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Econometric Analysis of the Currency Crisis as a Consequence of Inflation Targeting

Abstract: This paper analyzes the unanalized topic in macroeconomic (monetary) politics, which is the emergence of the currency crisis as a consequence of targeting inflation. Many central banks adopted inflation targeting under a pressure from the IMF. Sudden depreciation of exchange rate which results from a fall of foreign exchange reserves to a critically low level (below an optimal level) leads to currency crisis due speculative attack. The most widely used model in the decision of creating process of monetary policy in inflation targeting regime is the macroeconomic model of a small open economy from the group New Keynesian model.

Keywords: inflation targeting, currency crisis, monetary strategy, foreign exchange reserves, New Keynesian model.

JEL Classification: C22, E31, E52, E58.

1. Introduction

The primary reason for accumulating foreign exchange reserves is to insure against a costly foreign exchange crisis. A foreign exchange crisis occurs as a result of a sudden depreciation of the exchange rate, caused by a fall in foreign exchange reserves to a critically low level (below the optimal level), due to a speculative attack. A foreign exchange crisis occurs as a result of a depreciation of the exchange rate of at least 25% cumulatively over 12 months or if the depreciation is at least 10% greater than in the previous 12 months. Foreign exchange crises are very costly, especially when they are accompanied by a banking crisis, which

is often the case. Estimates of these costs range from 10% to 25% of annual GDP, sometimes more.

A foreign exchange crisis is a phenomenon characteristic of both fixed and flexible exchange rate regimes. A foreign exchange crisis is characterized by speculators who conduct one-way foreign exchange transactions. A foreign exchange crisis occurs when there is a so-called speculative attack, i.e. participants in the foreign exchange market rapidly sell the domestic currency and buy a foreign one in the event of any major negative shock such as financial instability, inappropriate macroeconomic policy and exchange rate regime (first-generation foreign exchange crisis), loss of confidence in the domestic currency (second-generation foreign exchange crisis), and the like.

The most widely used model in the decision making process of monetary policy in inflation targeting regime is a macroeconomic model of a small open economy from the group New Keynesian model. Also, the model implies that real variables such as real interest rates and real exchange rate are about their long-term trends. Deviation from the long-term trend is called a gap, which reflects where the economy currently. This is important to note because the central bank measures can only affect the gaps but not long-term trends.

The basic hypothesis to be tested in paper is whether inflation targeting generates a currency crisis. In order to show that inflation targeting leads to currency crisis, using a model of inflation targeting, we simulated a scenario with the assumption that an economy is exposed to a strong and lasting exchange shocks.

The rest of this paper is organized as follows. Section 2 considers a preliminary examination of literature from the relevant scientific field. The hypotheses of interest are given in Sections 3 and 4. Section 3 describes the econometric model to be used in the analysis of the currency crisis as a consequence of inflation targeting. Section 4 considers the data, methodologies and variables used in the study. A conclusion is given in Section 5.

2. Literature Review

Krušković (2023) found that after the initial shock of foreign exchange reserves, the exchange rate appreciation occurs, which can be explained by the fact that a higher level of foreign exchange reserves gives investors and rating agencies a lower country risk, which can consequently lead to appreciation of the foreign exchange rate. In this way, the price reaction is neutralized. Consequently, the

growth of foreign exchange reserves leads to the growth of economic activity measured by GDP growth. Krušković and Maričić (2014) examine how the adoption of inflation targeting affects the movement of the risk premium. The hypothesis they want to test is that the adoption of inflation targeting affects the reduction of the country risk premium by affecting the formation of a more stable macroeconomic environment through a more stable and predictable inflation rate in the medium and long term. Krušković (2016) shows that the exchange rate is a more significant transmission mechanism than the interest rate both in emerging markets and Serbia, and therefore that the exchange rate targeting is more favorable monetary strategy than inflation targeting in these countries. Woodford (2012) argues that monetary policy may indeed affect the severity of risks to financial stability, but that it is possible to generalize an inflation targeting framework to take account of financial stability concerns alongside traditional stabilization objectives. The resulting framework can still be viewed as a form of flexible inflation targeting; in particular, the paper proposes a target criterion that would still imply an invariant long-run price level, despite fluctuations over time in risks to financial stability or even the occurrence of occasional financial crises. Krušković (2021) found if there is a shock of the exchange rate, which would lead to depreciation of the exchange rate, a central bank may decide to guise instability on the foreign exchange market with foreign exchange interventions, thereby preventing a sudden exchange rate depreciation, which would then require a smaller reaction by the interest rate. Namely, through foreign exchange interventions, the central bank greatly absorbs the depreciation shock and, consequently, inflation is lower. As a result of lower price growth, the need for a monetary policy response to an interest rate is also lower. Dorich, Labelle St-Pierre, Lepetyuk and Mendes (2018) evaluate whether an increase in the inflation target to 3% or 4% could improve macroeconomic stability in the Canadian economy. They found that the magnitude of the benefits hinges critically on two elements: the availability and effectiveness of unconventional monetary policy tools at the effective lower bound and the level of the real neutral interest rate. In particular, they show that when the real neutral rate is in line with the central tendency of estimates, raising the inflation target yields some improvement in macroeconomic outcomes. There are only modest gains if effective unconventional monetary policy tools are available. In contrast, with a deeply negative real neutral rate, a higher inflation target substantially improves macroeconomic stability regardless of unconventional monetary policy. Muhammad (2022) found that to correct the disequilibrium in the balance of payments, central banks (monetary authorities) need to give equal consideration to other policy measures along with the monetary instruments to accomplish stability in a country's balance of payments account. Ball (2014) argues that policymakers would do better to target four percent inflation. A four percent target would ease the constraints

on monetary policy arising from the zero bound on interest rates, with the result that economic downturns would be less severe. This benefit would come at minimal cost because four percent inflation does not harm an economy significantly. Sheedy (2014) argues that a monetary policy of nominal GDP targeting can improve the functioning of incomplete financial markets when incomplete contracts are written in terms of money. By insulating households' nominal incomes from aggregate real shocks, this policy effectively completes financial markets by stabilizing the ratio of debt to income. Also, objective of replicating complete financial markets should receive substantial weight even in an environment with other frictions that have been used to justify a policy of strict inflation targeting. De Grauwe and Ji (2016) analyze the relation between the level of the inflation target and the zero lower bound imposed on the nominal interest rate. They find that when the inflation target is too close to zero, the economy can get gripped by "chronic pessimism" that leads to a dominance of negative output gaps and recessions, and in turn feeds back on expectations producing long waves of pessimism. Low inflation targets create the risk of persistence of recessions and low growth. Blanco (2016) studies the optimal inflation target in a menu cost model with an occasionally binding zero lower bound on interest rates and find that the optimal inflation target is 5%, much larger than the rates currently targeted by the Fed and the ECB, and also larger than in other time- and state-dependent pricing models. Higher inflation does indeed increase the gap between old and new prices, but it also increases firms' responsiveness to idiosyncratic shocks. By increasing the inflation target, policymakers can reduce the probability of hitting the zero lower bound, avoiding costly recessionary episodes. Apel and Claussen (2017) analyse the advantages and disadvantages of different ways of formulating inflation targets that involve an interval. They find that if the inflation target is credible, monetary policy can be flexible and consider factors other than inflation – such as output and employment – even without an interval. Ascari and Sbordone (2013) find that higher trend inflation is associated with a more volatile and unstable economy and tends to destabilize inflation expectations. Fouejieu and Ebeke (2015) investigates the effects of the adoption of inflation targeting on the choice of exchange rate regime in emerging markets, conditional on certain macroeconomic conditions. They find that inflation targeting countries on average have a relatively more flexible exchange rate regime than other emerging markets and that the marginal effect of inflation targeting adoption on the exchange rate flexibility increases with the duration of the inflation targeting regime in place, and with the propensity scores to adopt it. Kadria and Ben Aissa (2014) show that the lag in effect of inflation targeting on public deficit performance proves to be shorter and gradual for emerging countries that have adopted this monetary strategy and disciplining effect of inflation targeting on fiscal policy. Combes, Debrun, Minea and Tapsoba (2014) show that interactions between fiscal rules

and inflation targeting matter a great deal for policy outcomes. Specifically, the combination of fiscal rules and inflation targeting appears to deliver more disciplined macroeconomic policies than each of these institutions in isolation. Airaudo, Buffie and Zanna (2016) find that management of the exchange rate greatly enhances the efficacy of inflation targeting. In a flexible exchange rate system, inflation targeting incurs a high risk of indeterminacy where macroeconomic fluctuations can be driven by self-fulfilling expectations. Moreover, small inflation shocks may escalate into much larger increases in inflation ex post. Both problems disappear when the central bank leans heavily against the wind in a managed float. Castillo (2014) introduces a strategy to model a small open economy, whose central bank has established two simultaneous policy objectives: an inflation target and a maximum limit for nominal exchange rate volatility, and finds that each instrument is efficient in accomplishing its own target. Nevertheless, a coordinated effort is required for central bank policymakers before employing both instruments simultaneously, in order to avoid sending mixed signals to economic agents about its monetary policy stance, and endanger the achievement of its inflation target. Davis and Fujiwara (2015) show that as central banks become less credible they are more likely to adopt a pegged exchange rate, and crucially the empirical link between central bank credibility and the tendency to peg the exchange rate depends on trade openness. Andersson and Jonung (2017) conclude that the band should be explicit for several reasons. Most important, an inflation-targeting central bank should be open and transparent to the public regarding its actual ability to control inflation. Gillitzer and Simon (2015) find that a 'divine coincidence' between headline inflation and output gap stabilisation is less apparent than when inflation targeting was introduced. This has led some to call for a fundamental re-engineering of inflation targeting regimes: either adopting explicit dual mandates or replacing headline inflation with a target inflation measure more closely related to domestic output gaps. They argue instead for an evolution in the practice of CPI inflation targeting. Benlialper, Cömert and Öcal (2017) suggest that during the period under investigation (2002-2008), central banks in developing countries implementing inflation targeting tolerated appreciation by remaining inactive in the case of appreciation, but fought against depreciation pressures beyond some threshold. They are unable to detect a similar asymmetric response for inflation targeting advanced countries suggesting that an asymmetric policy stance is particular to inflation targeting developing countries. Neely (2017) explains the reasons for large decline in official assets, China's policy choices and howthose choices could affect the U.S. economy. Canzoneri and Cumby (2013) suggest that discretion may be the better part of valor: pure inflation targeting may come closer to the optimal policy than exchange rate smoothing. A secondary result may also be of some interest: foreign exchange interventions have a stronger impact on inflation

and output in an inflation targeting regime than do sterilized interventions; the Taylor rule augments the effects of a given intervention. Carrière-Swallow, Jácome, Magud and Werner (2016) find that where inflation remains high and volatile, achieving durable price stability will require making central banks more independent. Where inflation targeting regimes are well-established, remaining challenges surround assessments of economic slack, the communication of monetary policy, and clarifying the role of the exchange rate. Ouyang and Rajan (2016) explore the impact of inflation targeting on real exchange rate volatility as well as in terms of its two component parts, i.e. relative tradable prices across countries (external prices) and the sectoral prices of tradables and non-tradables within countries (internal prices). Also, compare the inflation and growth effects of inflation targeting regimes with non-inflation targeters.

3. Model

The most widely used model in the decision making process of monetary policy on inflation targeting is a macroeconomic model of a small open economy from the group New Keynesian model. The main feature of this model is to define the target (inflation target) and the instrument (in this case, the reference interest rate) that the central bank wants to achieve. As the inflation targeting central bank is more transparent, it means that market participants have access to more information, making future central bank actions more predictable. Therefore, it is an advantage of this type of model, as compared to the classical models based Keynesian economy, the role of the active rational expectations.

Also, the model implies that real variables such as real interest rates and real exchange rate are about their long-term trends. Deviation from the long-term trend is called a gap, which reflects where the economy is currently.

Imported inflation is modeled in a simple way as a linear combination of imported inflation in the previous period and foreign inflation (π_t^*) adjusted for the change in the nominal exchange rate (Δs_t). The inertia of the movement of import prices means that the change in the exchange rate and foreign price not currently reflected in import prices, and the correction to take place gradually. Here it is assumed that the importers for some time have in stock goods imported into the past at old prices.

$$\pi_t^m = \rho^{\pi m} \cdot \pi_{t-1}^m + (1-\rho^{\pi m}) \cdot (\pi_t^* + \Delta s_t) \tag{1}$$

Uncovered interest rate parity equation is the basis for determining the nominal exchange rate s_t. Interest rates i_t and i_t^* represent yields on the domestic and foreign currency, respectively. As the local currency is usually ariskier currency, additional yield is sought, which represents the risk premium ($prem_t$). Therefore, when comparing these yields, the difference must be corrected for the risk premium. In the end, the final difference ($-i_t + i_t^* + prem_t$) is the uncovered interest parity, and if it shows that the yields on local currency higher (the difference is negative), the domestic currency will become more attractive. This will increase the demand for domestic currency, and will come to an appreciation of the exchange rate in the current period. At the same time, the appreciation of the exchange rate in the current period to the next period after the initial appreciation of the expected depreciation of the exchange rate that would equalize returns (Es_{t+1} depreciate). In addition to domestic and foreign interest rates, the exchange rate is influenced by other factors not included in the model (political uncertainty, international environment) and they would be covered by the exchange rate shock (ε_t^s). Thus defined theoretically uncovered interest parity in this model adjusted for central bank intervention in the foreign exchange market directed to preventing the cycle of the exchange rate. If there are pressures on the depreciation of the exchange rate, the central bank sells foreign currency, which reduces foreign exchange reserves and thereby neutralizes the exchange rate changes.

$$s_t = Es_{t+1} + (-i_t + i_t^* + prem_t)/4 - \omega \cdot FX\text{int}_t + \varepsilon_t^s \tag{2}$$

Expected changes in the exchange rate (Es_{t+1}) in equation (2) represents the expectations of market participants on the basis of which they make decisions about the profitability of investments. Assumption of the model is that rational expectations are formed at a level between the previous level of the exchange rate and a model designed for the future.

The original Taylor rule is thatthe central bank reacts to the output gap ($\hat{y}_t$). If the economy is booming, the output gap is positive and the interest rate should be increased, thereby tightening monetary policy. However, if the central bank keeps inflation stable, this would create a favourable macroeconomic conditions, which would consequently stabilize fluctuations in the output gap. In this case, the central bank would not have to respond to the output gap with the interest rate.

Central bank intervention in the foreign exchange market aimed at preventing the cycle of the exchange rate (equation 2), is defined so that in case of any change in the exchange rate the Central Bank will intervene in the foreign exchange market:

$$FX\text{int}_t = \omega^1 \cdot \Delta s_t / 4 \tag{3}$$

Since these are without costs, central bank intervention in the foreign exchange market, affect the change in the level of foreign exchange reserves:

$$FXrezerve_t = FXrezerve_{t-1} - FX\text{int}_t \tag{4}$$

The remaining equations are simple identities for the conversion of different growth rates.

$$p_t = p_{t-1} + \pi_t / 4 \tag{5}$$

$$\pi 4_t = p_t - p_{t-4} \tag{6}$$

$$s_t = s_{t-1} + \Delta s_t / 4 \tag{7}$$

4. Empirical data and results

4.1. The function of the impulse response

The model parameters can be determined in several ways and with the most commonly used combination of approaches. When data is available for a very long period of time, it is possible to use econometric estimation to determine the various economic ties. However, developing countries are the most commonly encountered in the course of history with major structural changes, which is why the time series data often contains fractures which, combined with the lack of some statistical data, drastically reduces the possibility of obtaining reliable estimate. For these reasons, the calibration in which the parameters are adjusted in accordance with the economic logic of the theory so that they better reflect macroeconomic developments in specific countries is most commonly used. The calibration can help various studies and experiences of other countries.

Since it is not the intention of the model to represent a specific country, the model parameters are calibrated and have values approximate to those often encountered in the literature. Instead of calibration, the response function model to different shocks will be shown. This analysis is most often used during calibration to determine whether the model behaves in accordance with our expectations.

The initial assumption is that the economy is in a state of balance (equilibrium) and that at time $t = 1$ affects one shock, for example, price growth of 1%. Then a simulation is created with these assumptions and, based on the results, analyses are made to assess how individual shocks affect the economy.

Response function models to individual shocks are described below. The main characteristic of this analysis is the assumption that at some point the economy affects only one shock, which facilitates the tracking of the shock through all monetary transmission channels. Graphs in Figure 1 represent deviations of variables from steady state, which means that the stationary variables must at some point return to the starting value. This assumption is not valid for non-stationary variables, such as price level, the level of the nominal exchange rate, and the level of foreign exchange reserves.

4.2. Currency crisis as a consequence of inflation targeting

Central bank intervention in the foreign exchange market can be a useful addition to the monetary policy interest rate. Although the central bank has no obligation to defend the exchange rate target, in terms of a small open economy, the exchange rate depreciation over the import price spills over to domestic inflation and thus undermines macroeconomic stability. In this case, the central bank would have to respond to the depreciation of the exchange rate by increasing interest rates to make? the local currency more attractive and thereby prevent a speculative attack. However, if the assessment that the shocks are temporary in nature, the central bank often intervenes in the foreign exchange market to stabilize the exchange rate.

Foreign exchange interventions can contribute to the preservation of confidence in the domestic currency and increasing liquidity in the foreign exchange market. This shows the central bank commitment to the stability of the exchange rate and increases confidence in the financial system. While it is unlikely that the currency crisis occurs so quickly that the central bank will have no warning about the foreign exchange market crash, in developing countries and emerging markets, due to the lack of deep foreign exchange markets, the regime of a flexible exchange rate may cause the collapse of the foreign exchange market and lead to a foreign exchange crisis.

Downfall of the foreign exchange market would be preceded by a sudden outflow of capital, which would increase the demand for foreign, safer currency, so there was a sudden and large depreciation of the exchange rate volatility. Withdrawal of foreign currency from the foreign exchange market would reduce liquidity and further increase the risk of collapse of the foreign exchange market.

In order to show that inflation targeting leads to currency crisis, using a model of inflation targeting, we simulated a scenario with the assumption that an economy is exposed to a strong and lasting exchange shocks.

Writer who created assumes that there is pressure to each quarter exchange rate depreciated 5% (about 20% per year). An important assumption of the simulation is that these shocks are unpredictable, which means that the central bank and market participants recognize them only when they are realized. This assumption means that at time t the foreign exchange market is known for shock at the same time, but not for the shock at time $t + n$.

If we assume that the central bank actively intervened to mitigate the effects of a dysfunctional foreign exchange market, it would have led to a significant fall in foreign exchange reserves. An additional assumption of the model is that changes in the level of foreign exchange reserves affected the country's risk premium, which would create additional pressures on the exchange rate.

Equation foreign intervention ($FX\text{int}$) is defined as follows:

$$FX\text{int}_t = \omega^1 \cdot (s_t - s_{t-1}) \tag{8}$$

where $(s_t - s_{t-1})$ is the change in the exchange rate, and parameter ω^1 reflecting how firmly the central bank uses foreign exchange intervention to prevent the cycle of the exchange rate. Since this is an arbitrary decision of the central bank and the situation in which it is located, the simulated response to exchange rate changes of varying intensity. The Central Bank reactes on the depreciation of the exchange rate by selling foreign currency, which leads to a fall in foreign exchange reserves:

$$reserve_t = reserve_{t-1} - FX\text{int}_t \tag{9}$$

Exchange rate in the model equations is formed by the uncovered interest parity which includes the effect of intervention of the central bank. Parameter (ω^{fx}) represents the estimated effect of foreign exchange intervention on exchange rate movements and may depend on many factors, one of which would be the credibility of the central bank. The sign of foreign intervention in the exchange rate equation is negative, so that, in the event of a positive (depreciation) exchange rate shock (ε_t^s), the sale of foreign exchange reserves affects the opposite of shock, ie. its neutralization:

$$s_t = Es_{t+1} + (-i_t + i_t^* + prem_t) - \omega^{fx} \cdot FX\text{int}_t + \varepsilon_t^s \tag{10}$$

The risk premium in the short term depends on changes in foreign exchange reserves ($FX\text{int}$) while in the long term tends to the equilibrium state ($prem^{ss}$) and is defined as follows:

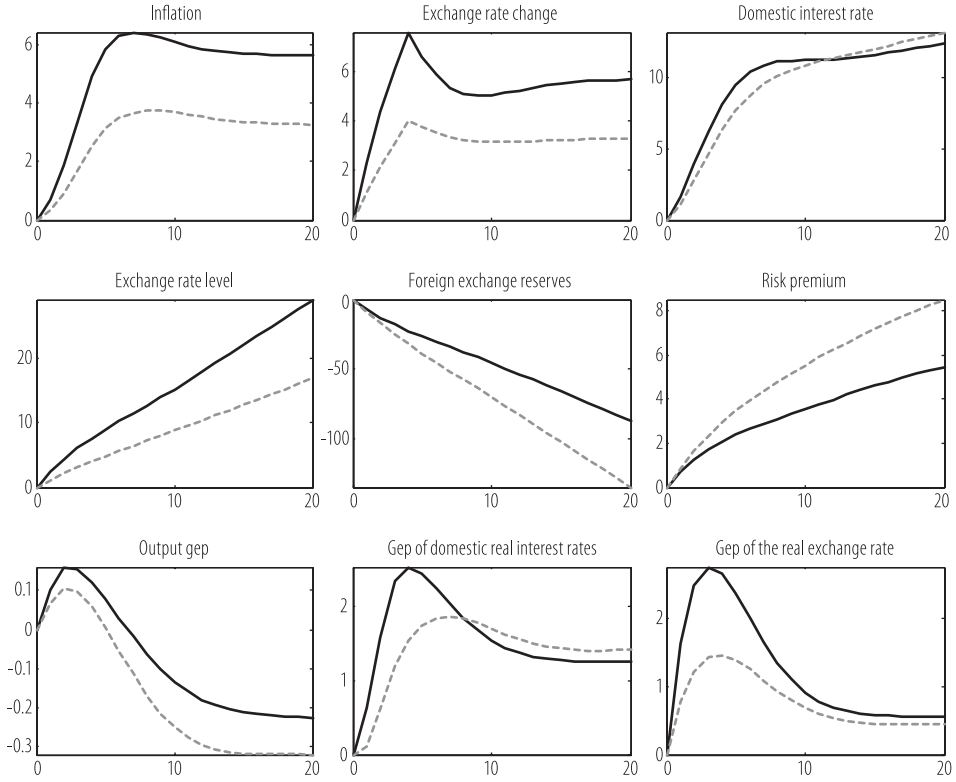
$$prem_t = \rho^{prem} \cdot prem_{t-1} + (1-\rho^{prem}) \cdot prem^{ss} + \rho^{fx} \cdot FX\text{int}_t + \varepsilon_t^{prem} \tag{11}$$

In Figure 1 we can see the simulation results for a period of five years. The dashed line represents a simulation of the central bank, which uses a more powerful foreign intervention ($\omega^1 = 8$) of the central bank, whose simulation is presented as a solid line ($\omega^1 = 3$). Note that in the case when the central bank reacts more by intervening in the foreign exchange market, the exchange rate depreciates less (the shock of 20% per year, the exchange rate depreciated slightly over 3%). It is interesting to note that the profile of the interest rate is very similar in both cases, although the central bank that intervenes more frequently, due to small disturbances in the foreign exchange market, faces a smaller increase in inflation. The reason for this phenomenon is that in the case of a stronger reaction with foreign exchange interventions, due to the larger decline in foreign exchange reserves, there is a greater increase in country risk premium. This, consequently, means that market participants require an additional contribution to the national currency and central bank must also respond to these disorders by increasing interest rates.

If we look at what happens to the real sector, we see that the gaps in output initially increases as a result of a stronger positive effect of real depreciation of the exchange rate against the inert reaction of monetary policy. However, this effect is short-lived, as the rise in interest rates is inevitable, which results in the tightenening of monetary policy and acts negatively on the output gaps in the future. Increasing interest rates is a consequence of rising inflation due to the inevitable depreciation of the exchange rate on the one hand and rising risk premiums due to a fall in foreign exchange reserves on the other.

In both simulated scenarios, currency pressures are significantly neutralized, since the exchange rate depreciated on average about 5.5% per year in the scenario with a smaller reaction of foreign exchange reserves and around 3.5% in the scenario with a stronger reaction. The end result of both scenarios are inevitably higher interest rates, lower levels of foreign exchange reserves, and a currency crisis.

Figure 1: Currency crisis as a consequence of inflation targeting



Source: Refinitiv Datastream

Conclusion

A foreign exchange crisis is a phenomenon characteristic of both fixed and flexible exchange rate regimes. A foreign exchange crisis is characterized by speculators who conduct one-way foreign exchange transactions. A foreign exchange crisis occurs when there is a so-called speculative attack, i.e. participants in the foreign exchange market rapidly sell the domestic currency and buy a foreign one in the event of any major negative shock such as financial instability, inappropriate macroeconomic policy and exchange rate regime (first-generation foreign exchange crisis), loss of confidence in the domestic currency (second-generation foreign exchange crisis), and the like.

Once a speculative attack begins, no country can avoid massive capital outflows and a rapid reduction in foreign exchange reserves. If the central bank wants to defend the exchange rate target (fixed exchange rate regime) or a sharp depreciation of the exchange rate (flexible exchange rate regime) after the start of a speculative attack, it should implement an increase in the interest rate and a contraction in the money supply. However, these measures would cause output contractions and an increase in unemployment.

Inflation targeting implies that central bank uses and adjusts interest rate as the main instrument of monetary policy while exchange rate is formed on the market, although the exchange rate channel has a more important influence on macroeconomic trends than interest rate in a small open economy. Interest rate has a more important role in developed countries. Inflow of capital spurs the appreciation of exchange rate which has negative influence on competitive power, output, employment and economic growth. High interest rate needed for achievement and maintenance of inflation targeting leads to inflow of risk capital which can become outflow in any moment. In anticipation of possible depreciation of exchange rate, speculative attack and outflow of capital happen. When trying to stabilize foreign exchange market, which might imperil achievement of inflation targeting, central bank will sell foreign exchange reserves. However, foreign exchange reserves can be decreased to a critically low level (below an optimal level) so that their further usage will not be credible. Increasing interest rate could be another possible reaction of central banks. However, interest rate can not be increased infinitely and it can reach the limit. Further increase above that limit would cause a loss of credibility and a significant decline of economic growth. It is impossible to protect the exchange rate when both possibilities are used, namely a decrease of foreign exchange reserves and and increase of interest rate. New adjustment of exchange rate is necessary at a significantly higher level. That adjustment causes depreciation. Sudden depreciation of the exchange rate which results from the fall of currency reserves to a critically low level (below the optimal level) leads to foreign currency crisis due to a speculative attack.

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