Norway	1982.10	0.034	1.585	.	-0.877
Sweden	1982.10	0.000	7.281	.	2.840
Finland	1982.10	0.000	5.508	.	-0.609

Continued on next page

Table A1.—*Continued*

Country	Date	*p*-value Pr <= z	Exchange-rate change: %Δ(e-e*)	Interest-rate change: %Δ(i-i*)	Foreign-reserve change: %Δ(r-r*)
Sweden	1982.11	0.031	1.721	.	-0.372
Norway	1983.03	0.083	0.356	.	-1.511
Norway	1983.06	0.069	0.810	.	-1.189
Norway	1984.02	0.077	1.703	.	-0.218
Sweden	1985.11	0.083	0.700	.	-0.850
Norway	1986.05	0.007	3.911	3.006	0.505
Finland	1986.08	0.007	0.271	3.740	-1.930
Norway	1987.01	0.026	0.689	2.506	-1.883
Norway	1987.11	0.049	1.785	0.774	-1.752
Finland	1991.10	0.080	0.199	0.175	-3.011
Sweden	1991.11	0.098	0.051	-0.031	-3.311
Sweden	1992.08	0.066	0.320	0.312	-3.258
Finland	1992.08	0.061	0.276	0.641	-2.813
Norway	1992.09	0.000	1.562	5.104	-8.781
Sweden	1992.09	0.000	1.294	6.596	-6.904
Finland	1992.09	0.000	7.374	0.790	-6.238
Norway	1992.11	0.008	0.546	3.881	-1.895
Sweden	1992.11	0.000	6.422	-1.022	-4.513
Norway	1992.12	0.054	3.071	0.222	-0.903
Finland	1992.12	0.088	0.511	0.774	-1.986

Appendix B: Nordic and German exchange-rate regimes, 1971-1992

Table B1. Norwegian exchange-rate regimes, 1971-1992

August to November 1971: Norway abandoned the Bretton Woods Agreement and the krone was placed on a controlled float.
December 1971 to April 1972: Norway joined the Smithsonian Agreement and the krone was once again bilaterally pegged to the US dollar.
May 1972 to February 1973: Norway was an associate member of the "Snake in the Tunnel" Agreement.
March 1973 to November 1978: The currencies in the Snake floated together as the Snake left the Tunnel.
December 1978 to September 1990: Norway pegged the krone to a basket of (12-14) currencies of its most important trading partners. Initially the US dollar had double-weight (25%), reduced in August 1982 to single-weight (11%). From July 1984 the weights were calculated as a geometric average. At first the borders for intervention were kept secret, but from August 1985 they were openly declared to be +/- 2.25%.
October 1990 to December 1992: Norway pegged to a single currency, the ecu. In January 1991 Norway also entered into bilateral agreements with several other European countries to gain intervention-support to defend the krone in case of need.
December 10, 1992: Norway abandoned the fixed exchange-rate after severe speculative attacks, and the krone was allowed to float.

Table B2. Swedish exchange-rate regimes, 1971-1992

August to November 1971: Sweden abandoned the Bretton Woods Agreement and the krona was placed on a controlled float.
December 1971 to February 1973: Sweden also joined the Smithsonian Agreement.
March 1973 to August 1977: Sweden was an associate member of the Snake agreement.
September 1977 to April 1991: Sweden pegged the krona to a basket of 15 currencies of its most important trading partners. Initially the US dollar had double-weight, reduced in the middle of 1985 reduced to simple weight. At first the borders of intervention were kept secret (later revealed to have been +/-2.25%), but from the summer of 1985 they were openly declared to be +/- 1.5%.
May 1991 to November 1992: Sweden pegged to the ecu.
November 19, 1992: The krona was allowed to float.

Table B3. Finnish exchange-rate regimes, 1971-1992

August to November 1971: Finland abandoned the Bretton Woods Agreement and the markka was placed on a controlled float.
December 1971 to May 1973: Finland also joined the Smithsonian Agreement.
June 1973 to October 1977: Finland unofficially pegged the markka to a trade-related currency-basket.
November 1977 to May 1991: The currency-basket was official policy. In June 1985 the Bank of Finland changed from a "competitiveness-oriented exchange-rate policy" to a "price-stability-oriented policy".
June 1991 to August 1992: Finland pegged to the ecu.
September 8, 1992: The markka was allowed to float.

Table B4. German exchange-rate regimes, 1971-1992

May to November 1971: Germany abandoned the Bretton Woods Agreement and the mark was allowed to float.
December 1971 to March 1972: Germany also joined the Smithsonian Agreement.
April 1972 to February 1973: Germany created the "Snake in the Tunnel" Agreement together with France, Italy, the Netherlands, Belgium, and Luxemburg.
March 1973 to February 1979: The currencies in the Snake floated together as the Snake left the Tunnel.
On March 13, 1979, Germany entered the European Monetary System (EMS), which besides the original Snake-countries also included Denmark, and Ireland. On June 1, 1990, the monetary, economic, and social union of the Democratic Republic of (East) Germany and the Federal Republic of (West) Germany began. Banknotes of the Democratic Republic were exchanged at 1:1 with the mark.

Appendix C: Nordic and German devaluations and revaluations, 1971-1992

Table C1. Norwegian devaluations and revaluations, 1971-1992

	Change	Comments
1971-12-21	-1%	NOK devaluation against gold.
1973-11-18	+5%	Revaluation in the "Snake".
1976-10-18	-1%	Devaluation in the "Snake" (3% against the DEM).
1977-04-04	-3%	Devaluation in the "Snake".
1977-08-28	-5%	Devaluation in the "Snake".
1978-02-13	-8%	Devaluation in the "Snake", and unilateral against the Snake.
1978-10-16	-2%	Devaluation in the "Snake".
1982-08-02	-3.5%	Devaluation due to a change in the index-weights; the weight of USD is cut by half.
1982-09-06	-3%	Devaluation against the currency-basket.
1984-07-01	-2%	Devaluation due to a change from arithmetic average to geometric average in calculating the weights in the basket.
1984-09-22	-2%	Devaluation.
1986-05-11	-10%	Devaluation.
1992-12-10		The Norwegian krone starts to float.

Table C2. Swedish devaluations and revaluations, 1971-1992

	Change	Comments
1973-02-12	-5%	SEK devaluation together with the US dollar.
1976-10-17	-3%	Devaluation in the "Snake".
1977-04-04	-6%	Devaluation in the "Snake".
1977-08-28	-10%	Devaluation on abandoning the Snake.
1981-09-14	-10%	Devaluation against the currency-basket.
1982-10-08	-16%	Devaluation against the currency-basket.
1992-11-19		The Swedish krona starts to float.

Table C3. Finnish devaluations and revaluations, 1971-1992

	Change	Comments
1971-12-20	-5.6%	FIM devaluation against gold.
1973-02-15	-5%	FIM devaluation together with the US dollar.
1977-04-05	-6%	Devaluation in response to Swedish and Norwegian exchange-rate adjustments inside the "Snake".
1977-09-01	-3%	Devaluation in response to exchange rate adjustments inside the "Snake".
1978-02-17	-8%	Devaluation in response to the devaluation of NOK.
1979-09-21	+1.3%	Revaluation to soften domestic inflation imported from abroad.
1980-03-25	+1.7%	Revaluation because of foreign inflation.
1982-10-06	-4.3%	Devaluation after speculation on Swedish or Norwegian devaluations.
1982-10-10	-6%	Devaluation in response to devaluation of SEK.
1984-03-27	+1%	Revaluation.
1986-05-16	-1.6%	Devaluation in response to devaluation of NOK.
1989-03-17	+3%	Revaluation.
1991-11-14	-12.3%	Devaluation.
1992-09-08		The Finnish markka starts to float.

Table C4. German devaluations and revaluations, 1971-1992

	Change	Comments
1971-12-20	+4.61%	DEM revaluation against gold.
1973-02-14	+10%	Revaluation in response to USD devaluation (DEM unchanged in terms of gold).
1973-03-14	+3%	DEM revaluation in terms of gold.
1973-06-29	+5.5%	Revaluation of the DEM within the "Snake".

Appendix D: F-tests

The following F-tests were used to identify differences in variance, i.e., heteroscedasticity, in the time-series before the final time-series analysis was made.

D1. Norway

D1.1. F-tests of the Norwegian exchange-rates

Time-period 1: September 1971 to November 1978

There were four short Norwegian exchange-rate regimes from September 1971 to November 1978 (Appendix B.1). Before calculating variance, three observations considered outliers were removed (deleted); June 1973 (German mark revalues 5.5%); November 1973 (Norwegian revaluation); and February 1978 (Norwegian devaluation). (Appendices C.1 and C.4 list Norwegian and German devaluations and revaluations.) F-tests in Table D1.1.1 below

showed no significant difference in variance between these four sub-periods that were therefore combined into a single period.

Table D1.1.1. One-tailed F-tests of the Norwegian exchange-rate regimes, 8/71 – 11/78

			p-values		
	N	σ^2	2	3	4
1: Sept. 71 – Nov. 71	3	0.0001530	0.235	0.168	0.235
2: Dec. 71 – April 72	5	0.0000719		0.442	0.404
3: May 72 – Feb. 73	10	0.0000697			0.272
4: March 73 – Nov. 78	66	0.0001030			-

Note: The F-tests are based on estimated variance before time-series analysis, and might therefore differ somewhat from the estimated variances in the main text that were calculated after time-series analysis.

Time-periods 1, 2, and 3: September 1971 to December 1992

Outliers for period 1 were deleted as above. Before computing the variance for period 3, an additional observation, December 1992, was excluded. F-tests (Table D1.1.2) showed significant differences between period 1 and 2, and between periods 2 and 3, but not between periods 1 and 3.

Table D1.1.2. One-tailed F-tests of the Norwegian exchange-rates regimes, 9/71 – 12/92

			p-values	
	N	σ^2	2	3
1: Sept.71 – Nov. 78	84	0.000096	0.000	0.358
2: Dec. 78 – Sept. 90	142	0.0002710		0.001
3: Oct. 90 – Dec. 92	26	0.0000836		-

Note: See Table D1.1.1.

D1.2. F-tests of the Norwegian foreign reserves

No outliers were excluded and preliminary F-tests (Table D1.2.1) showed no significant difference in variance between periods 2 and 3, which were then combined.

Table D1.2.1. One tailed F-tests of the Norwegian foreign reserves, 4/75 – 8/85

	N	σ^2	*p*-value 3
2: April 75 – April 80	61	0.004632	0.348
3: May 80 – Aug. 85	64	0.005121	-

Note: See Table D1.1.1.

Time-periods 1, 2, and 3: September 1971 to August 1992

Again no outliers were excluded, but now F-tests showed significant differences in variance between all three time-periods.

Table D1.2.2. One tailed F-tests of the Norwegian foreign reserves, 9/71 – 8/92

	N	σ^2	*p*-value 2	3
1: Sept. 71 – March 75*	43	0.0363940	0.000	0.000
2: April 75 – Aug. 85	125	0.0048570		0.000
3: Sept. 85 – Aug. 92	84	0.0020047		-

Notes: See Table D1.1.1.

* Period 1 was square-root transformed before F-tests were performed.

D1.3. F-tests of the Norwegian interest-rates

Norway introduced a market-based interest-rate in mid-1985, after which the time series became much smother and stable. No changes appeared during the period from September 1985 to October 1992 that necessitated further divisions of the time series, wherefore no F-tests are presented.

D2. Sweden

D2.1. F-tests of the Swedish exchange-rates

Time-period 1: September 1971 to August 1977

Four outliers were deleted: February and June 1973, and April and August 1977. The F-tests then showed significant differences between subperiods 1 and 3, and 3 and 4. Only subperiod 1(4) contain enough observations for further time-series analysis.

Table D2.1.1. One tailed F-tests of the Swedish exchange-rate regimes, 9/71 – 8/77

			p-value		
	N	σ^2	2	3	4
1: Sept. 71 – Nov. 71	3	0.000125	0.132	0.020	0.326
2: Dec. 71 – April 72	5	3.57E-05		0.157	0.155
3: May 72 – Feb. 73	9	1.86E-05			0.006
4: March 73 – Aug. 77	51	0.000109			-

Note: See Table D1.1.1.

Time-periods 1(4), 2, and 3: March 1973 to November 1992

Subperiod 4 from period 1 above was then tested against the following periods. Outliers were deleted: April and August 1977, September 1981, October 1982, March 1991, and November 1992. F-tests (Table D2.1.2) showed significant differences in variance between periods 1(4) and 2, as well as between periods 2 and 3.

Table D2.1.2. One tailed F-tests of the Swedish exchange-rate regimes, 3/73 – 11/92

			p-value	
	N	σ^2	2	3
1(4): March 73 – Aug. 77	51	0.000109	0.008	0.06
2: Sept. 77 – April 91	161	0.000197		0.002
3: May 91 – Nov. 92	18	5.42E-05		-

Note: See Table D1.1.1.

D2.2. F-tests and Chow-tests of the Swedish foreign reserves

Time-period 1: September 1971 to March 1973

F-tests showed no significant difference in variance between the two first subperiods in period 1, so they were treated as one.

Table D2.2.1. One tailed F-tests of the Swedish foreign reserves, 9/71 – 3/73

			p-value
	N	σ^2	2
1: Sept. 71 – Nov. 71	3	0.0000211	0.091
2: Dec. 71 – March 73	16	0.0015430	-

Note: See Table D1.1.1.

Time-periods 1, 2, 3, 4, and 5: September 1971 to December 1992

Outliers were excluded: October 1976, July and September 1977, October 1982, June 1985, November 1991, and August - December 1992. F-tests (Table D2.2.2) showed that period 1 and 2 were then clearly separated from each other, but doubt remained about period

2, 3, and 4, because of the economic changes, and resulting policy-changes, during those periods.

Table D2.2.2. One-tailed F-tests of the Swedish foreign reserves, 9/71 – 12/92

					p-value			
			N	σ^2	2	3	4	5
1: Sept.	71 – March	73	19	0.001407	0.012	0.005	0.013	0.000
2: April	73 – Aug.	77	51	0.003823		0.323	0.423	0.008
3: Sept.	77 – Sept.	82	60	0.004343			0.237	0.017
4: Oct.	82 – May	89	78	0.003654				0.002
5: June	89 – Dec.	92	37	0.008050				-

Note: See Table D1.1.1.

Time-periods 2, 3, 4, and 5: April 1973 to May 1989

The F-tests above did not show any differences in variance between periods 2, 3 and 4. Two Chow-tests were therefore done (Tables D2.2.3 and D2.2.4) which showed differences between periods 2, 3, and 4 as suspected, so they were also treated separately.

Table D2.2.3. Structural Change Test between periods 2 and 3, with a break point in August 1977

Test	Num DF	Den DF	F-value	Pr > F	1/ F-value	Pr > F
Chow	11	92	0.51	0.889	1.961	0.108
Predictive Chow	23	80	0.43	0.988	2.326	0.012

Table D2.2.4. Structural Change Test between time periods 3 and 4, with a break point in September 1982

Test	Num DF	Den DF	F Value	Pr > F	1/ F-value	Pr > F
Chow	10	122	1.00	0.4486	-	-
Predictive Chow	82	50	2.23	0.0014	-	-

D2.3. F-tests of the Swedish interest-rates

Sweden introduced a market-based interest-rate in November 1985. No changes appeared during the period from November 1985 to December 1992 that necessitated further divisions of the time series, wherefore no F-tests are presented.

D3. Finland

D3.1. F-tests of the Finnish exchange-rates

Time-periods 1-6: September 1971 to December 1992

Outliers were deleted: June 1973, April 1977, February 1978, March 1980, October 1982, November 1991, and September 1992. F-tests (Table D3.1.1) showed that periods 1, 2, and 3 could be combined into a single period from September 1971 to October 1977, and periods 4 and 5 could be combined into another period from November 1977 to May 1991, leaving a third period from June 1991 to August 1992. The final months were dropped as too few.

Table D3.1.1. One-tailed F-tests of the Finnish exchange-rate regimes, 9/71 – 12/92

			p-value					
	N	σ^2	2	3	4	5	6	7
1: 9/71 – 11/71	3	0.000211	0.268	0.548	0.298	0.260	0.033	0.340
2: 12/71 – 5/73	18	0.000148		0.100	0.382	0.493	0.021	0.089
3: 6/73 – 10/77	51	0.000262			0.043	0.019	0.001	0.216
4: 11/77 – 5/85	88	0.000172				0.315	0.006	0.096
5: 6/85 – 5/91	72	0.000154					0.011	0.071
6: 6/91 – 8/92	14	4.71E-05						0.004
7: 9/92 – 12/92	3	0.000414						-

Note: See Table D1.1.1.

D3.2. F-tests of the Finnish Foreign-reserves

Time-periods 1, 2, and 3: September 1971 to October 1977

One outlier was excluded, September 1976. F-tests then showed that periods 1 and 2 could be combined into a single period from September 1971 to May 1973, but there was a significant difference in variance with the following period. Period 4, from November 1977 to May 1985 was heteroscedastic and was therefore transformed and treated also separately.

Table D.3.2.1. One tailed F-tests, of the Finnish Foreign-reserves, 9/71 – 10/77

			p-values	
	N	σ^2	2	3
1: Sept. 71 – Nov. 71	3	0.002616	0.530	0.214
2: Dec. 71 – May 73	18	0.003314		0.005
3: June 73 – Oct. 77	52	0.010818		-

Note: See Table D1.1.1.

Time-periods 5 and 6: June 1985 to July 1992

No outliers were excluded. F-tests indicate a significant difference in variance between periods 5 and 6 which were therefore treated separately.

Table D.3.2.2. One tailed F-tests, of the Finnish Foreign reserves, 6/85 – 7/92

			p-value
	N	σ^2	6
5: June 85 – June 91	72	0.00763	0.000
6: July 91 – July 92	15	0.05427	-

Note: See Table D1.1.1.

D3.3. F-tests of the Finnish short-term interest-rates

Time-periods 1 and 2: January 1986 to August1992

Outliers were deleted: August, and October 1986, May, and September, and December 1991, and April 1992. F-tests indicated no significant difference in variance for periods 1 and 2, so they were combined.

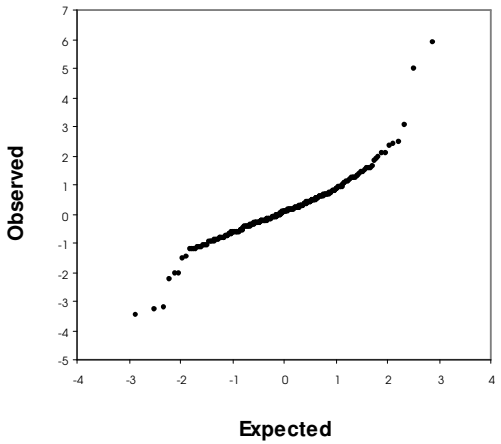
Table D.3.3.1. One tailed F-tests, of the Finnish short-term interest-rate, 1/86 – 8/92

			p-value
	N	σ^2	2
1: Jan. 86 – May 89	39	0.001639	0.091
2: June 89 – Aug. 92	35	0.002561	-

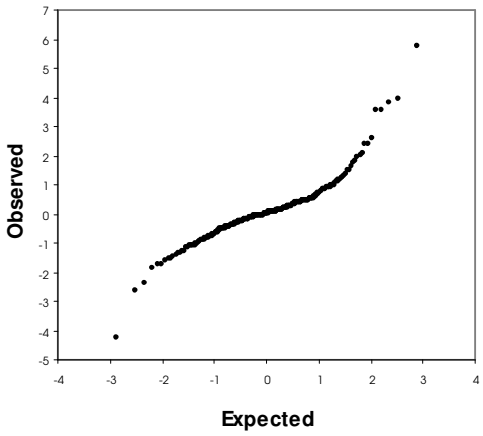
Note: See Table D1.1.1.

Appendix E. Normal probability-plots of the observed indices of speculative pressure

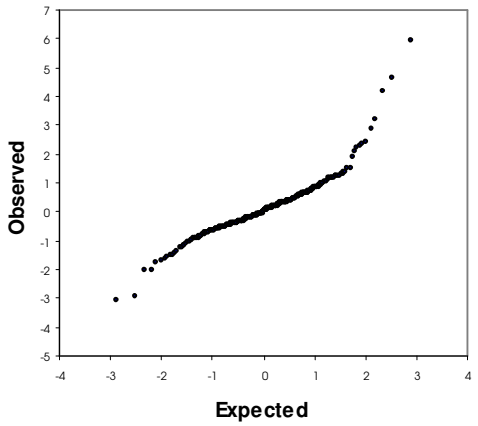
Norway



Sweden



Finland



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