Essays on Monetary Policy and Financial Crises

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To my parents

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Abstract

The aim of this thesis is to analyze the role of central banks in the context of financial crises. In particular, the thesis examines (i) the potential monetary policy's role in causing a financial crisis and (ii) the central bank's management in times of crises.

After a brief introduction in chapter 1, chapter 2 examines if US monetary policy implicitly responds to asset price booms. Using real-time data and a GMM framework, a Taylor-type rule with an asset variable that captures phases of booms and busts in the real estate market is estimated and yields two main findings. Firstly, the Fed does implicitly respond to asset price booms in the real estate market. Secondly, these responses are typically pro-cyclic. This finding indicates that the interest rate setting behavior of the US monetary policy implicitly contributes to increase the risk of financial crises.

Chapter 3 analyzes the economic costs associated with the central banks' decisions to intervene or not to intervene in case of speculative attacks. The central bank can either abstain from intervening or start an intervention, which in turn can be successful or unsuccessful. Therefore, the analysis takes into account three different types of currency crises: (i) an immediate depreciation, (ii) a successful defense, and (iii) an unsuccessful attempt to defend the exchange rate. The empirical study reveals that the decision of the central bank to intervene is risky. If the central bank intervenes and succeeds she can on average achieve the best growth performance. However, if the interventions are not maintained and the currency depreciates the subsequent output loss is particularly severe. Abstaining from an intervention yields a scenario with a relatively small drop in output.

Chapter 4 extends the previous analysis and takes a closer look at the economic dynamics after a speculative attack. The results indicate that the macroeconomic developments differ considerably with respect to the three different types of crises. Monetary authorities therefore play a central role in determining the economic course and costs of currency crises.

Chapter 5 analyzes the role of the TARGET2 system against the background of the European debt and banking crisis. In particular, the real gains and losses of holding TARGET2 claims in the case of Germany are assessed. The analysis finds that by the end of 2013 Germany has incurred accumulated losses of around 13 billion euros in real terms ('99 const. prices). Calculating the losses and gains of every member country in the euro area suggests that the TARGET2 system can be considered an implicit redistribution mechanism with a volume of about 30 billion euros (current prices). The TARGET2 system cannot replace necessary reforms, but can provide time and money to reduce intra-EMU imbalances.

Finally, chapter 6 outlines the most important results and concludes with a summary.

Zusammenfassung

Die vorliegende Dissertation analysiert den Zusammenhang zwischen Geldpolitik und Finanzkrisen. So wird einerseits die Rolle der Goldpolitik als mögliche Ursache von Finanzmarktverwerfungen und andererseits das Notenbankverhalten während einer Finanzkrise diskutiert.

Nach einer kurzen Einführung in Kapitel 1 wird anschließend in Kapitel 2 untersucht, inwiefern Vermögenspreise implizit als Ziel der US-amerikanischen Geldpolitik dienen. Als Analyseinstrument wird eine modifizierte Taylor-Regel verwendet. Diese wird auf Basis von Echt-Zeit-Daten mittels Generalisierter Momentenmethode (GMM) geschätzt. Zusätzlich wird die Schätzgleichung um eine Vermögenspreisvariable erweitert, um Vermögenspreisentwicklungen entsprechend berücksichtigen zu können. Die Schätzergebnisse zeigen, dass die US-amerikanische Geldpolitik implizit auf Vermögenspreisentwicklungen reagiert. Zudem deuten die Resultate auf eine prozyklische Reaktion seitens der Notenbank hin. Dieses Vorgehen jedoch dürfte die Geldpolitik vor eine Herausforderung stellen, da hierdurch ein Umfeld geschaffen wird, in dem Vermögenspreisblasen leichter entstehen können.

Kapitel 3 analysiert die volkswirtschaftlichen Kosten von Zentralbankmaßnahmen bei einer spekulativen Attacke gegen eine Währung. In einer solchen Situation muss sich die Notenbank entscheiden, entweder auf dem Devisenmarkt zu intervenieren oder die Währung unmittelbar abwerten zu lassen. Entscheidet sich die Notenbank für Interventionen, können diese wiederum erfolgreich oder erfolglos sein. Vor diesem Hintergrund ergeben sich drei verschiedene Währungskrisentypen: (i) sofortige Abwertung, (ii) erfolgreiche Verteidigung und (iii) erfolglose Verteidigung. Die empirische Analyse der mit diesen drei Währungskrisen verbundenen ökonomischen Kosten zeigt, dass es sich um eine riskante Interventionsentscheidung der Notenbank

handelt. Während erfolgreiche Interventionsmaßnahmen keine volkswirtschaftlichen Kosten nach sich ziehen, sind jedoch erfolglose Interventionen mit entsprechend hohen Kosten verbunden. Bei einer Entscheidung für eine sofortige Abwertung ist hingegen nur mit äußerst geringfügigen Wachstumseinbußen zu rechnen.

Kapitel 4 erweitert die vorherige Analyse dahingehend, dass insbesondere die volkswirtschaftlichen Anpassungsmechanismen näher betrachtet werden. So wird auf Grundlage eines Panel-VAR-Modells untersucht, wie verschiedene makroökonomische Indikatoren hinsichtlich des Auftretens der drei Währungskrisen reagieren. Zusätzlich ermöglicht dieses Vorgehen, das Krisenmanagement von Notenbanken im Zusammenhang mit den drei Krisentypen zu analysieren und zu bewerten. Die Schätzergebnisse zeigen, dass Zentralbankmaßnahmen während einer Währungskrise fundamental die makroökonomischen Anpassungen und die damit verbundenen volkswirtschaftlichen Kosten bestimmen.

Kapitel 5 untersucht die Bedeutung der so genannten TARGET2-Salden vor dem Hintergrund der Europäischen Banken- und Schuldenkrise. So werden im Rahmen dieser Analyse die realwirtschaftlichen Kosten für Deutschland berechnet, die auf Grund von TARGET2-Ungleichgewichten entstehen können. Die Berechnungen zeigen, dass Deutschland zum Ende des Jahres 2013 realwirtschaftliche Kosten in Höhe von 13 Mrd. Euro (in Preisen von 1999) entstanden sind. Werden die realwirtschaftlichen Kosten für alle Mitgliedsländer des Euroraumes berechnet, so implizieren die Ergebnisse, dass aktuell das TARGET2-System einem Umverteilungsmechanismus mit einem Volumen von etwa 30 Mrd. Euro gleichkommt. Das TARGET2-System ermöglicht daher in der aktuellen Krisensituation die Bereitstellung von Geld und Zeit, um realwirtschaftliche Ungleichgewichte innerhalb des Euroraumes abzubauen.

Abschließend werden die wichtigsten Ergebnisse in Kapitel 6 zusammengefasst.

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Chapter 1

Introduction

1.1 Motivation

Since the onset of the financial crisis in 2007 the role of monetary policy has gained increasing attention in academic literature. It became evident that monetary policy in the context of financial crises needed to be deeply analyzed. Among the most important research questions are for example: What is the monetary policy's role in causing a financial crisis? How should a central bank respond to financial stress scenarios? How should monetary policy be conducted to provide (implicit) stabilization mechanisms in times of crises?

A common practice to analyze the central bank's role in causing a financial crisis is to use the so-called Taylor (1993) rule. If, for instance, the central bank deviates from the Taylor rule, i. e. from the policy path that would be associated with the achievement of the monetary policy's objectives, the monetary authority can sow the seeds for financial distortions.[1] Primarily, the Taylor rule was intended to be a guideline for central bankers. However, by a positive analysis, Taylor (1993) has shown that the Taylor rule is in principle able to reconstruct the implemented monetary policy of a central bank, and thus it is a useful tool in order to analyze the central bank policy of a period in question by comparing the actual interest rate with the Taylor rule interest rate. For instance, Taylor (1998) has analyzed the US monetary policy within different time frames. The results indicate that since the mid-1980s the US monetary policy has generally been in line with the interest rate based on the Taylor rule and has therefore contributed to lower inflation rates as well as to lower volatility of real GDP – a time period that is often referred to as the Great Moderation (Taylor, 1998). Although low consumer price inflation corresponds with one of the US monetary policy goals, namely price stability, there have been substantial

[1] Typically, price stability is considered to be the most important objective of monetary policy. Further goals are full employment, balanced economic growth, moderate long-term interest rates, exchange rate stability and financial market stability (see, e. g., Mishkin, 2013, pp. 434).

increases in asset prices since the mid-1980s until the onset of the financial crisis in 2007. This development seems to be a challenge for monetary policy. The question arises whether a "wrong" monetary policy, i. e. an interest rate setting behavior of the central bank without considering asset prices appropriately, might have played a crucial role with respect to increasing asset prices, and thereby contributing to the occurrence of the finical crisis in 2007.

When faced with financial stress a central bank has to decide how to react. In particular, the dynamics of currency crises strikingly highlight the role a central bank can play in case of a crisis event. Currency crises can be very heterogeneous events. The outcome of currency crisis ranges from sharp declines in output to even increases in output (see, e. g., Gupta et al., 2007). One possible explanation for these different crisis outcomes can be due to means of monetary policy, e. g. by the implementation of different crisis strategies of the central bank. The central bank can basically decide whether to defend the domestic currency or to abstain from an intervention policy. This gives rise to three different types of currency crises, namely, (i) immediate depreciation, (ii) successful defense, and (iii) unsuccessful defense. In this context, empirical studies indicate that a central bank's crisis management in case of a speculative attack indeed seems to play an important role. Eichengreen and Rose (2003), for instance, point out that the failure to defend the domestic currency is accompanied by severe economic costs. However, the authors do not adequately examine the central bank's crisis policy, as different types of crises are intermingled. Since the authors combine an immediate depreciation and an unsuccessful defense to the successful attack scenario within the analysis, their results do not provide information concerning the decision whether a central bank should try to defend the domestic currency or not. Therefore it is of particular interest to asses the economic costs associated with respective central banks' decisions in case of speculative attacks.

Besides an explicit crisis management, it might be also helpful if the monetary authority implements implicit stabilization mechanisms. They are especially useful if immediate crisis responses are necessary as they avoid a complex decision making process. In this context, the TARGET2 system of the euro area plays an important role since the 2009 ongoing debt and banking crisis in Europe. The TARGET2 system is an interbank payment system that was established to process efficiently cross-boarder transfers of the Eurosystem. However, it can be currently considered to be part of an implicit stabilization mechanism. As capital accounts of EMU member countries – and thus capital flows – no longer reflect current account balances, the member countries of the currency union face respective balance-of-payment imbalances. Without a mechanism that substitutes for missing capital flows (or even capital flight), the recent development might have resulted in a balance-of-payments crisis with a collapsing euro area. The academic literature on TARGET2 balances has become quite extensive over the last three years (see, e. g., Cecchetti et al., 2012; Fahrholz and Freytag, 2012; Sinn and Wollmershäuser, 2012a,b). The studies primarily focus on potential risks and costs, which are associated with a breakdown of the euro area, and thus the TARGET2 system. CESifo (2014), for instance, calculates the potential losses for Germany in case of a euro area collapse and the subsequent insolvencies of the respective crisis economies. The calculation suggests that holding TARGET2 claims might lead to potential losses of about 470 bn. euros. These studies, however, seem to neglect the aspect that the TARGET2 system might be associated with current economic costs. To better understand how these current economic costs and benefits of such implicit stabilization mechanisms could arise, an adequate analysis seems essential.

1.2 Structure of the thesis

To cope with these research questions the thesis is organized as follows: Chapter 2 examines if US monetary policy (implicitly) responds to asset price booms. Using real-time data and a GMM framework, a Taylor-type rule augmented by an asset variable that captures phases of booms and busts in the real estate market is estimated. The analysis identifies quasi real-time booms and busts using an asset cycle dating procedure and yields two main findings. Firstly, the Fed does implicitly respond to asset price booms in the real estate market. Secondly, these responses are typically pro-cyclic and their intensity changes over time. These findings indicate that the interest rate setting behavior of the US monetary policy implicitly contributes to the formation of asset price bubbles, thereby increasing the risk of financial crises.

Chapter 3 analyzes the economic costs associated with the central banks' decisions to intervene or not to intervene in case of speculative attacks. The central bank can either abstain from intervening or start an intervention, which in turn can be successful or unsuccessful. Therefore, an adequate analysis of the costs of currency crises has to take into account three different types of currency crises: (i) an immediate depreciation without any central bank interventions, (ii) a successful defense, and (iii) an unsuccessful attempt to defend the exchange rate. The empirical study reveals that the decision of the central bank to intervene or to remain passive is risky. If the central bank intervenes and succeeds she can on average achieve the best growth performance. However, if the interventions are not maintained and the currency depreciates the subsequent output loss is particularly severe. Abstaining from an intervention yields a scenario with a relatively small drop in output. Giving in to a speculative attack rather than trying to fight it can thus be a suitable option for a risk-averse central bank.

Chapter 4 extends the previous analysis and takes a closer look at the economic dynamics after a speculative attack by explicitly taking into account the interdependencies between macroeconomic fundamentals within a panel VAR framework. This approach enables to gain further insights in the adjustment processes following the three types of currency crises and the potential role of central banks in reducing the costs of currency crises. Moreover this chapter takes a deeper look at various components of aggregate demand (e. g. private consumption, investment, exports and imports) as well as further important macroeconomic indicators (e. g. debt-to-GDP ratio and unemployment rate). The results indicate that the macroeconomic developments differ considerably with respect to the three different types of crises. Monetary authorities therefore play a central role in determining the economic course and costs of currency crises. Specifically, a central bank has two options to mitigate the costs of speculative attacks, namely an immediate depreciation and a successful defense. If a central bank intervenes she might be able to stabilize the exchange rate only temporarily and risks to ultimately fail facing the worst of the three scenarios with the highest economic costs.

To adequately analyze the role of the TARGET2 system against the background of the European debt and banking crisis, chapter 5 evaluates the current economic costs and benefits of the TARGET2 system. In particular, this chapter assesses the real gains and losses of holding TARGET2 claims in the case of Germany. While Germany's nominal gains depend on the development of the nominal interest rate, the real gains are determined by the real interest rate as well as the real exchange rate. The analysis finds that by the end of 2013 Germany has incurred accumulated losses of around 13 billion euros in real terms. Additionally, the calculation of the losses and gains of every member country in the euro area suggests that the TARGET2 system can be considered an implicit redistribution mechanism with a volume of about 30 billion euros. On the one hand, this implicit redistribution mechanism might help to finance necessary (real) economic adjustments. On the other hand, as the real gains and losses only mirror the real economic differences in the EMU, the TARGET2 system cannot replace necessary reforms, but can provide time and money to reduce intra-EMU imbalances.

Finally, chapter 6 concludes with a brief summary and outlines the most important and significant results.

Chapter 2

The Fed's TRAP – A taylor-type Rule with Asset Prices

Chapter 2 has been published as Erler et al. (2013). I would like to thank conference participants at Bayreuth (Postgraduate Seminar), Kiel (Annual Meeting of the German Economic Association) and Rom (XIX International Tor Vergata Conference on Money, Banking and Finance) for many helpful suggestions. In particular, the very helpful comments by Christian Drescher, Egon Görgens, Bernhard Herz, Damir Križanac, and Franz Seitz are gratefully acknowledged. I would also like to thank John B. Taylor for his very useful comments.

2.1 Motivation

During the Great Moderation the US, like most developed economies, has been subject to modest consumer price inflation. While this development conforms with one of the Fed's goals, as these focus on consumer price inflation, there have also been considerable increases in asset prices until the set in of financial crisis in 2007. From 1985q1 to 2007q1 consumer prices rose quarterly on average 0.76 %, while corporate equity and real estate prices increased 2.74 % and 1.29 %, respectively.[1] Among the often discussed reasons for the spreads between growth rates of consumer and asset prices are different price elasticities (see Belke et al., 2008) and the "paradox of credibility"[2] (see Borio et al., 2003). Since asset prices are claims on future goods and services, it should come as no surprise that former Federal Reserve Chairman Alan Greenspan already asked in 1996:

> "But where do we draw the line on what prices matter? Certainly prices of goods and services now being produced – our basic measure of inflation – matter. But what about futures prices or more importantly prices of claims on future goods and services, like equities, real estate, or other earning assets?"

Economic literature on these questions is still twofold. The traditional view claims that asset prices should only be taken into account to the extent that these influence consumer price inflation ("benign neglect" strategy), whereas the new view claims that asset price booms should be dampened to prevent high-cost busts ("lean against the wind" strategy). Since there is no common sense about the optimal response to

[1]Consumer price inflation is approximated by changes in the Consumer Price Index for all urban consumers including all items. Changes in corporate equity prices are generated from the S&P 500 Index and those of real estate prices stem from the FHFA Index.

[2]The "paradox of credibility" states that a credible monetary policy can induce boom and bust cycles in asset markets. It implies that the anchoring of inflation expectations for consumer markets at reasonable levels will head excess liquidity to asset markets.

asset price booms, we should first take a closer look at the main problems regarding this question.

1. Problem of identification: Bernanke and Gertler (1999, 2001) argue that it is not possible to identify asset price booms in real-time with sufficient certainty. Roubini (2006) claims that even if their identification come with some degree of uncertainty, these information should in general not be ignored.

2. Problem of information: Kohn (2008) argues that responses to asset price booms require central banks to have an information advantage against other market participants. Cecchetti (2005) holds against that central banks have different incentives and different measures to act in case of a similar assessment of the underlying asset price.

3. Problem of destabilization: Posen (2006) claims that pricking asset price booms can trigger market panics, whereas Borio (2005) points out that 'leaning against the wind' should take place in the early stage of asset price booms to avoid unpredictable market behavior.

4. Problem of focus: Bernanke and Gertler (1999) argue that the mere focus on price stability reduces the likelihood of financial crises. But Borio and Lowe (2002) state that the sole focus of monetary policy on consumer price stability does not necessarily lead to a stable financial system since asset price booms indicate excess liquidity even though other indicators neglect any indications.

5. Problem of transmission: Interest rate increases do not necessarily dampen the formation of asset price booms (see Kohn, 2008), but it has to be considered that changes in interest rates have a stronger effect on investors as expected due to the 'risk-taking'-channel of monetary transmissions, which affects the willingness to take risk (see Gambacorta, 2009).

6. Problem of economic costs: While the traditional view points out that pricking an asset price boom causes collateral damage for the real economy and other not directly affected asset markets, the new view annotates that a mild collateral damage of an early intervention should be seen as an insurance premium against an even worse damage in the wake of a later asset price bust (see Bordo and Jeanne, 2002).

The debate whether to respond to asset price booms (or not) is not conclusively discussed in literature yet and is still open to further discourse.

To date the Fed officially follows the traditional view not to respond to asset price booms. We examine if US monetary policy at least implicitly responds to asset price booms. Using real-time data and a GMM framework we estimate a Taylor-type rule as shown in Clarida et al. (1998) and Orphanides (2001). In our article we use a modified Taylor rule to investigate the monetary policy of the Fed.[3] Empirical studies show, that the interest rate setting behavior of the Fed – except from the period prior to financial crisis – can certainly be explained by the Taylor rule (see Taylor, 2007; Poole, 2007). Despite all this however, the rule is unable to provide accurate and satisfying explanations for this period of controversy. The aim of this article is therefore to search for potential alternatives to adequately interpret the behavior of the Fed. To take account of asset price movements we extend a Taylor-type rule by a dummy variable that captures asset price booms.[4] This dummy variable refers to real estate prices which take up an important share in households' asset portfolio. Moreover, real estate prices seem to have a close connection to monetary conditions (see Deutsche Bundesbank, 2007, pp. 19). By using deflated asset prices we attempt to extract shifts in relative prices with respect to consumer prices.[5]

[3]On principle Taylor-type rules can either be applied in a prescriptive way, that sets recommendations on how central banks should act, or in a descriptive way, in order to examine the interest rate setting behavior of central banks.

[4]It is crucial to note, that we do not refer to asset price bubbles.

[5]Deflated asset prices indicate the development of relative prices between the asset in question and the underlying consumer basket. The applied consumer price index (all items) is used as a proxy for economy-wide price developments.

The article is organized as follows. Section 2.2 describes the asset cycle dating procedure that we use to identify phases of asset price booms. The empirical framework which consists of a Taylor-type Rule with Asset Prices (TRAP) is given in section 2.3. The results of our estimations are discussed in section 2.4. Our main findings are summarized in section 2.5.

2.2 Asset cycle dating procedure

To analyze the Fed's reaction function on real estate prices we need an approach that captures asset price movements. The Fed mainly focuses on medium-term developments to ensure consumer price stability due to significant time lags in the conduct and effect of monetary policy. In this vein, we suppose that its responses to asset price booms would most likely also focus on medium-term developments of asset prices. For that reason we employ an asset cycle dating procedure that is able to filter medium-term developments by identifying asset price cycles.

The results of recent empirical studies show that asset price cycles seem to be more volatile and frequent than real business cycles (see Avouyi-Dovi and Matheron, 2005; Claessens et al., 2010). Possible reasons are rigidities and frictions[6] as well as different price elasticities[7]. Since the characteristics of asset price cycles are different from those of real business cycles some modifications are necessary. Following Pagan and Sossounov (2003) and IMF (2003) asset price cycles are identified using a modified

[6] In general, asset price cycles are subject to less rigidities and frictions than real business cycles are. For instance, real markets are often characterized by sticky prices, whereas asset prices usually respond more quickly.

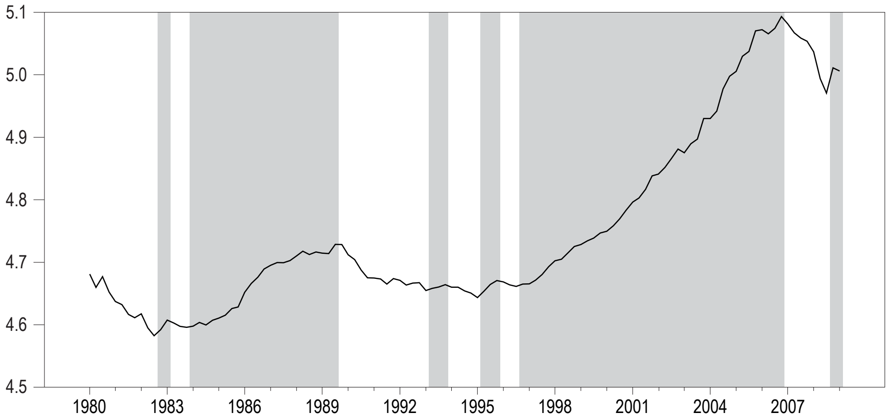
[7] In the short-term, most asset markets, such as the real estate market, have a relative inelastic supply since the asset supply can often not be adjusted without some lag of time. For instance, the supply of houses can increase only gradually since the building of an house requires time. In the long-term, the supply curve is more elastic.

Bry-Boschan cycle dating procedure (Bry and Boschan, 1971).[8] Similar to Pagan and Sossounov (2003, pp. 24) we do not use smoothed data and do not remove outliers to consider unusual movements in time series (e. g., stock market crash in 1987). Furthermore, we include several censoring criteria in order to avoid spurious phases. The main characteristics of our procedure can be summarized in two steps. Firstly, we identify the initial local extrema by searching the input data for peaks and troughs in a rolling five quarter window. Secondly, pairs of peaks and troughs are chosen to meet the constraints for minimal duration of cycles (four quarters) and phases (two quarters). Since we use quarterly data our minimal duration of cycles and phases are the shortest possible duration constraints. A cycle denotes the period from one peak to another peak and a phase describes the period between a peak and a trough. Phases from troughs to peaks refer to booms, whereas phases from peaks to troughs refer to busts.

After determining peaks and troughs we summarize our results in an asset variable. We choose a dummy variable to map developments in asset prices since we focus on the question if the Fed responds to asset price booms in a systematic way, independently of the depth and length of booms as these information come with great uncertainty. The dummy variable takes on the value one if the asset market is in a boom phase at time t and zero otherwise.

Using this procedure we identify five complete booms and five complete busts in the ex post time series of deflated US real estate prices (see figure 2.1). A summary statistic on the identification of ex post cycles in the US real estate market is given in table 2.1.

[8]The Bry-Boschan cycle dating procedure is a non-parametric technique for dating real business cycles, but is for example also used to identify asset price cycles in corporate equity markets (see, e.g., Edwards et al., 2003; Kaminsky and Schmukler, 2003; Pagan and Sossounov, 2003; Biscarri and Gracia, 2004; Gonzalez et al., 2005).



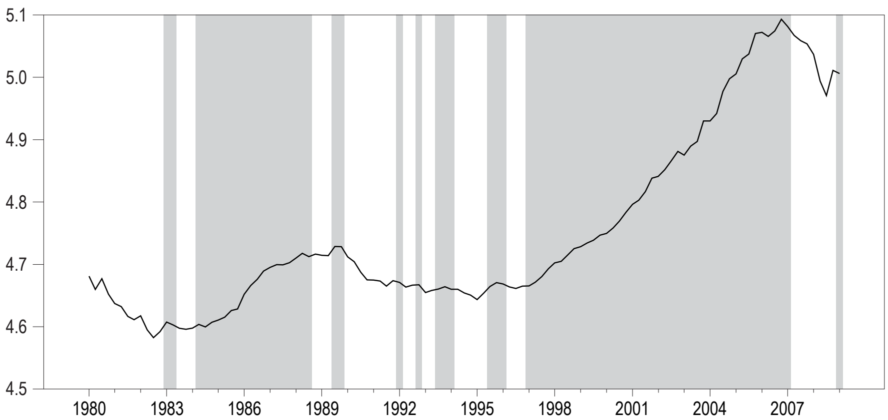
Notes: Boom phases are shaded gray.

Figure 2.1: Ex post booms of deflated US real estate prices

Table 2.1: Statistics on boom and bust phases in US real estate prices

	Ex post		Real-time	
	Booms	Busts	Booms	Busts
Number	5	5	8	8
Average duration	14	6	9	4
Average amplitude	12.5	–4.7	7.1	–1.9

Note: Statistics are based on complete cycles between 1980q1–2009q1 only.



Notes: Boom phases are shaded gray.

Figure 2.2: Real-time booms of deflated US real estate prices

The average duration of boom phases is more than two times longer than the duration of bust phases. Boom phases also have a more than two times higher amplitude.

To assess whether the Fed responds to asset price booms in the real estate market, it is important to rely only on data that were available to the Fed at the time of decision making (see Orphanides, 2001). Hence, we make an additional modification to our cycle dating procedure. While the algorithm bases on the ex post time series, the peaks and troughs are obtained recursively, i. e. by using only data up to the corresponding real-time data point. The resulting dummy variable indicates quasi real-time boom and bust phases of deflated US real estate prices (see figure 2.2). A summary statistic on the identification of quasi real-time cycles in the US real estate market is also given in table 2.1.

By comparing asset price cycles of real estate prices for the ex post and quasi real-time time series the aspect of uncertainty in decision making of monetary policy becomes obvious. The quasi real-time approach identifies more and smaller cycles compared to the ex post approach.

2.3 Empirical framework

To estimate the monetary policy reaction function of the Fed we use a Taylor-type rule.[9] The original Taylor rule is modified by a smoothing term to capture monetary policy's gradual interest rate adjustments (see Goodfriend, 1987). Since it is our purpose to estimate whether the Fed responds to real estate prices – as it does on inflation gap and output gap – we additionally implement the previously derived asset variable. Following Orphanides (2001) we use real-time data for our estimations.

[9] The original Taylor rule is given by $r = p + 0.5y + 0.5(p - 2) + 2$, where r is the federal funds rate, p is a proxy for the expected inflation rate and y is the output gap. The inflation target and long-term real interest rate are assumed to be constant and appraised to be 2 (Taylor, 1993).

Our Taylor-type rule is given by:

$$i_t = \rho i_{t-1} + (1-\rho)[\gamma \Delta y_t^* + \pi_t^* + \delta(E_t \pi_{t+4} - \pi_t^*) + \beta(y_t - y_t^*) + \phi av_t] + \epsilon_t,$$

where i_t is the effective federal funds rate and ρ is its monetary policy smoothing parameter. The equilibrium real interest rate is approximated by the product of the first-order difference of real-time output potential Δy^* and its estimated relation parameter γ.[10] The inflation target π_t^* is designed to be time-varying and is approximated by real-time 10 year ahead inflation forecasts (FRBP, 2007).[11] The output gap is based on the difference between the real-time real output y and its long-term potential y^*. The long-term real output potential is estimated by means of the HP-filter (Hodrick and Prescott, 1997) and is based on the real-time series of real output.[12] The real output is extended by 12 quarter forecasts obtained from an autoregression.[13] We add these to the real output to cope with the end-of-sample problem of the HP-filter (see Baxter and King, 1995, pp. 18). The inflation gap is given by the difference between the real-time 4 quarter ahead inflation forecast $E_t \pi_{t+4}$ and the time-varying inflation target π_t^*. Our asset variable introduced in section 2.2 is denoted by av_t. The error term ϵ_t is i. i. d. The indices $t+x$ represent the period in question and E_t is the expectation operator. The sources of our data are the Bureau of Economic Analysis, the Board of Governors of the Federal Reserve System, the Federal Housing Finance Agency and the Federal Reserve Bank of Philadelphia.

[10] Since the equilibrium real interest rate is an unobserved variable it needs to be estimated. Our estimations build on the economic postulate that in a market equilibrium real interest rates should be conform with the economy's marginal productivity of capital.

[11] Reasons and consequences of a time-varying inflation target are given by Ireland (2007).

[12] As it is common with data that come with a quarterly frequency the smoothing parameter is chosen to be $\lambda = 1,600$ (see, e. g., Baxter and King, 1995).

[13] The first five forecasts are taken from the Philadelphia Fed's real-time data set. The optimal lag length of the autoregression is determined by step-wise least squares estimations with a maximum lag length of 8 and approved p-values up to 10 %.

In general, the estimation of monetary policy reaction functions is subject to the methodical challenge of endogeneity since the left-hand and right-hand variables are interdependent and simultaneously determined in the same period. The reverse causality from the federal funds rate to the explanatory variables violates the essential assumption for least squares regressions of contemporaneously uncorrelated explanatory variables and error terms since the explanatory variables are not exogenous.[14] As a result the estimated parameters would be endogeneity biased and inconsistent. For instance, the asset variable should be affected by changes in the federal funds rate – given validity of the present value theory – since its underlying asset price is subject to changes in the discount factor of its expected income stream. To account for this problem the explanatory variables are instrumentalized and estimated by the generalized method of moments (GMM). As instruments we use the own lagged realizations since these should be uncorrelated with the error term and highly correlated with their future realizations.[15] The optimal weighting matrix is used to obtain the iterated GMM estimator (see Hall, 2005).

2.4 Estimation results

Using this empirical framework we estimate parameters for the full sample and for rolling subsamples since we are interested in the Fed's general reaction as well as its changes over time. The full sample covers the period from 1985q1–2007q1. The starting point of the sample is chosen with respect to the constrained availability of real-time data and the beginning of the Great Moderation (see Stock and Watson, 2002). The end of sample accounts for regime shifts in the conduct of the Fed's mon-

[14]By definition, explanatory variables x_t are said to be endogenous if they are correlated with the equation's error term ϵ_t.

[15]The high correlation between the own realizations reduce the standard errors compared with other less correlated variables (see Wooldridge, 2002, pp. 101). The GMM provides the additional benefit that it also accounts for measurement uncertainties to which our estimation could be subject to.

etary policy due to the installation of unconventional measures during the financial crisis.[16]

The upper part of table 2.2 illustrates the parameters of the Taylor-type rule for the full sample estimation. The full sample estimates of the baseline policy rule indicate that the Fed responds strongly to expected inflation gap ($\delta = 6.73$) and output gap ($\beta = 0.85$). The estimate of the interest rate smoothing parameter ($\rho = 0.80$) suggests that only one fifth of the federal funds rate is influenced by current inflation gap and output gap. The remaining part of the explained variation is determined by its previous realizations. The parameter of potential output growth ($\gamma = 0.91$) indicates the Fed's perception of the equilibrium real interest rate, which should be equivalent to the long-term potential output growth. All parameters are highly statistically significant. Indeed, the parameters for the inflation and output gap differ from those proposed by Taylor (1993), but these parameters are still reasonable and mirror the Taylor-principle after all. Particularly, the parameter $\delta > 1$ ensures that the federal funds rate moves more than one-for-one with inflation. Otherwise, inflation could become highly volatile (see Taylor, 1998).

The estimation results in the lower part of table 2.2 describe the Fed's reaction function including the dummy variable for asset price booms in the real estate market. All estimated parameters are close to the baseline results and the dummy variable is statistically significant. The negative sign of its parameter suggests that the Fed has set a lower federal funds rate in the presence of a boom phase in the real estate market. If the real estate market experiences a boom phase, then the federal funds rate is set 100 basis points lower in the long run than our baseline rule without taking asset prices into account implies. Additionally, by considering the interest rate smoothing parameter the current level of the federal funds rate is set about 20 basis points below

[16] The installation of unconventional measures makes it hard to estimate reasonable parameters for Taylor-type rules.

Table 2.2: Parameters of the Taylor-type rule for the full sample estimation

	ρ	γ	δ	β	ϕ
Baseline:					
Coefficient	0.80	0.91	6.73	0.85	–
Standard Error	0.02	0.06	0.65	0.19	–
p-value	0.00	0.00	0.00	0.00	–
Observations			89		
Standard Error of Estimate			0.35		
J-Statistic			11.43		
Baseline with asset prices:					
Coefficient	0.80	1.19	6.04	1.16	−1.00
Standard Error	0.02	0.11	0.69	0.21	0.39
p-value	0.00	0.00	0.00	0.00	0.01
Observations			89		
Standard Error of Estimate			0.33		
J-Statistic			11.97		

Notes: As instruments we use a constant and the first four lags of federal funds rate, inflation, expected inflation, potential growth and output gap, respectively. Furthermore, when estimating the Taylor-type rule with the asset variable we add the first four lags of its own realizations to the set of instruments. The J-Statistic for both estimations takes the value of 11.42 and 11.08, respectively. In each case the null hypothesis of valid instruments is not rejected.

the estimated baseline rate. Our results of the full sample estimation indicate that the Fed responds pro-cyclic to asset price booms. These estimation results are not sensitive to stronger restrictions on minimum duration of cycles up to 8 quarters.

Moreover, to ensure the robustness of our estimation results we substitute our dummy variable av_t using two alternative approaches to capture asset price movements. Table 2.3 lists the estimation results.

(1) We capture asset price movements using a HP-filter generated cycle variable. Asset price movements are forecasted using an AR(8) process of asset price growth rates to cope with end-of-sample problems of the HP filter. The resulting asset price time series is recursively distinguished into a trend and cyclic component. The results for the HP-filter generated variable are similar to our estimation results with

Table 2.3: Parameters of the Taylor-type rule for the full sample estimation using two alternative approaches to capture asset price movements

	ρ	γ	δ	β	ϕ
(1) HP-filter gap					
Coefficient	0.79	0.91	5.84	1.11	−0.23
Standard Error	0.02	0.05	0.40	0.20	0.11
p-value	0.00	0.00	0.00	0.00	0.03
(2) Growth rate					
Coefficient	0.81	0.98	6.56	1.01	−0.04
Standard Error	0.02	0.05	0.54	0.18	0.04
p-value	0.00	0.00	0.00	0.00	0.37

Notes: The J-statistic of each estimation indicates that overidentifying restrictions are valid with 14.32 for the HP-filter gap and 15.18 for the growth rate, respectively.

respect to the sign and significance level.[17] The HP-filter generated cyclic component confirms that the Fed responds to boom phases in the real estate market in a pro-cyclic manner.

(2) We capture asset price movements using annualized quarterly growth rates of real estate prices. The approach asks if the Fed responds to short-term developments in asset prices. This contrasts with our initial assumption on the Fed's time horizon but is justifiable if one assumes that policy time lags are sufficient small for asset markets. The asset variable depicts a negative but insignificant coefficient. This result is in line with those of Bernanke and Gertler (1999) and supports our initial assumption that the Fed does most likely not focus on short-term developments of asset prices.

So far, we have examined how monetary policy responds to asset price booms in general by considering the full sample. In the next step the focus of our analysis shifts from full sample to rolling subsamples. The estimations of rolling subsamples should give an indication when and to what extent changes in the monetary reaction function

[17] Variations in the smoothing parameter of the HP filter do not substantially change our main results with respect to the sign and significance level.

Table 2.4: Summary statistics of bull market coefficients for rolling subsample estimations

	Total	Positive	Negative
Number of significant	38	2	36
Number of insignificant	12	1	11
Maximum of significant	5.20	5.20	-1.39
Mean of significant	-0.59	4.80	-0.89
Minimum of significant	-1.39	4.39	-0.52
Effective maximum of significant	1.61	1.61	-0.29
Effective mean of significant	-0.13	1.49	-0.22
Effective minimum of significant	-0.29	1.38	-0.12

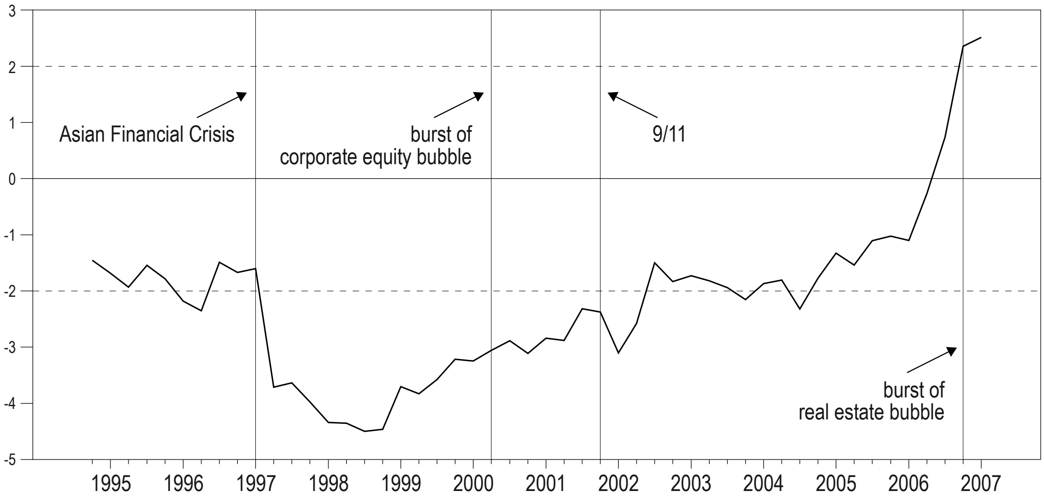
have taken place. The subsamples cover the period from 1985q1–2007q1. Each subsample has a window of 10 years and moves on one period after every accomplished estimation.[18] Table 2.4 reports summary statistics on the 50 realizations of the asset variable.

Out of the 50 estimated parameters 38 are significant at the 10 %-level, whereof 2 have a positive and 36 a negative sign. Considering their effective means[19] the estimation results indicate that during boom phases in case of a negative (positive) sign the Fed has set the federal funds rate on average 22 (149) basis points below (above) the level that would have been set in the absence of a boom phase. These figures point out that on average the Fed has responded stronger to asset price booms in case of an anti-cyclic monetary policy (parameter with a positive sign) than in case of a pro-cyclic monetary policy (parameter with a negative sign).

Given these results the question arises whether periods exist in which the Fed has responded in a pro-cyclic or anti-cyclic manner to asset price booms. To obtain an impression of these periods figure 2.3 shows all estimated t-values of the dummy variable for each subsample. At first glance, the parameters of subsequent subsamples appear to be clustered since positive and negative parameters are grouped together.

[18]Due to small samples either the two step GMM procedure is applied or if possible the optimal weighting matrix is used to obtain the iterated GMM estimator.

[19]'Effective' refers to the product of the asset cycle coefficient ϕ and $(1-\rho)$, whereas ρ describes the interest rate smoothing parameter.



Notes: For instance, the t-value shown for 1994q4 is inferred from the estimated coefficient of the asset variable for the rolling subsample from 1985q1–1994q4.

Figure 2.3: T-values of the Taylor-type rule for the rolling subsample estimations

Considering the signs and significance levels along the timeline it is remarkable that both point to specific patterns. A few quarters previous to the peak of the recent real estate market bubble the parameter of our dummy variable switches from insignificant negative to significant positive. The observable clusters and patterns previous to this peak in the real estate market give reason to assume that – until a certain point in time – the Fed responded pro-cyclic to boom phases in the real estate market. After this certain point in time the Fed took anti-cyclic measures. By asking what determines this certain point in time one could – for instance – think of an event, such as a suddenly prevailing perception of the FOMC-members that the real estate market has exceeded its sound fundamental level so far that it might evoke a negative feedback to the economy in a way that the achievement of the Fed's goals would be undermined.

2.5 Conclusions

While consumer price inflation is modest, increases in asset prices seem to be a challenge for monetary policy. This article focuses on the following question: Does US monetary policy implicitly respond to asset price booms? We extend a GMM Taylor-type monetary reaction function with a dummy variable which captures asset price booms in the US real estate market. This dummy variable is created by means of an asset cycle dating procedure. This procedure identifies initial local extrema by searching the input data for peaks and troughs in a rolling five quarter window. Moreover, the pairs of peaks and troughs are chosen to meet the constraints for minimal duration of cycles and phases. Our full sample estimation results give reason to suppose that in general US monetary policy responds pro-cyclic to boom phases in the real estate market.

However, our results raise a remarkable question: Did the Fed promote the real estate market by means of loose monetary policy in order to extend boom phases? This question cannot be answered fully yet. Nevertheless, we hint at some interesting aspects. Facing political pressure, the Fed could have had the incentive to extend boom phases in the real estate market. At the same time, many government actions have taken place to encourage home ownership, e. g. the Community Reinvestment Act in 1977, the American Dream Downpayment Act in 2003 and the establishment of (more or less) government sponsored enterprises such as Freddie Mac, Fannie Mae, and Ginnie Mae. Indeed, there is no clear empirical evidence that these government actions directly contribute to the subprime boom (see, e.g., Ellis, 2008; Kroszner, 2008). But this tells nothing about the impact of government pressure on the Fed's monetary policy so that these actions could have nevertheless indirectly contributed. Indeed, Alan Greenspan warned the Congress in 2004 that Freddie Mac and Fannie Mae have reached too much market power – 'too-big-too-fail' – and therefore are in need of more monitoring and regulation. But according to our analysis the Fed did not increase interest rates in response to increasing real estate prices. Without the installation of explicit countermeasures these statements could create by itself an expansionary monetary impulse. In this vein, the absence of a tighter monetary policy could be a driving force for further increases in asset prices (see Meltzer, 2002).

The estimation results of rolling subsamples support our general finding that the Fed does implicitly respond procyclic to asset price booms. Moreover, these results of rolling subsamples do also point to changing responses to asset price booms over time. The responses seem to follow specific patterns, as the Fed changed its intensity and direction of responses previous to the peak of the latest real estate bubble. These changes could be interpreted as part of an implicit "leaning against the wind" strategy.

Chapter 3

To Intervene, or Not to Intervene: Monetary Policy and the Costs of Currency Crises

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3.1 Introduction

Contrary to the typical public perception, currency crises can have very different economic outcomes, ranging from bust to boom. Turkey, for example, was subject to six currency crises between 1994 and 2006, which had quite different real effects (see figure 3.1). While output declined severely after the currency crises of 1994 and 2000, it hardly changed after the crisis of 1998. Output even increased in the aftermath of the currency crises of 2003, 2004 and 2006.

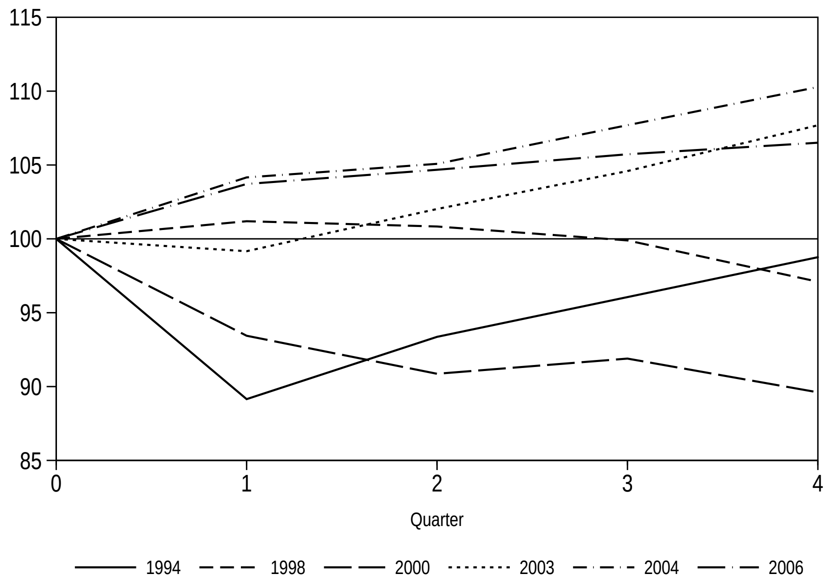

Figure 3.1: Turkey: Real GDP and currency crises (1993 – 2007)

One possible determinant of these different crisis outcomes could be the monetary authority's crisis management. The central bank has in principle two options to respond to a speculative attack. She can either remain passive or intervene in the foreign exchange market in order to avoid a depreciation (see figure 3.2). If she decides to intervene, she can then either succeed or fail depending on the extent of her own actions and the strength of the speculative attack. These interactions between monetary authority and speculative traders give rise to the following four

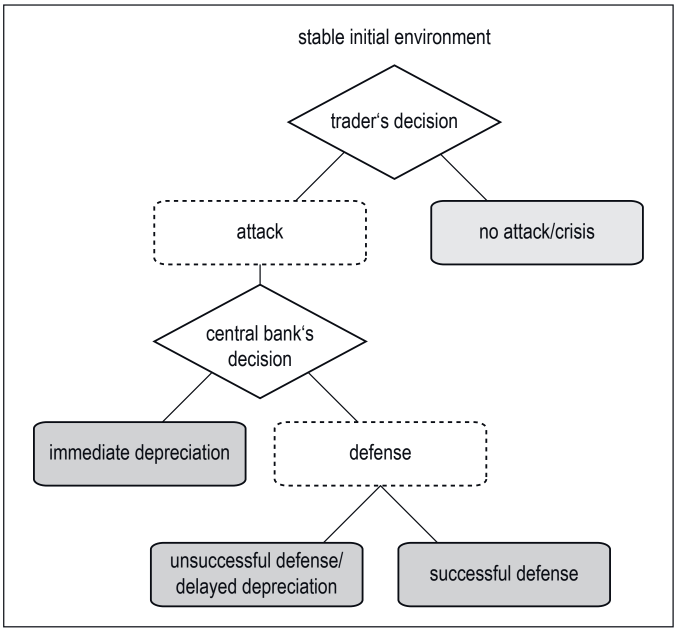

Figure 3.2: Basic structure of a speculative attack (see Bauer and Herz, 2010)

outcomes: no attack and three different types of currency crises, namely, immediate depreciation, successful defense and unsuccessful defense.[1]

So far neither the theoretical nor the empirical literature has adequately accounted for the role of monetary authorities in speculative attacks and thus the differences between the three types of currency crises.[2] First-generation models by Krugman (1979) and Flood and Garber (1984) explain a speculative attack in terms of underlying fundamentals, in particular a too expansionary fiscal policy with a central bank unsuccessfully attempting to defend the peg. In terms of our decision tree (see figure 3.2), the analysis is focused on the dichotomy *no attack vs. unsuccessful defense.* Second-generation models as proposed by Obstfeld (1994), Eichengreen et al. (1996)

[1]To simplify terminology we uniformly apply the term depreciation to devaluation as well as depreciation events, since currency crises – as we define them (see section 3.2) – are not limited to de jure or de facto fixed exchange rate regimes.

[2]See, e. g., Bauer and Herz (2010) and Daniëls et al. (2011), who explicitly model the simultaneous interactions between policy makers and speculative traders.

and Jeanne (2000) introduce the costs and benefits of exchange market interventions for a central bank and emphasize the role of self-fulfilling expectations and multiple equilibria. Implicitly these models focus on situations of *no attack vs. immediate depreciation*. The so-called third generation of currency crisis models encompasses very heterogeneous approaches and focuses on quite different issues, e. g. the fragility in the banking and financial system (see, e. g., Krugman, 1999; Chang and Velasco, 2001; Burnside et al., 2004), or the role of private information (see, e. g., Morris and Shin, 1998; Heinemann, 2000). Again, a common feature of these studies is their dichotomic approach, i. e. they compare general *crisis* with *no crisis* scenarios and neglect the heterogeneity of currency crises.

Empirical studies of currency crises also use binary crisis variables (*crisis* vs. *no crisis*), albeit in a somewhat different way.[3] In order to identify crisis events two basic approaches are typically used. A first approach identifies currency crises as substantial depreciations. The *significant depreciation* measure, as used by Frankel and Rose (1996), Milesi-Ferretti and Razin (1998) and Bussière et al. (2010), covers two types of crisis events: a speculative attack during which the central bank (i) does not undertake any defensive measures and lets the domestic currency depreciate immediately and (ii) an unsuccessful attempt of the central bank to defend the exchange rate. In terms of our approach (see figure 3.2) this crisis definition combines two types of crisis events, namely *immediate depreciation* and *unsuccessful defense*. A second popular way of proceeding is based on the so-called exchange market pressure index (EMPI) which takes into account any substantial action of central banks and/or speculative traders and is typically constructed as the weighted sum of depreciation rate, loss in reserves and interest rate increase (see, e. g., Eichengreen et al., 1995; Bussière and

[3]While the theoretical literature has typically focused on the pre-crisis period to analyze the causes of currency crises, the vast empirical literature on currency crises can be differentiated into two major approaches: (i) studies that focus on crisis prediction (see, e. g., Bussière and Fratzscher, 2006; Gerdesmeier et al., 2009; Melvin and Taylor, 2009), and (ii) studies that analyze the aftermath of currency crises in particular output effects (see, e. g., Gupta et al., 2007; Cerra and Saxena, 2008).

Fratzscher, 2006; Cerra and Saxena, 2008; Klaassen and Jager, 2011). Thus, it does not account for the heterogeneity of currency crises but rather combines all three types of events, namely *immediate depreciation*, *unsuccessful defense*, and *successful defense*.

Our investigation into the role of monetary policy by differentiating between the three types of currency crises particularly relates to Eichengreen and Rose (2003). By analyzing the economic costs of successful attacks and successful defenses, the authors find that a successful attack is on average followed by a 3 % loss of GDP in the following year. However, as the authors combine an immediate depreciation and an unsuccessful defense to the successful attack scenario, their results do not provide information regarding the important decision whether a central bank should intervene or not. Another noteworthy study is the work by Gupta et al. (2007), as the output effects of currency crises are analyzed in a more general approach. The authors adopt the crisis classification of other studies. In particular, they only treat those periods as crisis years that were already tagged by a majority of other studies, thereby intermingling different types of crisis definitions. Their empirical results indicate that crises can have very different economic outcomes and are typically more severe in the case of large capital inflows during pre-crisis periods, fewer capital market restrictions, lower trade openness and higher external long-term debt. Again, due to the encompassing crisis definition it remains unclear what role central bank policies could have in explaining the diversity of crisis outcomes. Cerra and Saxena (2008) and Bussière et al. (2010) point out a new way to examine the persistence of output effects in the aftermath of currency crises. Their findings suggest that currency crises are accompanied by a persistent output loss of 2–6 % of GDP relative to the no-crisis trend. Nevertheless, as both studies are based on aggregated crisis definitions, namely the EMPI in the study of Cerra and Saxena (2008) and the significant depreciation measure in the case of Bussière et al. (2010) they do not differentiate between the three types of crises. For this reason, the role of the central bank's crisis management cannot be assessed adequately.

The main contribution of this paper is to evaluate the role of central bank interventions for output effects of speculative attacks. We adequately distinguish the various types of currency crises and identify the three cases of (i) an immediate depreciation without any central bank interventions following a speculative attack, (ii) a successful defense, and (iii) an unsuccessful attempt to defend the exchange rate, i. e. interventions followed by a depreciation. We find that intervention policies do make a difference for the economic development after a currency crisis. The decision of the central bank to intervene or to remain passive is risky. If the central bank intervenes and succeeds she can achieve the best growth performance on average. However, if the interventions are not maintained and the currency depreciates the subsequent output loss is particularly severe. Abstaining from an intervention, i. e. allowing an immediate depreciation, yields an "intermediate" scenario with a relatively small drop in output. Giving in to a speculative attack rather than trying to fight it can thus be an interesting option for a risk-averse central bank.

The paper is organized as follows. Section 3.2 briefly discusses our approach to differentiate the three types of crises. Section 3.3 presents some stylized facts. The empirical framework which evaluates the economic consequences of the different types of crises is outlined in section 3.4. The analysis is based on two complementary approaches. Firstly, a static panel analysis explicitly examines the impact of the three types of currency crises for output growth given several macroeconomic control variables. Secondly, a dynamic panel analysis complements the static analysis and evaluates the dynamic responses of various macroeconomic variables in the aftermath of a crisis. Section 3.4 also discusses several robustness issues that are crucial for the interpretation of the results. The main findings are summarized in section 3.5.

3.2 The (not-so-trivial) definition of currency crises

In the following we use a stylized version of the monetary model of the exchange rate to define the different types of currency crises (see, e. g., Eichengreen et al., 1994; Klaassen and Jager, 2011). Money supply equals the sum of domestic credit, D_t, and international reserves measured in domestic currency, R_t:

$$M_t = D_t + R_t. \tag{3.1}$$

Equation (3.1) can be approximated by

$$\Delta m_t \approx \frac{\Delta M_t}{M_{t-1}} = \Delta d_t + \Delta r_t, \tag{3.2}$$

with $\Delta d_t = \Delta D_t / M_{t-1}$ and $\Delta r_t = \Delta R_t / M_{t-1}$ where low letter variables denote logs.

We assume standard money demand functions for two countries – home and foreign, with asterisks denoting foreign country variables

$$m_t - p_t = \beta y_t - \alpha i_t, \tag{3.3}$$

$$m_t^* - p_t^* = \beta y_t^* - \alpha i_t^*, \tag{3.4}$$

where m_t denotes the money supply, p_t the price level, y_t the real income, i_t the nominal interest rate, α the interest rate semi-elasticity and β the income elasticity of money demand. Further assuming purchasing power parity,

$$s_t = p_t - p_t^*, \tag{3.5}$$

with s_t as the nominal exchange rate yields

$$s_t = m_t - m_t^* - \beta(y_t - y_t^*) + \alpha(i_t - i_t^*). \tag{3.6}$$

Taking first differences, and using equation (3.2) leads to

$$\Delta s_t + \Delta i_t - \Delta r_t = \Delta d_t - \Delta m_t^* + \Delta i_t^* - \beta(\Delta y_t - \Delta y_t^*) + (1+\alpha)(\Delta i_t - \Delta i_t^*). \quad (3.7)$$

The left-hand side of equation (3.7) comprises the central elements of the crisis definitions in a straightforward way. In case of a speculative attack the central bank can either adjust interest rates (Δi_t) and/or intervene in the foreign exchange market (Δr_t) and/or let the currency depreciate (Δs_t).[4] We characterize the three types of crises, namely immediate depreciations, successful interventions, and unsuccessful interventions, along two dimensions. On the one hand we use changes of the exchange rate (Δs_t) and on the other hand we use an intervention index (INTX) in order to describe the central bank behavior (see Bauer and Herz, 2010). The intervention index is defined as the standard deviations weighted sum of interest rate changes and percentage changes in reserves (INTX $= \Delta i_t/\sigma_{\Delta i_t} - \Delta r_t/\sigma_{\Delta r_t}$). To identify specific crisis events we apply the subsequent set of rules which follows the stylized time structure of a speculative attack (see figure 3.2):

1.a A depreciation is significant if it is larger than the average of the exchange rate changes during the previous 12 months plus two times the standard deviation of these changes. Additionally, the exchange rate change has to be greater than 5 %.[5] All means and standard deviations in this study are calculated time and country specific.

[4]In practice, a central bank clearly has more policy tools than equation (3.7) suggests. For simplicity, we do not discuss in detail, for example, realignments and changes in exchange rate bands as monetary tools, since they could be subsumed under changes of the exchange rate. Analogously, exchange rate orientated open market operations should be accounted for by interest rate adjustments (see Klaassen and Jager, 2011, p. 77).

[5]Increases of the exchange rate of less than 5 % are not classified as significant depreciations even if they exceed the standard deviation threshold, e. g. in a strictly managed exchange rate regime (see Bauer and Herz, 2010). In fact, a managed exchange rate regime is typically announced with a respective exchange rate band (see, for example, Ilzetzki et al., 2008).

1.b Analogously, an intervention is considered to be significant if the INTX exceeds the average value during the previous 12 months plus three standard deviations.[6]

2.a A successful defense in year T is defined as a significant intervention in month s of year T without a significant depreciation during the subsequent 12 months.

2.b An unsuccessful defense in year T is defined as a significant intervention in month s of year T followed by a significant depreciation during the subsequent 12 months.

2.c An immediate depreciation in year T is defined as a significant depreciation without a significant intervention during the preceding 12 months.

Given our definition an unsuccessful defense might also be characterized as a delayed depreciation. Once a central bank has started to intervene in the foreign exchange market she could end the intervention and let the currency depreciate for basically two reasons: either she is no longer able to intervene, e. g. the reserves are depleted, or she is not willing to further intervene, e. g. the expected benefits of the intervention policy no longer exceed the expected costs. As we cannot differentiate between these two situations we use the terms unsuccessful defense and delayed depreciation interchangeably.

Our empirical analysis is in principle based on annual data due to data limitations. However, as the data relevant for the timing of currency crises, namely interest rates, exchange rates and reserves, are typically available at higher frequencies, we determine the crisis events on the basis of monthly data and assign them to the respective years (see, e. g., Bussière et al., 2010). A major problem in identifying crisis events is to appropriately differentiate whether subsequent crises are individual events or part

[6]We apply a more restrictive threshold than in the case of depreciations to account for central banks' adjustments of reserve holdings that are due to portfolio alignment only and are not due to intentional intervention in the foreign exchange market.

of an ongoing currency crisis. After determining currency crisis events we apply a one-year window and drop all crises with overlapping time windows, i. e. crises have to be at least two years apart to be considered as distinct currency crises.[7] By doing so we ensure that the effects of a specific crisis type in year T are not biased by other nearby currency crises. If, for instance, a successful defense occurs in year T and an unsuccessful defense in year $T + 1$, the post-crisis effects of the successful defense could be influenced by the effects of the unsuccessful defense. Therefore, to avoid possible interferences in such a situation, these two crisis events are dropped from our analysis.

3.3 Some stylized facts

In our sample of 32 emerging market economies, covering the years from 1960–2011, we identify 163 crisis events with 42 immediate depreciations, 87 successful interventions and 34 unsuccessful interventions.[8] To better understand the role of macroeconomic fundamentals and central bank policies in the course of currency crises we examine several macroeconomic indicators in the pre- and post-crisis periods.[9]

To appropriately analyze the central bank's role during currency crises, one first has to answer the question whether the post-crisis economic development is a consequence of the corresponding crisis type or it rather mirrors the underlying causes of the crisis. Put differently, our crisis classification could be subject to an endogeneity problem. Either the central bank determines the way through the crisis and thus

[7]See Bussière et al. (2010) for a similar approach. Moreover, in section 3.4.3 we apply an alternative time window to check the robustness of these crisis definitions.

[8]See appendix for a detailed description of the data. The used data set was checked and corrected for outliers.

[9]The post-crisis period is defined as the crisis year and the first post-crisis year, as our crisis definition is based on monthly data and a crisis can last for twelve months. The pre-crisis period covers the average development of three pre-crisis years. We also applied different lengths (from 1 to 4 years) of the pre-crisis and crisis period and have found our results to be robust.

the post-crisis economic performance, or the economic development determines the central bank's ability to defend the exchange rate successfully or not. Against this background, it is essential to show that the pre-crisis economic environment cannot be assigned with bad or good economic fundamentals. Only in this case, our crisis classification will not be linked to specific post-crisis economic outcomes by construction, and thus we are able to make adequate statements about the central bank's response to a currency crisis (see, e. g. Eichengreen and Rose, 2003).

We follow the literature and focus in particular on output, consumer prices, current account balances, private capital inflows, the real effective as well as the nominal exchange rate, money and reserves (see, e. g., Calvo and Reinhart, 2000; Chiodo and Owyang, 2002; Hong and Tornell, 2005; Gupta et al., 2007; Lahiri and Végh, 2007; Bussière et al., 2010).

In our analysis output growth plays a fundamental role, as the costs of currency crises are often measured in terms of output loss. By taking inflation into account we consider two aspects. On the one hand we control for the economic consequences of high inflationary periods and on the other hand it serves as a policy response indicator (see, e. g. Hong and Tornell, 2005; Bussière et al., 2010).

Changes in the current account balance and foreign private capital inflows might affect output growth, if – for instance – less foreign capital is available. Due to a lack of financial resources firms might be unable to finance investments (see, e. g. Hong and Tornell, 2005), and hence output growth is likely to slow down (see, for example Calvo and Reinhart, 2000; Gupta et al., 2007).

Exchange rate changes can mitigate the negative effects of a currency crisis. A depreciation of the domestic currency that translates into a real devaluation enhances the economy's competitiveness and fosters exports (see Gupta et al., 2007).[10]

[10]Though, at the same time the nominal depreciation increases the real value of the country's foreign debt that is not denominated in domestic currency.

Likewise, monetary policy could support or restrain economic growth. A tighter monetary policy can increase the chance to defend the exchange rate successfully, yet it can also have a negative impact on growth at least in the short to medium term (see, among others, Chiodo and Owyang, 2002; Lahiri and Végh, 2007).

Moreover we take the country's exchange rate regime into account. For example, in case of a hard peg policy, a depreciation of the exchange rate might imply greater uncertainty in the course of a speculative attack than in the case of a more flexible exchange rate regime and could therefore have a negative impact on output growth (see, e. g. Eichengreen and Rose, 2003). Additionally, we include the change in foreign exchange reserves in order to account for a country's ability to defend the exchange rate.

Table 3.1 provides summary statistics with respect to the macroeconomic environment during the pre-crisis and post-crisis period.[11] In addition it provides a summary of the results of the non-parametric Wilcoxon test that examines whether the alternative economic indicators differ from one type of crisis to the other.[12]

Column 1 reports the sample mean for the no-crisis periods. Columns 2 – 5 display the means for the pre-crisis and post-crisis periods, distinguishing between the three types of currency crises. Shaded areas denote statistically significant differences between the crisis events. Since the test allows to compare only two crisis types simultaneously, a single shaded value indicates that the respective crisis in each case is statistically significant different from the two other types of crises at the 5 % level.[13]

[11] See section 3.4.3 regarding the tests of additional variables.

[12] We additionally performed the Kolmogorov-Smirnov test which yields identical results.

[13] For example, to examine pre-crisis inflation rates we perform 3 Wilcoxon tests, namely, (i) immediate depreciation vs. successful defense, (ii) immediate depreciation vs. unsuccessful defense and (iii) successful defense vs. unsuccessful defense. As a result, we obtain 2 out of 3 significant test statistics. The first statistic indicates that successful interventions have significant lower pre-crisis inflation rates than immediate depreciations. The second statistic shows that successful interventions are associated to significant lower pre-crisis inflation rates compared to unsuccessful interventions. Given that, the value of pre-crisis inflation rate is shaded gray in case of a successful defense.

Table 3.1: Mean values of macroeconomic indicators by different crisis events

Variable	no crisis (1)	all crises (2)	immediate depreciation (3)	successful defense (4)	unsuccessful defense (5)
pre-crisis					
Output growth	0.059	0.046	0.037	0.049	0.050
Inflation	0.059	0.091	0.106	0.072	0.123
Current account	−0.008	0.004	−0.007	0.017	−0.015
Private capital inflows	0.016	0.012	0.013	0.012	0.012
Δ Real effective exchange rate	0.005	0.013	0.021	0.002	0.030
Δ Nominal exchange rate	0.014	0.086	0.124	0.047	0.137
Δ M1	0.159	0.217	0.212	0.199	0.266
Δ Total reserves	0.182	0.162	0.135	0.175	0.164
Exchange rate regime	6.8	8.2	9.5	7.2	9.2
post-crisis					
Output growth	0.059	0.036	0.029	0.054	0.002
Inflation	0.059	0.101	0.111	0.062	0.186
Current account	−0.008	0.002	−0.016	0.010	0.005
Private capital inflows	0.016	0.009	0.009	0.009	0.007
Δ Real effective exchange rate	0.005	−0.008	−0.002	0.011	−0.056
Δ Nominal exchange rate	0.014	0.143	0.167	0.024	0.403
Δ M1	0.159	0.197	0.183	0.149	0.327
Δ Total reserves	0.182	0.099	0.160	0.100	0.032
Exchange rate regime	6.8	8.8	9.7	7.3	11.3

Notes: The post-crisis period is defined as the crisis year and the first post-crisis year. The pre-crisis period covers the average development of three pre-crisis years. We also applied different lengths of the pre-crisis and crisis period and have found our results to be robust.
A nominal depreciation is defined as an increase in the nominal exchange rate. A real depreciation is given by a decrease in the real effective exchange rate. The Exchange rate regime classification is based on Ilzetzki et al. (2008) and ranges from 1 to 15 – from de facto pegged to de facto floating. Shaded areas denote statistically significant differences at the 5 % level of one type of crisis compared to the two other types of crises within the respective group.

Table 3.1 indicates that there is only weak evidence for systematic pre-crisis differences between the three types of crises. With the exception of inflation and the exchange rate regime the macroeconomic indicators do not differ significantly between the three types of crises during the pre-crisis period. In the case of inflation we find a significant pre-crisis difference between a successful defense and the other two types of crises, i. e. between on the one hand the case of a stable exchange rate and on the other hand a drop of the exchange rate either due to an immediate depreciation or an unsuccessful defense. The pre-crisis inflation rate of successful interventions is about 7.2 % (column 4) and significantly lower than the pre-crisis inflation rates of immediate depreciations (10.6 %) and unsuccessful interventions (12.3 %). In the case of the exchange rate regime we also find some evidence for pre-crisis differences.[14] Successful interventions are associated with somewhat less flexible exchange rate regimes (ERA index of 7.2) than immediate depreciations (9.5) and unsuccessful defenses (9.2).

Taking together, the summary statistics do not seem to indicate major pre-crisis differences in fundamentals between the three types of currency crises.

In contrast, the test statistics indicate that post-crisis there are considerable differences in macroeconomic developments between the different types of crises. For instance, we find significant differences between output growth in the case of unsuccessful defenses, which is the lowest (0.2 %), immediate depreciations with an intermediate value of 2.9 % and successful defenses with the highest value of 5.4 %.

Differences between the three crisis types can also be found for inflation, the nominal exchange rate as well as the real effective exchange rate. In the case of inflation, the depreciation events, i. e. immediate depreciations and unsuccessful interventions, are associated with significantly higher inflation than successful defenses. The increase in inflation is especially strong in case of unsuccessful interventions. Real

[14] We use the ERA fine classification, ranging from 1 to 15 – from de facto pegged to de facto floating (see Ilzetzki et al., 2008).

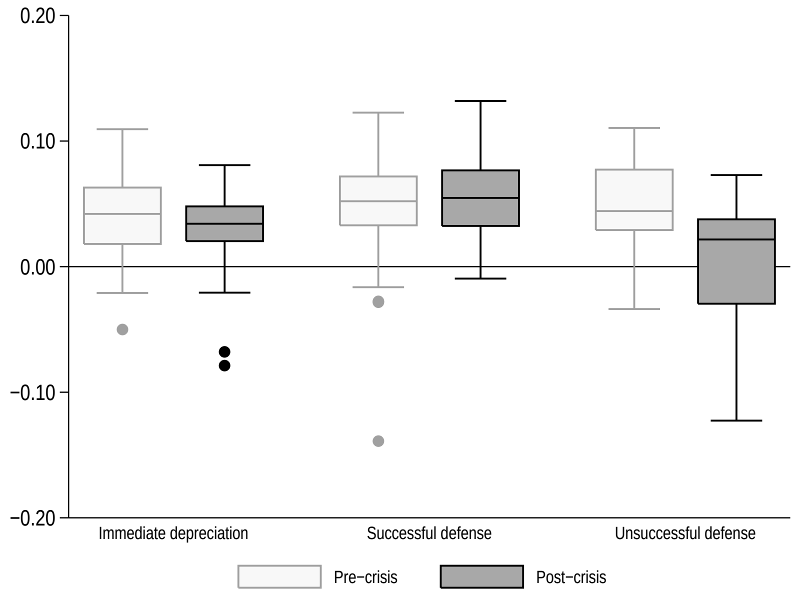

Figure 3.3: Currency crises and output growth

depreciations are significantly stronger in the aftermath of an unsuccessful defense as the relatively high inflation is overcompensated by the very high nominal depreciation. Likewise, immediate depreciations are associated with a significant depreciation of the nominal exchange rate, which is not as pronounced as in case of unsuccessful interventions. In case of successful defenses, a stable exchange rate can be observed as expected. We also find significant differences in the behavior of total reserves. For unsuccessful interventions the growth of total reserves is significantly slower than in the case of the other two crisis types.

To gain further insight in the crisis differences, figure 3.3 provides further information on output growth for the pre- and post-crisis periods. The light gray shaded box plots exhibit the distribution of pre-crisis output growth while the dark gray shaded boxes display the distribution of post-crisis output growth.[15] A successful defense of the domestic currency does not seem to be associated with a significant deviation from the pre-crisis growth. Though, the post-crisis median is somewhat

[15]Regarding the definition of the pre-crisis and post-crisis period see footnote 9.

higher than the pre-crisis median (0.1 %). In case of an immediate depreciation the post-crisis median of output growth deviates from pre-crisis median by –0.6 % (see the two boxes on the left of figure 3.3). Furthermore, as the pre-crisis median tends to be above the post-crisis box, a slightly lower post-crisis growth seems to be likely. In contrast, in the case of unsuccessful interventions the distribution of the post-crisis growth is widespread and is strongly skewed towards negative output growth. The deviation of the post-crisis median from the pre-crisis median is –3.8 %. Most of the crises – nearly 75 % – are accompanied by growth rates, which are below pre-crisis level. Taken together, delayed depreciations are associated with high economic costs. In contrast, in case of an immediate depreciation output growth is only slightly lower while no significant decline in growth can be observed for successful interventions.

To summarize the stylized facts, we find only few differences in the pre-crisis period between the three types of crises while in the post-crisis period considerable differences in the economic development become apparent. We take this finding as a first evidence that crisis management – in particular the decision of the monetary authority to defend or to not adopt defensive measures – might be an important factor with respect to the economic development in the aftermath of a speculative attack.[16] On average, successful attempts to defend the exchange rate are associated with the best result in terms of output growth and inflation, while in the case of abandoned interventions high economic costs in terms of lower output growth and higher inflation seem to be likely. Abstaining from interventions, i. e. to let the domestic currency depreciate immediately, are associated with an intermediate development in output and inflation.

[16]When even removing country and time specific effects (see table 3.14), the pre-crisis differences disappear while the post-crisis differences are still statistically significant. This aspect also supports our view that the central bank's crisis management seems to play an important role concerning the economic costs of currency crises.

3.4 Empirical analysis

The empirical analysis is divided in two steps: (i) a static panel analysis examines the impact of the three types of currency crises on output growth given several macroeconomic control variables, (ii) a dynamic panel approach supports the static analysis and evaluates the dynamic responses of various macroeconomic variables in the aftermath of a crisis.

3.4.1 Output costs of currency crises

In a first step, we quantify the impact of crises on output growth and examine the role of central bank intervention policies and therefore the three types of currency crises based on two-way fixed effects panel regressions. Our benchmark equation is given by:

$$g_{it} = \alpha_i + \omega_t + \sum_n \beta_n \bar{x}_{ni} + \sum_{k=1}^{3} \alpha_k D_{kit-1} + \epsilon_{it},$$

where g_{it} is the output growth (annual growth in real GDP) in country i in year t, $\bar{x}_{ni}$ is a set of lagged explanatory control variables and ϵ_{it} is an i. i. d. error term. To eliminate business cycle effects we compute averages over the last three years, covering the period from $t-3$ to $t-1$. To quantify the impact of the different types of currency crises on output growth, we include the dummy variables D_{kit-1}. Specifically, D_{kit-1} takes on the value one for the year $t-1$ identified as a k type currency crisis in country i. We do not include contemporaneous values of x and D to avoid potential endogeneity problems (see, e. g., Hong and Tornell, 2005; Gupta et al., 2007; Bussière et al., 2010).[17] We additionally control for time-constant but

[17]The results do not qualitatively change when using contemporaneous currency crisis dummies instead.

cross-sectional varying effects (α_i) as well as time-varying but cross-section constant factors (ω_t). Heteroscedasticity and autocorrelation consistent standard errors are calculated. As macroeconomic controls we use the variables discussed in section 3.3 (see also table 3.1). The regression results are reported in table 3.2.

Column 1 of table 3.2 depicts the results of a pooled regression and corresponds to a simplified version of our benchmark equation.[18] The results for the crisis dummy variables indicate that the two types of crises that are associated with a depreciation, namely abstaining from interventions and delayed depreciations, are characterized by high economic costs. In the case of an immediate depreciation there is a statistically significant drop of output growth by –1.4 percentage points. The negative effect of unsuccessful interventions on output growth is even stronger with –5.7 percentage points. In contrast, successful defenses do not appear to have significant output effects. These results point to the considerable risk for a central bank if she intervenes to defend the exchange rate. If the central bank is successful there is no output loss. However, if she abandons the interventions, she is likely to face the worst outcome with the highest output loss of the three cases. In contrast, an immediate depreciation, i. e. the decision not to intervene, is likely to imply an only intermediate output loss. The empirical results also imply that to not differentiate between the different types means that the severe economic consequences of an unsuccessful intervention are underestimated and those of an immediate depreciation are overestimated. The economic effects of a successful defense are, most likely, judged too negative. For instance, if we use a crisis dummy that combines all three types of crises, the estimation results show a significant impact on growth of about –1.3 percentage points. Likewise, if we use two different crisis dummies that either indicate successful interventions or

[18] The equation for the pooled data regression is given by $g_{it} = \alpha + \sum_n \beta_n \bar{x}_{ni} + \sum_{k=1}^{3} \alpha_k D_{kit-1} + \epsilon_{it}$, where g_{it} is the output growth in country i in year t, x is the set of explanatory variables, D_k is the specific crisis dummy and ϵ_{it} is an i. i. d. error term. Regressions are estimated using OLS with robust standard errors.

Table 3.2: Output growth effects of currency crises by different types of crises

	Pooled (1)	Panel (2)	Panel (3)	Panel (4)
CPI inflation	−0.042***	−0.028*	−0.027*	−0.026*
	(−2.7)	(−1.7)	(−1.6)	(−1.6)
Current account	0.029	0.015	0.017	0.016
	(1.1)	(0.3)	(0.3)	(0.3)
Private capital inflows	−0.093	0.010	0.016	0.013
	(−1.6)	(0.1)	(0.2)	(0.1)
Δ Real effective exchange rate	0.016	0.034**	0.029**	0.030**
	(1.2)	(2.6)	(2.1)	(2.2)
Δ M1	0.036**	0.027*	0.026*	0.027*
	(2.1)	(1.6)	(1.6)	(1.6)
Δ Total reserves	0.008**	0.011***	0.009***	0.011***
	(2.5)	(4.2)	(3.2)	(4.1)
Immediate depreciation dummy	−0.014**	−0.010*	−0.012*	−0.011*
	(−2.3)	(−1.7)	(−1.9)	(−1.8)
Successful defense dummy	0.001	−0.001	−0.002	−0.002
	(0.3)	(−0.2)	(−0.5)	(−0.5)
Unsuccessful defense dummy	−0.057***	−0.050***	−0.052***	−0.052***
	(−4.7)	(−4.4)	(−4.5)	(−4.5)
(CPI inflation) × (im. dep.)		0.014		0.019*
		(1.2)		(1.9)
(CPI inflation) × (su. def.)		0.001		−0.004
		(0.1)		(−0.4)
(CPI inflation) × (un. def.)		−0.030		−0.018
		(−1.3)		(−0.9)
Exchange rate regime (err)			−0.000	−0.000
			(−0.7)	(−0.6)
(Exch. rate regime) × (im. dep.)			−0.000	−0.001
			(−0.4)	(−0.9)
(Exch. rate regime) × (su. def.)			0.000	0.000
			(0.2)	(0.2)
(Exch. rate regime) × (un. def.)			−0.002*	−0.001
			(−1.8)	(−1.3)
R^2 (within)	0.166	0.189	0.190	0.195
Country fixed effects	–	Yes	Yes	Yes
Time fixed effects	–	Yes	Yes	Yes
Obs.	547	547	547	547
Countries	28	28	28	28

Notes: Dependent variable: Output growth in country i in year t. T-values in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.10.

successful attacks – immediate depreciation and unsuccessful interventions – we find a significant impact on output growth for successful attacks of about –2.7 percentage points, thereby underestimating the negative consequences of unsuccessful defenses. Therefore, empirical studies, as provided by Eichengreen and Rose (2003) who treat immediate depreciations and unsuccessful interventions as successful attacks, might indicate that not trying to defend also leads to high economic costs. For that reason monetary authorities should rather try to defend the domestic currency more frequently than to immediately give in to a speculative attack. Based on those studies the costs of an unsuccessful defense seem to be relatively small compared to our differentiated analysis, while the economic costs of an immediate depreciation seem to be relatively high. However, our results suggest that – in contrast to an unsuccessful defense – allowing for an immediate depreciation in case of speculative attack is a reasonable alternative.

The remaining columns (2 – 4) contain the results of the two way fixed effects panel regressions. The estimated coefficients for the crisis dummies indicate an impact on growth that is similar to the pooled regression. Unsuccessful defenses are associated with the largest reduction in output growth ranging between –5.0 and –5.2 percentage points, while no significant output losses are found in the case of successful defenses. Again immediate depreciations can be considered as an intermediate case with a decline of the output growth rate in the range of –1.0 to –1.2 percentage points.

Since we find some evidence for pre-crisis differences between the three types of crises concerning inflation dynamics and the exchange rate regime, we allow for interaction terms between the specific crisis type and inflation as well as the exchange rate regime in order to control for these pre-crisis differences (see columns 2 – 4).[19] The estimation results weakly indicate that in the case of an immediate depreciation

[19] We also included additional interaction terms, e. g. private capital inflows, but do not find any other robust results.

the higher the pre-crisis inflation the more the economy benefits from a depreciation of the domestic currency (see column 4). The analysis also shows that in general the exchange rate regime does not have a significant effect on output growth (see column 3). However, when controlling for the impact of the exchange rate arrangement with respect to the three different types of currency crises, weak differences become apparent. In particular the results indicate, that if interventions fail the growth effects are particularly severe if the central bank tries to stabilize an exchange rate that was de facto floating during the pre-crisis period. Monetary authorities who do not pursue a consistent policy, i. e. unsuccessfully pegging a former floating exchange rate, suffer relatively high economic costs possibly related to an associated loss of confidence in the monetary authority.

Taken together, the empirical results illustrate the risk involved in exchange market interventions and the important role central banks play in the face of speculative attacks. If the central bank is successful in defending her currency, she achieves the best result in terms of output growth, namely no loss of output. However, if she is unable or unwilling to continue her interventions, she is likely to face the worst scenario with a considerable loss of output. If the monetary authority decides to abstain from interventions an intermediate scenario seems to follow with a moderate slowdown in output.

3.4.2 Macroeconomic dynamics of currency crises

In a next step we complement the static approach of section 3.4.1 with a dynamic analysis. We estimate a univariate panel autoregressive model in x applying the methodology used in Cerra and Saxena (2008), Bussière et al. (2010) and Kappler et al. (2011), and simulate impulse responses of several macroeconomic variables for the three different types of currency crises. This way we are able to analyze how the macroeconomic adjustments differ between the three types of currency crises.

Our benchmark model is given by:

$$x_{it} = \alpha_i + \omega_t + \sum_{j=1}^{3} \beta_j x_{it-j} + \sum_{k=1}^{3} \sum_{s=1}^{3} \alpha_{ks} D_{kit-s} + \epsilon_{it},$$

where x_{it} denotes the macroeconomic variable of interest in country i in year t. Since the dependent variable x_{it} is either defined as a growth rate or a ratio (e. g., output growth, inflation, current account over GDP or private capital inflows over GDP), the model specification accounts for the non-stationarity of x in levels[20] and for serial correlation of x. The dummy variable D_{kit-s} takes on the value one if a k type currency crisis occurs in country i in year $t - s$. We additionally control for time (ω_t) and country specific effects (α_i). The i. i. d. error term is denoted by ϵ_{it}. The lag length is set to three, as we do not find any significant coefficients beyond the third lag for most indicators.[21] Furthermore, heteroscedasticity consistent standard errors are computed. In order to avoid potential endogeneity problems we estimate a dynamic model for each variable that only captures the lagged effects of a currency crisis. To examine the crisis dynamics, namely the deviation from the no-crisis trend behavior, we simulate impulse response functions of several macroeconomic variables to shocks of the different types of crises.[22]

[20] Test statistics show that all underlying variables are integrated of order 1.

[21] We use a common lag length for all model specifications in order to ensure a direct comparison of impulse response functions of the different macroeconomic indicators (see Kappler et al., 2011, pp. 13).

[22] To ensure that the impulse response functions are not driven by overlapping currency crises we apply a time window, which determines the singular event status of a currency crisis, and consider only crisis events without overlapping time windows (see also section 3.2). Precisely, currency crises have to be two years apart to be kept in our analysis. We also applied different lengths of this time window (from 0 to 3 years) and have found our results to be robust (results are available upon request).

The upper part of figure 3.4 shows that the output effects of a currency crisis substantially differ between the three types of crises.[23] For immediate depreciations and unsuccessful interventions the impulse response functions show a V-shaped drop and recovery of output growth. Moreover, the decline in output growth in case of unsuccessful interventions is about threefold the drop in case of immediate depreciations. Successful defenses do not show any significant output effect. In addition, the results imply a highly persistent impact on the output level in the aftermath of an unsuccessful defense. In particular, the accumulated output loss is more than 5 percentage points after 5 years (see table 3.7).

Likewise inflation is characterized by distinct differences between the three types of crises in the post-crisis period. Both immediate depreciations and unsuccessful interventions appear to be associated with higher inflation during the post-crisis period. While immediate depreciations vaguely show a prolonged period of higher inflation rates up to 9 percentage points above trend, unsuccessful defenses seem to be followed by a strong one time inflation peak of about 11 percentage points. Again, no significant effects are found in the case of successful interventions.

Concerning current account effects, we find a particularly strong response in the case of unsuccessful interventions (see figure 3.5). The current account improves persistently and shows the largest effect of about 4 percentage points three years after the crisis, thereby mitigating the decline in output. Immediate depreciations are associated with a small improvement in the current account, whereas no change is apparent in the case of successful interventions.

In the case of private capital inflows, post-crisis the three types of crises are associated with diverging developments. While capital inflows show no significant response

[23] As recommended by Sims and Zha (1999), the interpretation of the impulse response functions presented in this paper is based on error bands with coverage .68 instead of conventional significance levels.

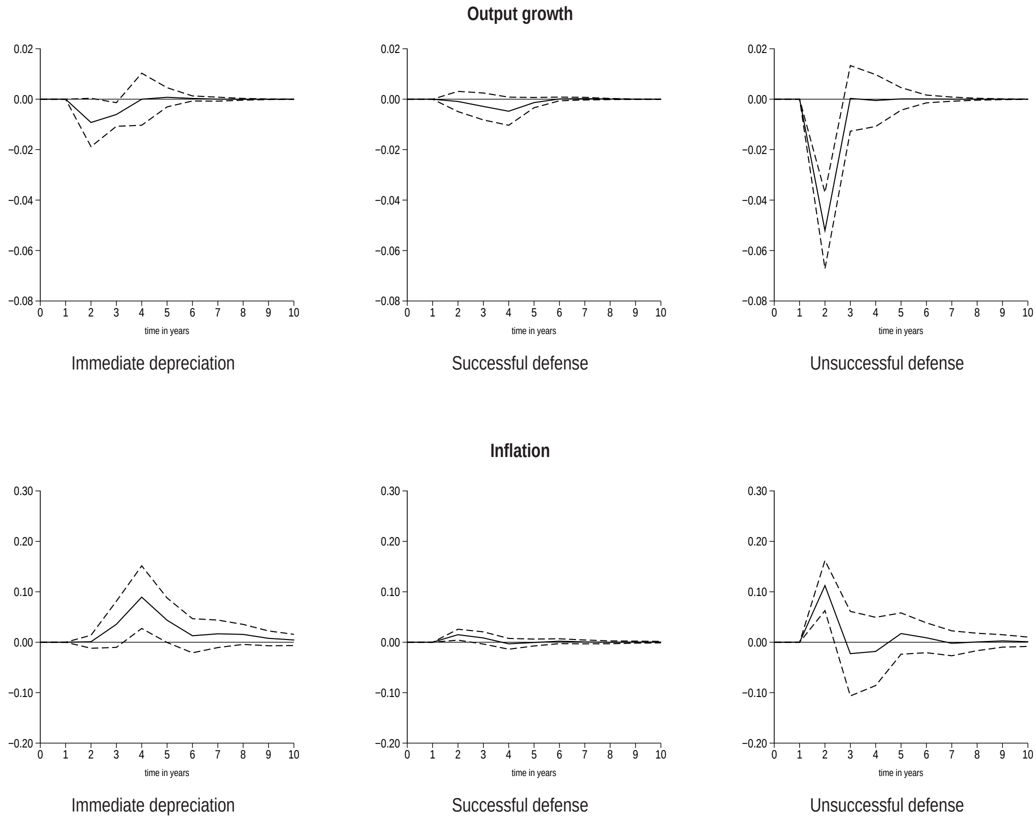

Figure 3.4: Impulse responses of output growth and inflation

in the case of successful interventions, they overshoot in the following period in the case of immediate depreciations. In contrast, they strongly decline in case of unsuccessful interventions and only recover slowly which might be related to increased uncertainty concerning the future economic development, further suggesting a loss of confidence among investors (see, e. g., Radelet and Sachs, 1998).[24]

Taken together the findings from the impulse response functions indicate that depreciation events – immediate depreciation and unsuccessful defense – are associ-

[24]From a first insight, the impulse response functions seem to show a somewhat different behavior compared to the test statistics of table 3.1. However, these differences are not surprising as table 3.1 only reports simple mean values, while the underlying regressions of the impulse response functions also consider important time series effects. The impulse response functions therefore indicate the details of the post-crisis dynamics, which are not captured by the simple comparison of the pre- and post-crisis mean values of table 3.1.

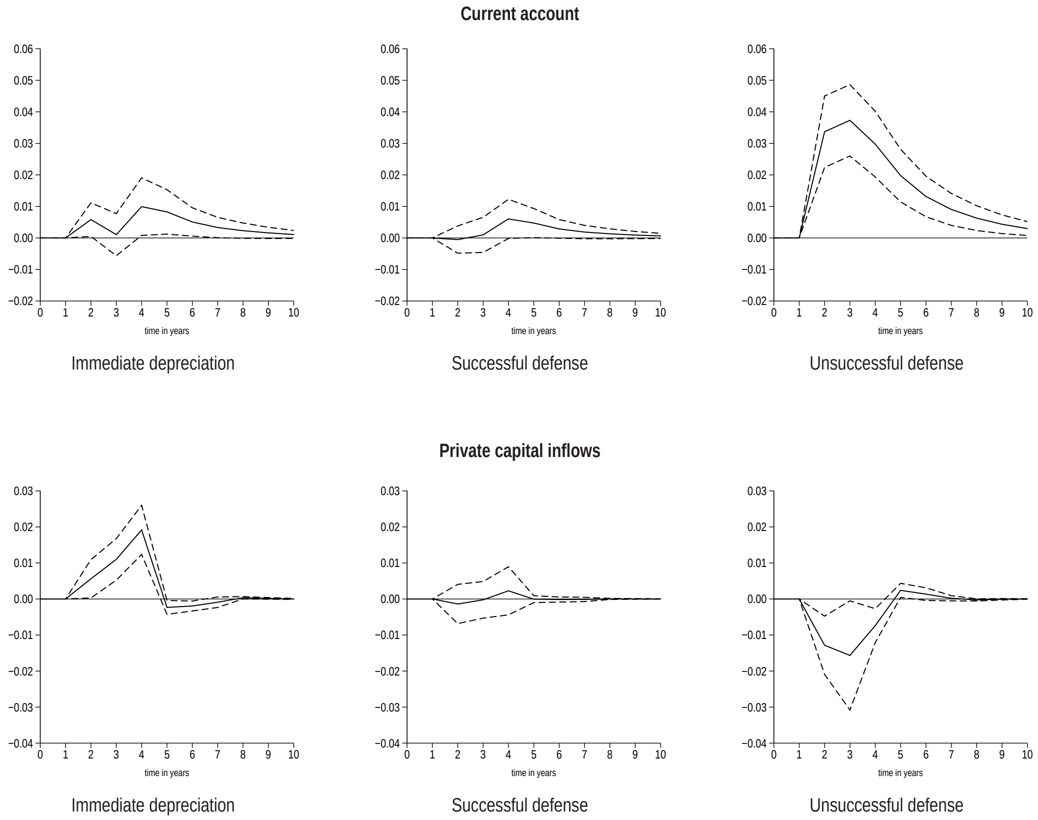

Figure 3.5: Impulse responses of current account and private capital inflows

ated with lower output growth and higher inflation during the post-crisis period.[25] Particularly, in case of an unsuccessful defense the output loss seems to be highly persistent. The empirical results provide further evidence on the risk associated with defending the domestic currency. On the one hand, if the central bank decides to let the currency depreciate without trying to defend it, the country is likely to face a mild recession. On the other hand, if she decides to intervene, she is either successful and avoids negative output effects or she abandons the exchange rate and most likely suffers high economic costs in terms of output loss. Monetary authorities that pursue an apparently consistent policy, i. e. either successfully defending the domestic currency or immediately giving in to a speculative attack, seem to fare best.

[25] Table 3.7 in the appendix provides an additional overview of the results obtained from the impulse response functions presented in this section.

In the inconsistent case of an unsuccessful defense, i. e. defending the exchange rate and later giving in to the speculative attack, negative expectational effects associated with the loss of the nominal exchange rate anchor are likely to lead to high economic cost in terms of output (see also Eichengreen and Rose, 2003). From this perspective, the case of an unsuccessful intervention seems to combine the worst of both worlds, namely the negative expectational and reputational effects due to the depreciation and the temporarily restrictive monetary policy in the futile attempt to defend the domestic currency.

3.4.3 Robustness analysis

Section 3.3 indicates that a central bank's crisis management seems to play a crucial role for the crisis outcome as the different types of currency crises do not depend on the pre-crisis economic development. Since we are interested in the economic impacts of the different types of crises, it is essential to show that there is no or at least weak evidence regarding the pre-crisis fundamentals' performance of the economies with respect to the different types of currency crises. Only if this is the case, the obvious different post-crisis outcomes are likely to be the consequences of the different types of currency crises (see also Eichengreen and Rose, 2003), thus indicating that the crisis management of the monetary authority might play an important role.

In the baseline analysis we have checked the macroeconomic data for pre-crisis differences between the three types. As we did not find significant results we took this finding as a first evidence that the central bank's decision to defend or to not defend might play a crucial role. To address this issue more deeply we additionally analyze to what extent the decision to intervene or to abstain from intervention is based on a cost-benefit analysis as proposed by second generation currency crisis models (see, e. g. Jeanne, 2000). To deal with this potential endogeneity, we compare pre-crisis forecasts of expected post-crisis economic developments between the three different types of crises.[26] Table 3.15 reports the on average expected post-crisis development with respect to the three types of crises. The results indicate that the forecasts concerning the post-crisis macroeconomic development do not differ significantly, pointing out the absence of reversed causality.

Moreover, we control for differences regarding the banking/financial sector stability. We test if a specific crisis type is vulnerable to instabilities in the banking/financial sector during the pre-crisis period and thus also to currency crises. Likewise, we examine whether there are pre-crisis differences concerning the external debt status, which could lead to a relevant currency mismatch. Table 3.16 indicates that there are no significant differences concerning the financial sector stability, however. The results therefore again point to the importance of the central bank behavior during currency crises.

In order to further discuss the endogeneity issue, we perform additional panel logit regressions to examine whether there are feedback effects from the pre-crisis and expected economic development with respect to the three different types of crises. Specifically, we test whether output growth, inflation, private capital inflows or current account imbalances increase the probability of (i) an immediate depreciation, (ii) a successful defense, (iii) an unsuccessful defense or (iv) a currency crisis in general. Nevertheless, to avoid ambiguities, the aim of our paper is not to explain the occurrence of a specific crisis type with respect to the underlying economic development. In particular, this research question is accounted for by the literature of early warning indicators. Notwithstanding, the vast empirical literature on early warning systems illustrates time and again, that macroeconomic variables are notoriously inapt and unreliable in predicting speculative attacks. Recent studies in general use a wide variety of economic variables. However, it is hard to find reliable

[26] As we are not aware of published forecasts, we approximate these values by means of autoregressive processes. On the basis of these estimated autoregressive models we then forecast the expected post-crisis development for each crisis event.

indicators. The prediction power still seems to be very poor, even "in sample" (see, e. g., Rose and Spiegel, 2011). Though, Bussière and Fratzscher (2006), for instance, show that the performance of early warning systems can be increased by the use of more complex empirical methods. However, those indicators are still accompanied by a rate of false alarms of more than 50 %, pointing out that the results of early warning systems/indicators do not seem to be that clear as they appear from a first insight. Furthermore, even theory – in particular the second generation of currency crisis models – proposes the existence of a large gray zone with respect to macroeconomic fundamentals. The environment of those fundamentals might be associated with the absence as well as the occurrence of a currency crisis at the same time (see, e. g., Jeanne, 2000). Taking all this into consideration, the empirical results and the theory could also be interpreted as evidence for the important role central banks play during speculative attacks.

In general, the empirical evidence of the panel logit regressions indicates that the pre-crisis macroeconomic performance does not increase the crisis probability (see table 3.12), since the lagged parameters of the different indicators in each regression are jointly insignificant. Only a few individual lags are statistically significant. In case of the aggregated crisis definition, solely the second lag of output growth is significant at the 5 % level. All other individual lags do not have a statistically significant impact on the probability of the occurrence of a crisis. We find a similar pattern for immediate depreciations – only the first lag of current account and the second lag of private capital inflows are significant at the 10 % level. Also, in case of a successful defense the first lag of output growth has a statistically significant impact on the likelihood of a crisis. For unsuccessful interventions we find all lags of inflation and the third lag of the current account balance to be significant. As the central bank's decision might also depend on the expected economic performance we additionally control for current and forecasted economic developments. Since some individual lags or forecast indicators appear to be statistically significant (see table 3.13) the results slightly hint to the the aspect that the different types of crises could be determined simultaneously. However, we do not find clear systematic differences in the occurrence of a crisis event between the three different types. Taken together, the results provide only weak evidence concerning the impact of the past and expected economic development for currency crises in year t.[27] Taking all this into consideration, the panel logit regressions on the one hand and the examination of the macroeconomic pre-crisis environment seem to indicate that the central bank essentially determines the way an economy will take through the crisis. The results again underline the importance of the central bank's crisis management for the crisis outcome.

To check the robustness of the results of section 3.4.1, we perform a number of sensitivity checks. In particular we examine the effects of more restrictive crisis definitions. The identification of crisis events depends crucially on the assumptions regarding significant depreciations, significant interventions and the time windows (see section 3.2). Hence, applying alternative thresholds within our crisis identification approach could even lead to a change in the crisis type that is assigned to a crisis event. We therefore analyze how the results of section 3.4.1 are subject to changes in the crisis identification procedure. Firstly, a depreciation is considered significant only if it is larger than the average of the exchange rate changes during the previous 12 months plus three times the standard deviation of these changes – rather than the two standard deviations assumed in section 3.2. Secondly, an intervention is considered to be significant if the INTX exceeds the average during the previous 12 months plus four standard deviations instead of the three standard deviations used before. Moreover, we change the time horizon for calculating the country and time specific

[27] Nevertheless, one could also expect, for example, banking sector vulnerability and external debt burden to be important factors influencing the crisis probability. When additionally controlling for these factors the results (available upon request) remain qualitatively unchanged.

standard deviations and means. Instead of 12 months we apply a 24 months window. Likewise, we increase the time span that determinates whether an intervention is considered to be either successful or unsuccessful from 12 to 24 months. Additionally, as opposed to the crisis identification approach used in section 3.2 we do not drop crisis events with overlapping time windows. The respective estimation results are shown in tables 3.8 – 3.11.

We find that the results of section 3.4.1 are robust and remain qualitatively unchanged. Given the several definitions the output effects of immediate depreciations are associated with a significant reduction in output growth between –1.1 and –1.6 percentage points.[28] In the case of unsuccessful defenses we again observe the most severe negative growth effects, which range between –2.7 and –5.3 percentage points, while successful defenses in general are not associated with statistically significant output effects.

To sum up, the empirical results of the robustness analysis again stress the risk of exchange rate interventions. A central bank that decides to defend the exchange rate can avoid an economic slowdown if she is successful, while she faces the most severe economic costs in terms of output if she is forced to abandon the exchange rate regime. An immediate depreciation results in an "intermediate" outcome with a small loss in output.

3.5 Conclusion

Contrary to the typical public perception, currency crises can be very heterogeneous events with quite different real effects. The monetary authorities with their decisions to intervene or not to intervene seem to play an important role for the economic costs

[28]Only one definition shows no significant effects for immediate depreciations (see table 3.9).

of such financial crises. In case of a speculative attack, a central bank can in principle either intervene in the foreign exchange market to defend the exchange rate or she can remain passive, i. e. abstain from an intervention. If the central bank decides to intervene she can then either succeed or fail and let the currency depreciate. This gives rise to three distinct crisis events, namely immediate depreciations, successful defenses and unsuccessful defenses.

Our empirical analysis indicates that a successful defense, i. e. the central bank is able to stabilize the exchange rate with her interventions, yields the best result in terms of output growth. In this case the central bank can basically counteract the speculative attack, apparently without facing any economic costs, e. g. a recession due to a restrictive monetary policy. However, there is no free lunch of exchange rate intervention. If the central bank starts to intervene in the currency market she faces the possibility of an unsuccessful defense either because she suspends her intervention voluntarily, e. g. the benefits of a stable exchange rate no longer exceed the costs of stabilizing, or involuntarily, e. g. as the reserves are depleted. Such an unsuccessful defense seems to be associated with the worst possible outcome with an average loss of around 5 per cent of GDP. If the central bank decides not to intervene, i. e. if she lets the domestic currency depreciate right away, she can expect an "intermediate" loss, with the economy passing through a mild recession. The decision to defend therefore is evidently quite risky. Abstaining from an intervention policy could be an interesting alternative for a conservative, risk-aware central bank.

3.6 Appendix

3.6.1 Regression results of the dynamic model

Table 3.3: Output growth effects by different crisis events

Output growth	Coef.	Std. Err.	t	Prob.
Output growth$_{t-1}$	0.352	0.089	3.97	0.000
Output growth$_{t-2}$	−0.117	0.070	−1.68	0.103
Output growth$_{t-3}$	−0.006	0.047	−0.14	0.891
imdep$_{t-1}$	−0.009	0.010	−0.97	0.339
imdep$_{t-2}$	−0.003	0.003	−0.94	0.353
imdep$_{t-3}$	0.001	0.010	0.12	0.908
sudef$_{t-1}$	−0.001	0.004	−0.23	0.819
sudef$_{t-2}$	−0.003	0.005	−0.50	0.619
sudef$_{t-3}$	−0.004	0.005	−0.74	0.464
undef$_{t-1}$	−0.052	0.015	−3.53	0.001
undef$_{t-2}$	0.019	0.011	1.74	0.092
undef$_{t-3}$	−0.007	0.009	−0.77	0.446
Constant	0.063	0.009	6.93	0.000

Notes: imdep = immediate depreciation, sudef = successful defense, undef = unsuccessful defense.

Table 3.4: Inflation effects by different crisis events

Inflation	Coef.	Std. Err.	t	Prob.
Inflation$_{t-1}$	0.567	0.251	2.26	0.031
Inflation$_{t-2}$	−0.209	0.213	−0.98	0.334
Inflation$_{t-3}$	0.204	0.066	3.10	0.004
imdep$_{t-1}$	0.001	0.013	0.07	0.948
imdep$_{t-2}$	0.035	0.045	0.79	0.436
imdep$_{t-3}$	0.069	0.054	1.27	0.213
sudef$_{t-1}$	0.015	0.011	1.39	0.173
sudef$_{t-2}$	0.000	0.009	−0.01	0.992
sudef$_{t-3}$	−0.005	0.007	−0.70	0.486
undef$_{t-1}$	0.112	0.050	2.24	0.033
undef$_{t-2}$	−0.087	0.073	−1.20	0.240
undef$_{t-3}$	0.018	0.036	0.50	0.619
Constant	0.064	0.026	2.46	0.020

Notes: imdep = immediate depreciation, sudef = successful defense, undef = unsuccessful defense.

Table 3.5: Current account effects by different crisis events

Current account	Coef.	Std. Err.	t	Prob.
Current account$_{t-1}$	0.815	0.063	12.91	0.000
Current account$_{t-2}$	−0.173	0.051	−3.39	0.002
Current account$_{t-3}$	0.059	0.063	0.94	0.357
imdep$_{t-1}$	0.006	0.005	1.08	0.287
imdep$_{t-2}$	−0.004	0.005	−0.73	0.471
imdep$_{t-3}$	0.010	0.008	1.31	0.201
sudef$_{t-1}$	−0.001	0.004	−0.12	0.904
sudef$_{t-2}$	0.001	0.004	0.31	0.762
sudef$_{t-3}$	0.005	0.005	1.13	0.267
undef$_{t-1}$	0.034	0.011	2.95	0.006
undef$_{t-2}$	0.010	0.006	1.60	0.119
undef$_{t-3}$	0.005	0.007	0.81	0.427
Constant	−0.001	0.010	−0.09	0.927

Notes: imdep = immediate depreciation, sudef = successful defense, undef = unsuccessful defense.

Table 3.6: Private capital inflow effects by different crisis events

Private capital inflows	Coef.	Std. Err.	t	Prob.
Private capital inflows$_{t-1}$	−0.063	0.081	−0.77	0.448
Private capital inflows$_{t-2}$	−0.073	0.043	−1.68	0.104
Private capital inflows$_{t-3}$	−0.061	0.068	−0.90	0.373
imdep$_{t-1}$	0.006	0.005	1.07	0.293
imdep$_{t-2}$	0.011	0.006	1.98	0.057
imdep$_{t-3}$	0.020	0.007	3.02	0.005
sudef$_{t-1}$	−0.001	0.005	−0.25	0.804
sudef$_{t-2}$	0.000	0.005	−0.06	0.955
sudef$_{t-3}$	0.002	0.007	0.32	0.749
undef$_{t-1}$	−0.013	0.008	−1.60	0.119
undef$_{t-2}$	−0.017	0.015	−1.11	0.277
undef$_{t-3}$	−0.009	0.004	−2.21	0.034
Constant	−0.013	0.003	−4.89	0.000

Notes: imdep = immediate depreciation, sudef = successful defense, undef = unsuccessful defense.

Table 3.7: Behavior of macroeconomic indicators after different crisis events

Year after crisis	1	2	3	4	5
Immediate depreciation					
Output	0.000	−0.009	−0.015	−0.015	−0.014
Inflation	0.000	0.001	0.036	0.088	0.042
Private capital inflows	0.000	0.006	0.011**	0.019***	−0.002
Current account	0.000	0.006	0.001	0.010	0.008
Successful defense					
Output	0.000	−0.001	−0.004	−0.009	−0.010
Inflation	0.000	0.015	0.008	−0.003	−0.001
Private capital inflows	0.000	−0.001	0.000	0.002	0.000
Current account	0.000	−0.001	0.001	0.006	0.005
Unsuccessful defense					
Output	0.000	−0.052***	−0.052**	−0.052*	−0.052*
Inflation	0.000	0.110**	−0.024	−0.019	0.017
Private capital inflows	0.000	−0.013*	−0.016	−0.007	0.002
Current account	0.000	0.033***	0.037***	0.030***	0.020**

Notes: Cumulative effects in percentage points for output. Percentage points for inflation. Percentage points over GDP for private capital inflows and current account. Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

3.6.2 Robustness analysis

Table 3.8: Output growth effects of currency crises by different types of crises

	Pooled (1)	Panel (2)	Panel (3)	Panel (4)
CPI inflation	−0.041***	−0.028*	−0.029**	−0.027*
	(−2.9)	(−1.9)	(−2.0)	(−1.9)
Current account	0.019	0.047	0.029	0.046
	(0.8)	(1.0)	(0.6)	(0.9)
Private capital inflows	−0.103*	0.005	0.004	0.008
	(−1.8)	(0.1)	(0.0)	(0.1)
Δ Real effective exchange rate	0.025*	0.038***	0.037***	0.040***
	(1.9)	(3.2)	(2.9)	(3.2)
Δ M1	0.031**	0.022	0.021	0.021
	(2.1)	(1.5)	(1.4)	(1.5)
Δ Total reserves	0.007**	0.008***	0.007**	0.008***
	(2.3)	(2.9)	(2.5)	(2.9)
Immediate depreciation dummy	−0.016*	−0.014*	−0.014*	−0.014*
	(−2.3)	(−1.9)	(−1.9)	(−1.8)
Successful defense dummy	−0.005	−0.005	−0.004	−0.004
	(−0.8)	(−0.8)	(−0.7)	(−0.7)
Unsuccessful defense dummy	−0.051***	−0.048***	−0.048***	−0.048***
	(−4.0)	(−4.1)	(−4.0)	(−4.0)
(CPI inflation) × (im. dep.)		−0.050*		−0.046
		(−1.7)		(−1.3)
(CPI inflation) × (su. def.)		−0.021		−0.028*
		(−1.5)		(−1.7)
(CPI inflation) × (un. def.)		−0.092***		−0.128***
		(−2.7)		(−2.9)
Exchange rate regime			0.000	0.000
			(0.3)	(0.1)
(Exchange rate regime) × (im. dep.)			−0.001	−0.000
			(−1.4)	(−0.2)
(Exchange rate regime) × (su. def.)			−0.000	0.001
			(−0.2)	(0.9)
(Exchange rate regime) × (un. def.)			−0.002*	0.001
			(−1.6)	(1.4)
R^2 (within)	0.131	0.172	0.156	0.175
Country fixed effects	–	Yes	Yes	Yes
Time fixed effects	–	Yes	Yes	Yes
Obs.	605	605	605	605
Countries	28	28	28	28

Notes: Dependent variable: Output growth in country i in year t. T-values in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.10.
As opposed to the definition used in section 3.2 we applied more restrictive thresholds. A depreciation is significant if it is larger than the average of the exchange rate changes during the previous 12 months plus three times the standard deviation of these changes. An intervention is considered to be significant if the INTX exceeds the average during the previous 12 months plus four standard deviations. Based on this definition, we identify 141 crisis events with 56 immediate depreciations, 60 successful interventions and 25 unsuccessful interventions.

Table 3.9: Output growth effects of currency crises by different types of crises

	Pooled (1)	Panel (2)	Panel (3)	Panel (4)
CPI inflation	−0.036**	−0.014	−0.018	−0.018
	(−2.4)	(−1.0)	(−1.1)	(−1.0)
Current account	0.046*	0.037	0.026	0.035
	(1.7)	(0.7)	(0.5)	(0.7)
Private capital inflows	−0.134**	−0.060	−0.063	−0.061
	(−2.3)	(−0.7)	(−0.8)	(−0.7)
Δ Real effective exchange rate	0.017	0.023*	0.020	0.022*
	(1.2)	(1.7)	(1.4)	(1.6)
Δ M1	0.034**	0.025	0.024	0.026*
	(2.1)	(1.5)	(1.6)	(1.6)
Δ Total reserves	0.009***	0.010***	0.010***	0.010***
	(2.8)	(3.1)	(2.9)	(3.1)
Immediate depreciation dummy	−0.007	−0.006	−0.007	−0.006
	(−0.9)	(−0.8)	(−1.0)	(−0.8)
Successful defense dummy	−0.001	−0.005	−0.005	−0.005
	(0.3)	(−0.3)	(−0.9)	(−0.8)
Unsuccessful defense dummy	−0.053***	−0.047***	−0.048***	−0.048***
	(−5.0)	(−4.4)	(−4.4)	(−4.4)
(CPI inflation) × (im. dep.)		−0.084		−0.169
		(−1.1)		(−1.4)
(CPI inflation) × (su. def.)		−0.002		−0.014
		(−0.2)		(−0.9)
(CPI inflation) × (un. def.)		−0.061***		−0.047**
		(−3.5)		(−2.2)
Exchange rate regime			−0.000	−0.000
			(−0.2)	(−0.2)
(Exchange rate regime) × (im. dep.)			−0.001	0.001
			(−0.8)	(1.3)
(Exchange rate regime) × (su. def.)			0.000	0.001
			(0.5)	(1.0)
(Exchange rate regime) × (un. def.)			−0.002***	−0.001
			(−3.0)	(−1.0)
R^2 (within)	0.151	0.183	0.172	0.188
Country fixed effects	–	Yes	Yes	Yes
Time fixed effects	–	Yes	Yes	Yes
Obs.	559	559	559	559
Countries	28	28	28	28

Notes: Dependent variable: Output growth in country i in year t. T-values in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.10.
As opposed to the definition used in section 3.2 we changed the time horizon for calculating the country and time specific SDs and means. Instead of 12 months we applied 24 months (see point 1 on page 34). Based on this definition, we identify 145 crisis events with 37 immediate depreciations, 71 successful interventions and 37 unsuccessful interventions.

Table 3.10: Output growth effects of currency crises by different types of crises

	Pooled (1)	Panel (2)	Panel (3)	Panel (4)
CPI inflation	−0.042***	−0.026	−0.028*	−0.026
	(−2.8)	(−1.6)	(−1.8)	(−1.6)
Current account	0.030	0.024	0.023	0.026
	(1.1)	(0.4)	(0.4)	(0.5)
Private capital inflows	−0.102*	0.031	0.023	0.030
	(−1.8)	(0.3)	(0.2)	(0.3)
Δ Real effective exchange rate	0.019	0.033***	0.029**	0.030**
	(1.5)	(2.7)	(2.2)	(2.3)
Δ M1	0.036**	0.027*	0.026*	0.027*
	(2.2)	(1.6)	(1.6)	(1.6)
Δ Total reserves	0.009***	0.013***	0.012***	0.013***
	(2.8)	(3.9)	(3.6)	(4.0)
Immediate depreciation dummy	−0.015**	−0.013**	−0.014**	−0.014**
	(−2.4)	(−2.1)	(−2.2)	(−2.2)
Successful defense dummy	0.002	−0.000	−0.002	−0.002
	(0.4)	(−0.1)	(−0.4)	(−0.4)
Unsuccessful defense dummy	−0.040***	−0.038***	−0.040***	−0.039***
	(−4.1)	(−4.3)	(−4.2)	(−4.2)
(CPI inflation) × (im. dep.)		−0.068		−0.067
		(−1.2)		(−1.0)
(CPI inflation) × (su. def.)		0.006		0.002
		(0.4)		(0.1)
(CPI inflation) × (un. def.)		−0.040*		−0.027
		(−2.0)		(−1.5)
Exchange rate regime			−0.000	−0.000
			(−0.4)	(−0.6)
(Exchange rate regime) × (im. dep.)			−0.001	−0.000
			(−1.2)	(−0.3)
(Exchange rate regime) × (su. def.)			0.000	0.000
			(0.0)	(0.1)
(Exchange rate regime) × (un. def.)			−0.002**	−0.001
			(−2.3)	(−1.4)
R^2 (within)	0.137	0.177	0.173	0.183
Country fixed effects	–	Yes	Yes	Yes
Time fixed effects	–	Yes	Yes	Yes
Obs.	578	578	578	578
Countries	28	28	28	28

Notes: Dependent variable: Output growth in country i in year t. T-values in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.10.
As opposed to the definition used in section 3.2 we changed the time horizon that is relevant for determining if an intervention is either successful or unsuccessful (see points 2 – 4 on page 35). Based on this definition, we identify 174 crisis events with 38 immediate depreciations, 82 successful interventions and 54 unsuccessful interventions.

Table 3.11: Output growth effects of currency crises by different types of crises

	Pooled (1)	Panel (2)	Panel (3)	Panel (4)
CPI inflation	−0.034***	−0.021	−0.016	−0.020
	(−2.7)	(−1.6)	(−1.2)	(−1.5)
Current account	0.033	0.026	0.026	0.024
	(1.3)	(0.5)	(0.5)	(0.5)
Private capital inflows	−0.110*	−0.020	−0.020	−0.017
	(−2.0)	(−0.2)	(−0.2)	(−0.2)
Δ Real effective exchange rate	0.020*	0.034***	0.034***	0.033***
	(1.7)	(3.1)	(2.8)	(2.8)
Δ M1	0.031**	0.020	0.020*	0.020
	(2.4)	(1.6)	(1.6)	(1.6)
Δ Total reserves	0.009***	0.010***	0.010***	0.010***
	(2.9)	(3.5)	(3.2)	(3.5)
Immediate depreciation dummy	−0.018***	−0.012**	−0.011**	−0.012**
	(−3.5)	(−2.4)	(−2.3)	(−2.3)
Successful defense dummy	−0.001	−0.002	−0.002	−0.002
	(−0.3)	(−0.5)	(−0.5)	(−0.5)
Unsuccessful defense dummy	−0.036***	−0.027***	−0.037***	−0.037***
	(−4.6)	(−3.3)	(−3.3)	(−3.3)
(CPI inflation) × (im. dep.)		0.011		0.014
		(1.1)		(1.2)
(CPI inflation) × (su. def.)		0.022***		0.019*
		(2.6)		(1.9)
(CPI inflation) × (un. def.)		−0.017		−0.010
		(−1.3)		(−0.6)
Exchange rate regime			−0.000	−0.000
			(−0.5)	(−0.3)
(Exchange rate regime) × (im. dep.)			0.000	−0.000
			(0.4)	(−0.4)
(Exchange rate regime) × (su. def.)			0.001*	0.000
			(1.8)	(0.7)
(Exchange rate regime) × (un. def.)			−0.001	−0.001
			(1.3)	(−0.8)
R^2 (within)	0.132	0.144	0.138	0.146
Country fixed effects	–	Yes	Yes	Yes
Time fixed effects	–	Yes	Yes	Yes
Obs.	670	670	670	670
Countries	28	28	28	28

Notes: Dependent variable: Output growth in country i in year t. T-values in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.10.
As opposed to the crisis identification approach used in section 3.2 we do not drop crisis events with overlapping time windows (see page 35). Based on this procedure, we identify 331 crisis events with 96 immediate depreciations, 161 successful interventions and 74 unsuccessful interventions.

Table 3.12: Exogeneity test – Panel logit regression I

	all crises (1)	immediate depreciation (2)	successful defense (3)	unsuccessful defense (4)
Individual lags				
Output growth				
$t-1$	2.665	−8.058	8.530*	12.316
	(0.9)	(−1.5)	(1.8)	(1.6)
$t-2$	−7.663**	−8.886	−7.384	1.270
	(−2.2)	(−1.3)	(−1.5)	(0.2)
$t-3$	2.285	8.205	2.354	0.814
	(0.8)	(1.1)	(0.6)	(0.1)
All lags are zero (Chi2)	5.095	5.526	4.482	2.697
Prob.	0.165	0.137	0.214	0.441
Inflation				
$t-1$	0.842	−0.307	0.658	2.667*
	(1.4)	(−0.1)	(0.6)	(1.9)
$t-2$	−1.537	−0.159	−2.120	−5.144*
	(−1.6)	(−0.0)	(−1.0)	(−1.9)
$t-3$	0.689	0.432	0.699	1.474*
	(1.5)	(0.2)	(1.0)	(1.7)
All lags are zero (Chi2)	3.364	0.137	1.305	4.671
Prob.	0.339	0.987	0.728	0.198
Current account				
$t-1$	−2.373	−12.087*	2.454	−1.424
	(−0.7)	(−1.8)	(0.5)	(−0.2)
$t-2$	3.819	8.607	2.180	9.569
	(0.9)	(1.0)	(0.4)	(0.9)
$t-3$	0.710	1.691	0.826	−19.425**
	(0.2)	(0.3)	(0.2)	(−2.0)
All lags are zero (Chi2)	1.825	4.125	1.943	4.703
Prob.	0.610	0.248	0.584	0.195
Private capital inflows				
$t-1$	1.394	−0.733	1.911	16.107
	(0.5)	(−0.1)	(0.5)	(1.4)
$t-2$	2.739	21.573*	−0.284	−0.450
	(1.0)	(1.7)	(−0.1)	(−0.0)
$t-3$	−0.370	−5.041	3.749	−6.767
	(−0.1)	(−1.0)	(0.9)	(−0.7)
All lags are zero (Chi2)	1.186	3.632	0.894	2.294
Prob.	0.756	0.304	0.827	0.514
Country & time fixed effects	Yes	Yes	Yes	Yes
Obs.	644	259	425	233
Countries	32	20	30	19

Notes: Dependent variable: Binary variable that takes on the value one if a crisis occurs and zero otherwise. Z-values in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.10.

Table 3.13: Exogeneity test – Panel logit regressions II

	all crises (1)	immediate depreciation (2)	successful defense (3)	unsuccessful defense (4)
Individual lags				
Output growth				
$t+1$ forecast	−62.128*	−31.030	−110.348**	−120.636
	(−1.7)	(−0.4)	(−2.1)	(−1.3)
t	−4.121	−10.632	4.572	−26.287***
	(−1.3)	(−1.4)	(0.8)	(−3.4)
$t-1$	12.880**	−0.950	16.549**	21.489
	(2.3)	(−0.1)	(2.0)	(1.4)
$t-2$	−9.085**	−8.925	−10.110*	−8.397
	(−2.3)	(−1.2)	(−1.9)	(−0.9)
$t-3$	−0.185	4.043	−0.579	−3.122
	(−0.1)	(0.5)	(−0.1)	(−0.3)
Inflation				
$t+1$ forecast	−2.605	−2.041	−3.455	−11.574*
	(−1.1)	(−0.4)	(−1.1)	(−1.8)
t	0.130	−0.383	−6.051	3.259
	(0.3)	(−0.3)	(−1.5)	(1.7)
$t-1$	2.300	1.354	3.272	4.295
	(1.6)	(0.3)	(1.6)	(0.8)
$t-2$	−2.315**	−1.490	−2.195	−6.482
	(−2.0)	(−0.3)	(−1.1)	(−1.4)
$t-3$	0.990*	1.088	1.212	2.613*
	(2.0)	(0.5)	(1.6)	(1.7)
Current account				
$t+1$ forecast	30.796	27.731	34.864	18.173
	(1.6)	(0.7)	(1.2)	(0.3)
t	−8.685**	−16.508*	−6.846	−34.387***
	(−2.4)	(−1.9)	(−1.3)	(−3.6)
$t-1$	−10.278	−22.288	−9.830	13.037
	(−1.1)	(−1.1)	(−0.7)	(0.5)
$t-2$	5.632	15.967	3.712	10.814
	(1.2)	(1.5)	(0.6)	(0.8)
$t-3$	−2.790	−2.630	−1.472	−25.050**
	(−0.7)	(−0.3)	(−0.3)	(−2.2)
Private capital inflows				
$t+1$ forecast	−30.623	15.189	−70.047	−19.370
	(−0.6)	(0.1)	(−0.9)	(−0.2)
t	−9.585**	−16.974**	−9.474	−13.887*
	(−2.6)	(−2.5)	(−1.6)	(−1.8)
$t-1$	−0.199	2.385	−1.490	37.905**
	(−0.1)	(0.3)	(−0.3)	(2.5)
$t-2$	0.746	23.530	−2.952	−16.231
	(0.2)	(1.5)	(−0.6)	(−1.6)
$t-3$	0.973	−5.939	3.731	−9.420
	(0.3)	(−0.9)	(0.8)	(−0.7)
Country fixed effects	Yes	Yes	Yes	Yes
Obs.	614	239	403	222
Countries	32	19	30	19

Notes: Dependent variable: Binary variable that takes on the value one if a crisis occurs and zero otherwise. Z-values in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.10.

Table 3.14: Mean values of macroeconomic indicators by different crisis events

Variable	no crisis (1)	all crises (2)	immediate depreciation (3)	successful defense (4)	unsuccessful defense (5)
pre-crisis					
Output growth	0.013	0.005	0.000	0.004	0.011
Inflation	−0.067	−0.015	−0.012	−0.015	−0.020
Current account	−0.009	0.000	−0.006	0.009	−0.016
Private capital inflows	0.005	0.002	0.003	0.002	0.002
Δ Real effective exchange rate	0.004	0.010	0.011	0.002	0.026
Δ Nominal exchange rate	−0.077	−0.029	0.004	−0.039	−0.043
Δ M1	−0.026	0.006	0.001	0.006	0.009
Δ Total reserves	0.034	0.026	0.005	0.037	0.024
Exchange rate regime	−1.5	−0.3	0.3	−0.8	0.2
post-crisis					
Output growth	0.013	−0.005	−0.009	0.009	−0.037
Inflation	−0.067	−0.003	−0.012	−0.031	0.075
Current account	−0.009	−0.003	−0.016	0.001	0.004
Private capital inflows	0.005	−0.003	−0.001	−0.003	−0.004
Δ Real effective exchange rate	0.004	−0.012	−0.012	0.010	−0.061
Δ Nominal exchange rate	−0.077	0.034	0.036	−0.054	0.244
Δ M1	−0.026	−0.007	−0.031	−0.036	0.091
Δ Total reserves	0.034	−0.030	0.027	−0.030	−0.091
Exchange rate regime	−1.5	0.3	0.423	−0.691	2.343

Notes: A nominal depreciation is defined as an increase in the nominal exchange rate. A real depreciation is given by a decrease in the real effective exchange rate. The Exchange rate regime classification is based on Ilzetzki et al. (2008) and ranges from 1 to 15 – from de facto pegged to de facto floating. Shaded areas denote statistically significant differences at the 5 % level of one type of crisis compared to the two other types of crises within the respective group.

Table 3.15: Post-crisis forecasts of macroeconomic indicators by different crisis events

Variable	all crises (1)	immediate depreciation (2)	successful defense (3)	unsuccessful defense (4)
post-crisis forecasts				
Output growth	0.043	0.040	0.047	0.038
Inflation	0.144	0.178	0.106	0.197
Current account	0.003	−0.008	0.013	−0.007
Private capital inflows	0.011	0.010	0.011	0.011

Notes: The forecast are obtained from estimating AR(3) processes. The lag length is set to three, as we do not find significant coefficients beyond the third lag for most indicators. Shaded areas denote statistically significant differences at the 5 % level of one type of crisis compared to the two other types of crises within the respective group.

Table 3.16: Mean values of financial stability indicators by different crisis events

Variable	all crises (1)	immediate depreciation (2)	successful defense (3)	unsuccessful defense (4)
pre-crisis development				
Ext. debt (short term) / GDP	0.073	0.071	0.072	0.077
Ext. debt (long term) / GDP	0.325	0.337	0.314	0.333
Ext. debt (total) / GDP	0.411	0.421	0.400	0.423
# of Banking crises	0.193	0.213	0.204	0.146
# of Financial crises	0.832	0.828	0.816	0.867

Notes: Shaded areas denote statistically significant differences at the 5 % level of one type of crisis compared to the two other types of crises within the respective group.

3.6.3 The data

Data sources

Table 3.17: The data

Data	Description	Source
Output growth	Growth of GDP (constant), yoy	WDI
Inflation	Change in consumer price index, yoy	WDI
Current account	Exports minus imports as a share of GDP, ratio	WDI
Private capital inflows	Foreign portfolio investments in the resp. economy as a share of GDP, ratio	IFS
Real effective exchange rate	–	WMM
Nominal exchange rate	Exchange rate LC per EUR or USD	WMM, IFS
Change in M1	Change in money stock, yoy	WMM
Change in total reserves	Change in foreign exchange reserves, yoy	WMM, IFS
Exchange rate regime	Exchange rate arrangements fine classification	IRR
Short term interest rate	–	WMM, IFS
Dates on financial crises	–	RR
External debt	External debt as a share of GDP	WDI

IFS: International Financial Statistics, IMF
IRR: Ilzetzki et al. (2008)
RR: Reinhart and Rogoff (2011)
WDI: World Development Indicators, World Bank
WMM: World Market Monitor, IHS Global Insight

List of countries (and anchor currency)

Argentina (US dollar), Brazil (US dollar), Bulgaria (Euro), Chile (US dollar), China (US dollar), Colombia (US dollar), Czech Republic (Euro), Ecuador (US dollar), Estonia (Euro), Hong Kong (US dollar), Hungary (Euro), India (US dollar), Indonesia (US dollar), Korea (US dollar), Latvia (US dollar), Lithuania (US dollar), Malaysia (US dollar), Mexico (US dollar), Pakistan (US dollar), Peru (US dollar), Philippines (US dollar), Poland (US dollar), Russia (US dollar), Singapore (US dollar), Slovak Republic (Euro), Slovenia (Euro), South Africa (US dollar), Sri Lanka (US dollar), Taiwan (US dollar), Thailand (US dollar), Turkey (US dollar), Venezuela (US dollar)

The anchor currency classification refers to the background material of Ilzetzki et al. (2008) which is available online at http://www.carmenreinhart.com/research/publications-by-topic/exchange-rates-and-dollarization.

Chapter 4

Defending against speculative attacks – It is risky, but it can pay off

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4.1 Introduction

Currency crises are considered to be painful events as they are often associated with poor economic developments, i. e. negative real growth, high inflation as well as severe trade and budget deficits. However, a closer look reveals that economic developments after currency crises differ considerably. Korea, for example, was subject to five currency crises between 1990 and 2006, which had quite different real effects (see figure 4.1).[1] While output growth remained relatively stable during the post-crisis periods of 1991 and 1995, it declined severely after the crisis of 1997/98. In the aftermath of the crisis in 2000 output growth decelerated only somewhat, while during the post-crisis period of 2005 output growth even increased.

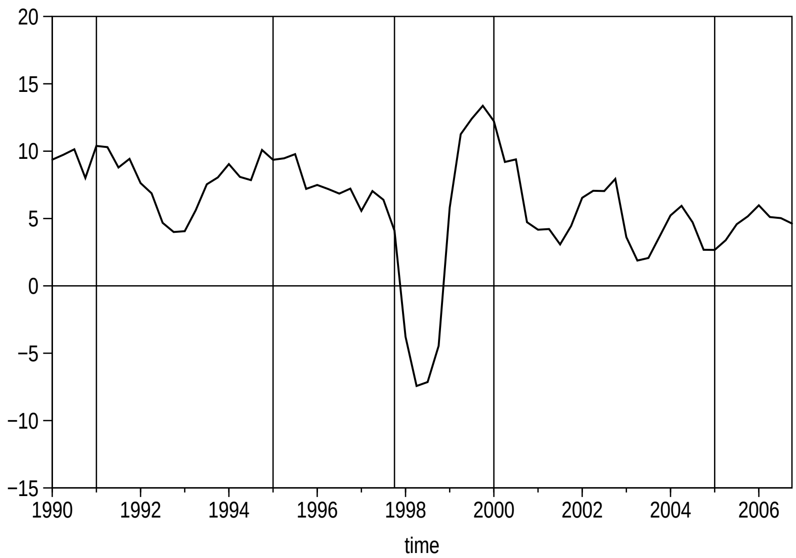

Figure 4.1: Korea: Real GDP and currency crises (1990 – 2006)

In analyzing why the economic costs of currency crises vary so greatly, neither theoretical nor empirical studies have paid much attention to central banks' inter-

[1]For details concerning the identification of crisis events, see section 4.5.1.

		Defensive action	
		No	Yes
Depreciation	No	no crisis	successful defense
	Yes	immediate depreciation	unsuccessful defense/ delayed depreciation

Figure 4.2: Crisis definitions

vention policies.[2] In case of a speculative attack the central bank can in principle either remain passive or intervene in the foreign exchange market in order to avoid a depreciation. This gives rise to the following four outcomes: three different types of currency crises, namely, (i) immediate depreciation, (ii) successful defense, and (iii) unsuccessful defense (see figure 4.2) and the no attack situation.[3] In this context an unsuccessful defense might also be characterized as a delayed depreciation. Once a central bank has started to intervene in the foreign exchange market she can end the intervention and let the currency depreciate for basically two reasons: she is no longer either able to intervene, e. g. the reserves are depleted, or she is not willing to further intervene, e. g. the expected benefits of the intervention policy do no longer exceed the expected costs. As we can not differentiate between these two cases we use the terms unsuccessful defense and delayed depreciation interchangeably.

This paper analyzes how central bank intervention policies affect the economic costs of currency crises. Accordingly, we distinguish the various types of currency

[2]Among the few exception are, e. g., Bauer and Herz (2007) and Daniëls et al. (2011), who explicitly model the simultaneous interactions between policy makers and speculative traders.

[3]Since currency crises – as we define them (see 4.5.1) – are not limited to de jure or de facto fixed exchange rate regimes and to simplify terminology, we uniformly apply the term depreciation to depreciation as well as devaluation events.

crises and identify the three cases. We find that intervention policies do make a difference for the economic development after currency crises. The empirical results provide evidence that a central bank has two options to mitigate the costs of speculative attacks, an immediate depreciation and a successful defense. Abstaining from an intervention, i. e. allowing an immediate depreciation, yields an "intermediate" scenario with only a relatively mild recession. If the central bank intervenes and permanently succeeds she can achieve the best economic performance and avoid output losses all together. However, if she is only able to stabilize the exchange rate transitorily and ultimately fails in her intervention policy, she faces the worst of the three scenarios with a particularly bad economic performance.

The paper closest to our empirical analysis of the costs of different types of currency crises is Eichengreen and Rose (2003), who analyze and compare the economic consequences of successful attacks and successful defenses. The authors find that a successful attack is on average followed by a loss of 3 % of GDP in the subsequent year. However, their results are not informative concerning the important decision whether a central bank should intervene or not intervene as they combine an immediate depreciation and an unsuccessful defense to the successful attack scenario. In another interesting study Gupta et al. (2007) analyze the output effects of currency crises in a more general approach. The authors adopt the crisis definitions of other studies, i. e. they only identify those periods as crisis years that were already tagged by a majority of other studies, thereby intermingling different types of crisis definitions. Their empirical results indicate that crises can have very different economic outcomes and are typically more severe in the case of large capital inflows during pre-crisis periods, fewer capital market restrictions, lower trade openness and higher external long-term debt. Again, due to the encompassing crisis definition it remains unclear what role central bank policies could have in explaining the diversity of crisis outcomes. Cerra and Saxena (2008) and Bussière et al. (2010) propose a new way to examine the persistence of output effects in the aftermath of currency crises. Their findings indicate that currency crises are associated with a permanent output loss of 2–6 % of GDP relative to the no-crisis trend. However, as both studies are based on aggregated crisis definitions, namely the so-called Exchange Market Pressure Index (EMPI) in the case of Cerra and Saxena (2008) and a significant depreciation measure in the study of Bussière et al. (2010) they can not differentiate between the three types of crises and the respective role of central banks.

The paper is organized as follows. Section 4.2 presents some stylized facts. The empirical analysis to evaluate the economic consequences of the different types of currency crises which is based on a panel VAR framework is outlined in section 4.3. The main findings are summarized in section 4.4.

4.2 Some stylized facts

To examine the economic consequences of the three types of crises, namely immediate depreciations, successful interventions, and unsuccessful interventions, we characterize these crisis events along two dimensions. On the one hand we use an intervention index (INTX) to capture the central bank's (no)intervention decision. The INTX is defined as the standard deviations weighted sum of interest rate changes and percentage changes in reserves ($\text{INTX} = \Delta i_t/\sigma_{\Delta i_t} - \Delta r_t/\sigma_{\Delta r_t}$). On the other hand we use changes of the exchange rate (Δs_t) to measure the outcome of the central bank's policy.[4]

Our empirical analysis is in principle based on annual data due to data limitations. However, as the data relevant for the timing of currency crises, especially interest rates, exchange rates and reserves, are typically available at higher frequencies, we

[4]To be more precise, we first check the input data for significant interventions and depreciations. In a second step, we examine whether the interventions are followed by deprecations within a 12-month time window or if both are single situations. This allows us to differentiate between the three crisis types. For further details see appendix and Bauer et al. (2012).

determine the crisis events on the basis of monthly data and assign them to the respective years (see, e. g., Bussière et al., 2010). An important issue in identifying crisis events is to appropriately differentiate whether subsequent crises are individual events or part of an ongoing crisis. After determining currency crisis events we apply a one-year window and drop all crises with overlapping time windows, i. e. crises have to be at least two years apart to be considered as distinct currency crises.[5] By doing so we ensure that the effects of a specific crisis type in year T are not biased by other nearby currency crises. If, for instance, a successful defense occurs in year T and an unsuccessful defense in year $T+1$, the post-crisis effects of the successful defense could be influenced by the effects of the unsuccessful defense. Therefore, to avoid possible interferences in such a situation, these two crisis events are dropped from our analysis.

Our sample covers the years from 1960–2011 and incorporates 32 emerging market economies. We identify 163 crisis events with 42 immediate depreciations, 87 successful interventions and 34 unsuccessful interventions.[6] To better understand the role of macroeconomic fundamentals and central bank policies on the course of currency crises we examine several macroeconomic indicators in the pre- and post-crisis periods. We follow the literature and focus in principle on output, consumer prices, current account balances and private capital inflows (see, e. g., Calvo and Reinhart, 2000; Hong and Tornell, 2005; Rancière et al., 2006; Gupta et al., 2007; Lahiri and Végh, 2007; Bussière et al., 2010). In addition, we consider components of aggregate demand to better understand how the different sectors of an economy behave in the wake of the different types of crises. Furthermore, we take into account the development of the unemployment rate, the real effective exchange rate, the nominal exchange rate, money, and reserves.[7]

[5]See Bussière et al. (2010) for a similar approach.

[6]See appendix for an overview concerning the identified currency crises across the different countries.

[7]See appendix for a detailed description of the data.

Output growth plays a crucial role in our analysis, as the costs of currency crises are often defined in terms of output loss. By taking inflation into account we consider on the one hand the economic consequences of high inflationary periods and on the other hand it serves as a policy response indicator (see, e. g. Hong and Tornell, 2005; Bussière et al., 2010).

Changes in the current account balance and foreign private capital inflows might affect real growth, if – for instance – less foreign capital is available. Real growth is likely to slow down (see, for example Calvo and Reinhart, 2000; Gupta et al., 2007), if firms are not able to finance investments due to a lack of financial resources (see, e. g. Hong and Tornell, 2005).

We decompose aggregate demand – private consumption, investment, exports and imports – to consider potential different transmission channels of the three types of crises. For instance, in the wake of an unsuccessful defense the exchange rate volatility rises and thus uncertainty increases. As a result private investments could decrease.

The impact of currency crises on exports and imports can be ambiguous. Exchange rate changes can mitigate the negative effects of a currency crisis, if the depreciation of the nominal exchange rate translates into a real devaluation. This enhances the economy's competitiveness and thus exports might increase (see Gupta et al., 2007).[8] However, currency crises could also be accompanied by negative effects on exports and imports (see, e. g., Ma and Cheng, 2005). In particular, depreciation events which lead to higher exchange rate volatility can increase the exchange rate exposure of trade businesses. Thus, importers and exporters may decide to lower their trade engagement in order to reduce the exchange rate risk.

[8] At the same time the nominal depreciation increases the real value of the country's foreign debt that is not denominated in domestic currency.

Despite the previously described effects, monetary policy could likewise support or restrain economic growth. A tighter monetary policy can increase the chance of a successful defense, yet it can also have a negative impact on growth at least in the short to medium term (see, among others, Chiodo and Owyang, 2002; Lahiri and Végh, 2007).

Moreover we take the country's exchange rate regime into account. For example, in case of a hard peg policy, a depreciation of the exchange rate might imply greater uncertainty in the course of a speculative attack than in the case of a more flexible exchange rate regime and could therefore have a more negative impact on real growth (see, e. g. Eichengreen and Rose, 2003). Finally, foreign exchange reserves are of interest as they are an important indicator of a country's ability to defend the exchange rate. Accordingly, reserve losses are an important dimension of the economic costs of currency crises.

Table 4.1 displays summary statistics with respect to the macroeconomic environment during the pre-crisis period (upper panel) and post-crisis period (lower panel).[9] In addition, it provides results of a non-parametric Wilcoxon test that examines whether macroeconomic fundamentals differ from one type of crisis to the other.[10] If macroeconomic fundamentals do not differ significantly in the pre-crisis period between the different types of crises while differences appear to be significant during the post-crisis period this could be an indication that central bank policy might have an important effect on the economic costs of currency crises. Column 1 of table 4.1 reports the sample mean for the no-crisis periods. Columns 2 – 5 of table 4.1 display the means for the pre-crisis and post-crisis periods, distinguishing between the three

[9]As our crisis definition is based on monthly data and a crisis can last for twelve months, the post-crisis period is defined as the crisis year and the first post-crisis year. The pre-crisis period covers the average development of three pre-crisis years. We also applied different lengths (from 1 to 4 years) of the pre-crisis and crisis period and have found our results to be robust.

[10]We additionally performed a Kolmogorov-Smirnov test which yields identical results.

Table 4.1: Mean values of macroeconomic indicators by different crisis events

Variable	no crisis (1)	all crises (2)	immediate depreciation (3)	successful defense (4)	unsuccessful defense (5)
pre-crisis					
Output growth	0.059	0.046	0.037	0.049	0.050
Inflation	0.059	0.091	0.106	0.072	0.123
Current account	−0.008	0.004	−0.007	0.017	−0.015
Private capital inflows	0.016	0.012	0.013	0.012	0.012
Private consumption growth	0.053	0.047	0.042	0.047	0.056
Investment growth	0.083	0.055	0.046	0.055	0.067
Export growth	0.092	0.075	0.063	0.081	0.077
Import growth	0.095	0.077	0.059	0.077	0.100
Debt-to-GDP ratio	0.442	0.403	0.391	0.391	0.453
Unemployment rate	0.072	0.076	0.094	0.065	0.082
Δ Real effective exchange rate	0.005	0.013	0.021	0.002	0.030
Δ Nominal exchange rate	0.014	0.086	0.124	0.047	0.137
Δ M1	0.159	0.217	0.212	0.199	0.266
Δ Total reserves	0.182	0.162	0.135	0.175	0.164
Exchange rate regime	6.8	8.2	9.5	7.2	9.2
post-crisis					
Output growth	0.059	0.036	0.029	0.054	0.002
Inflation	0.059	0.101	0.111	0.062	0.186
Current account	−0.008	0.002	−0.016	0.010	0.005
Private capital inflows	0.016	0.009	0.009	0.009	0.007
Private consumption growth	0.053	0.038	0.033	0.057	−0.002
Investment growth	0.083	0.029	0.028	0.072	−0.073
Export growth	0.092	0.067	0.049	0.083	0.047
Import growth	0.095	0.051	0.043	0.094	−0.042
Debt-to-GDP ratio	0.442	0.414	0.452	0.381	0.457
Unemployment rate	0.072	0.080	0.100	0.064	0.091
Δ Real effective exchange rate	0.005	−0.008	−0.002	0.011	−0.056
Δ Nominal exchange rate	0.014	0.143	0.167	0.024	0.403
Δ M1	0.159	0.197	0.183	0.149	0.327
Δ Total reserves	0.182	0.099	0.160	0.100	0.032
Exchange rate regime	6.8	8.8	9.6	7.3	11.3

Notes: A nominal depreciation is defined as an increase in the nominal exchange rate. A real depreciation is given by a decrease in the real effective exchange rate. The exchange rate regime classification is based on Ilzetzki et al. (2008) and ranges from 1 to 15 – from de facto pegged to de facto floating. Shaded areas denote statistically significant differences at the 5 % level of one type of crisis compared to the two other types of crises within the respective group.

types of currency crises. Due to the test design we are only able to analyze if one crisis type is statistically significant from the other two types, or if all three types are statistically significant from each other at the same time. A single shaded area therefore denotes a crisis type which is statistically significant different from the other two types at the 5 % level. Three simultaneously shaded areas point to statistically significant differences between the three types at the same time. For example, to examine pre-crisis inflation rates we perform three Wilcoxon tests, namely, (i) immediate depreciation vs. successful defense, (ii) immediate depreciation vs. unsuccessful defense and (iii) successful defense vs. unsuccessful defense. As a result, we obtain 2 out of 3 significant test statistics. The first statistic indicates that successful interventions have significantly lower pre-crisis inflation rates than immediate depreciations. The second statistic shows that successful interventions are associated with significantly lower pre-crisis inflation rates compared to unsuccessful interventions. Given this, the value of pre-crisis inflation rate is shaded gray in case of a successful defense.

Table 4.1 indicates that there is only weak evidence for systematic pre-crisis differences between the three types of crises. With the exception of inflation, import growth and the exchange rate regime, the macroeconomic indicators do not differ significantly between the three types of crises during the pre-crisis period. In the case of inflation we find a significant pre-crisis difference between a successful defense and the other two types of crises, i. e. between on the one hand the case of a stable exchange rate and on the other hand a drop of the exchange rate either due to an immediate depreciation or an unsuccessful defense. The pre-crisis inflation rate of successful interventions is about 7.2 % (column 4) and significantly lower than the pre-crisis inflation rates of immediate depreciations (10.6 %) and unsuccessful interventions (12.3 %). The pre-crisis growth rate of imports is significantly higher for unsuccessful interventions (10.0 %) compared to immediate depreciations (5.9 %) and successful interventions (7.7 %). In the case of the exchange rate regime we also find some evidence for pre-crisis differences.[11] Successful interventions are associated with somewhat less flexible exchange rate regimes (ERA index of 7.2) than immediate depreciations (9.5) and unsuccessful defenses (9.2). Taken together, the summary statistics do not point to major pre-crisis differences in fundamentals between the three types of currency crises.

In contrast, the test statistics indicate that there are considerable differences in post-crisis macroeconomic developments between on the one hand successful defenses and immediate depreciations and on the other hand unsuccessful interventions. For instance, real growth is highest in the case of successful defenses (5.4 %), immediate depreciations seem to be an "intermediate case" (2.9 %) and unsuccessful defenses show the lowest value (0.2 %).

Differences can also be found for inflation, consumption, investment, export and import growth, unemployment rate, and the nominal exchange rate as well as the real effective exchange rate. In the case of inflation, the depreciation events, i. e. immediate depreciations and unsuccessful interventions, are associated with significantly higher inflation than successful defenses. The increase in inflation is especially strong in case of unsuccessful interventions.

Consumption and investment both show the highest growth rates for successful interventions (5.7 % and 7.2 %). Immediate depreciations are associated with an intermediate development with a growth of consumption and investment of about 3 %, while they severely decline in the wake of an unsuccessful defense (−0.2 % and −7.3 %). In the case of exports we find significantly higher growth rates for successful interventions (8.3 %) than for immediate depreciations (4.9 %) and unsuccessful interventions (4.7 %). Concerning imports, the growth rate is again the highest for successful interventions (9.4 %), while immediate depreciations show an intermediate

[11] We use the ERA fine classification, ranging from 1 to 15 – from de facto pegged to de facto floating (see Ilzetzki et al., 2008).

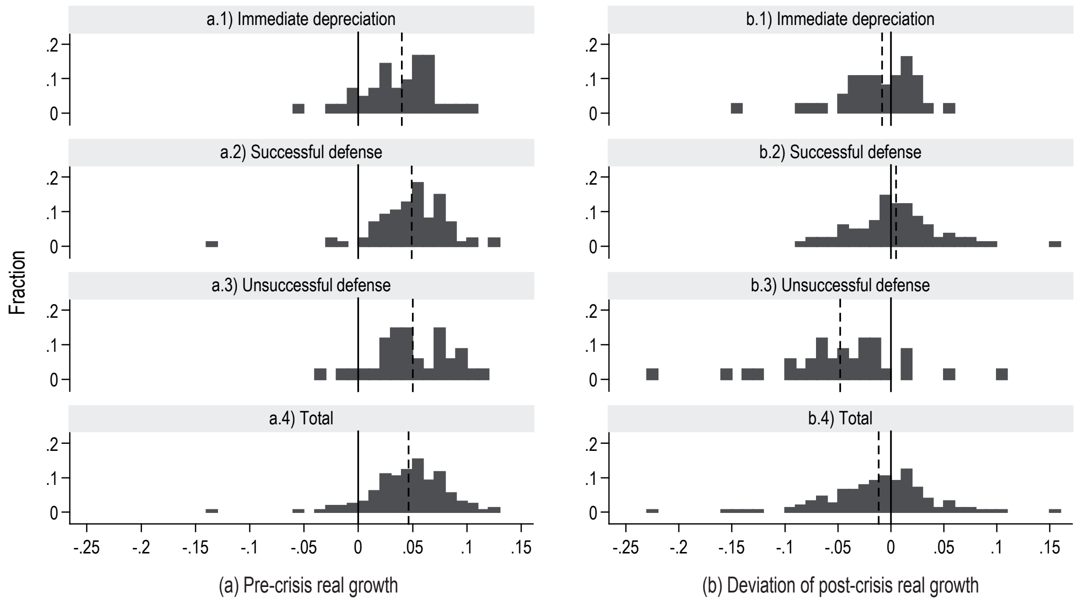

Figure 4.3: Currency crises and real growth (dashed lines indicate the respective crisis mean)

development with a post-crisis growth rate of 4.3 %. On the contrary, unsuccessful defenses are accompanied by a fall in imports of about −4.2 %. The unemployment rate is on average the lowest in the case of a successful defense of the exchange rate (6.4 %).

To gain further insights in the differences between the various types of crises, figure 4.3 provides further information on the costs of currency crises, namely on changes in output growth. The left panel exhibits the distribution of pre-crisis values while the right panel displays the distribution of the post vs. pre-crisis differences.[12] The left panel of figure 4.3 supplements the summary statistics of table 4.1. In particular the distribution of real growth rates is not significantly different between the three types of crises. However, when comparing post-crisis output performance (right panel of figure 4.3), significant differences become apparent.

[12]Regarding the definition of the pre-crisis and post-crisis period see footnote 9.

In case of an immediate depreciation and a successful defense only minor deviations of growth can be seen. On average output growth deviates from pre-crisis trend by −0.8 percentage points for immediate depreciations and by +0.5 percentage points for successful defenses (see histogram 4.3b.1 and 4.3b.2). The deviations from pre-crisis growth in the case of unsuccessful interventions are on average −4.8 percentage points and particularly widespread as well as strongly skewed towards negative deviations (see histogram 4.3b.3). Most of the crises – approximately 85 % – are contractionary.

To summarize, we only find few differences between macroeconomic fundamentals in the pre-crisis period with respect to the three types of crises while in the post-crisis period considerable differences are apparent. We take this finding as a first indication that crisis management – in particular the decision of the central bank to defend or to not defend – might be crucial for the economic development after a speculative attack.[13] Successful attempts to defend the exchange rate are associated with the best result in terms of output growth, while failed interventions are followed by the highest economic costs in terms of output losses. Immediate depreciations, i. e. abstaining from an intervention, are associated with an "intermediate" development.

4.3 Empirical analysis

The empirical analysis is based on two complementary approaches. Firstly, we examine the impact of the three types of currency crises on real growth, inflation, current account and private capital inflows in a panel VAR framework to explicitly take into account the interdependencies between these macroeconomic fundamentals. Secondly, a univariate panel autoregressive approach complements the panel VAR

[13] It is also worth mentioning that the pre-crisis differences almost disappear while the post-crisis differences are still observable and statistically significant when removing country and time specific effects. This further indicates that the central bank's crisis management could be an important determinant of the economic costs of currency crises.

analysis in order to evaluate the dynamic responses of various macroeconomic variables – in particular we take a deeper look at the components of aggregate demand.

4.3.1 A panel VAR approach

Our benchmark panel VAR model is given by:

$$X_{it} = \Gamma(L)X_{it} + \mathrm{F}(L)K_{it} + \omega_i + d_t + \epsilon_{it}, \tag{4.1}$$

where X_{it} is a vector of stationary[14] variables, namely real growth, inflation, current account, and private capital inflows. Generally, the criteria influencing the consequences of currency crises are overall economic stability, defensive power in economic terms and financial means for the defense. We thus choose four variables measuring these characteristics. Real growth serves as an indicator for economic stability and defensive power. Low inflation implies stable monetary policy in the past and thus a stable monetary system. Positive current account and high private capital inflows indicate both soundness of the economy and financial means to defend the currency. Size itself is an ambiguous variable as larger countries on the one hand have a higher defensive power but on the other hand also might attract a larger number of speculators. We thus omit a size variable like GDP and use current account and private capital inflows as ratios to GDP.

K_{it} is a vector of predetermined dummies describing the respective crisis type; $\Gamma(L)$ and $\mathrm{F}(L)$ are matrix polynomials in the lag operator with $\Gamma(L) = \Gamma_1 L^1 + \Gamma_2 L^2 + \ldots + \Gamma_q L^q$ and $\mathrm{F}(L) = \mathrm{F}_1 L^1 + \mathrm{F}_2 L^2 + \ldots + \mathrm{F}_q L^q$, and ϵ_{it} is a vector of

[14]We checked the stationarity of variables using several panel unit root tests. Precisely we implemented standard panel unit root test, namely the augmented Dickey and Fuller test (1979) (ADF), the Phillips and Perron test (1988) (PP), the Levin, Lin and Chu test (2002) (LLC) as well as the Im, Pesaran and Shin test (2003) (IPS). Additionally, to take potential dependencies between the panel individuals into account we implemented the test suggested by Pesaran (2007) (PESCADF). As in every case the null hypothesis of non-stationarity can be rejected, all test statistics indicate stationarity of variables (see table 4.3).

idiosyncratic errors. We additionally control for time-constant but cross-sectional varying effects (ω_i) as well as time-varying but cross-section constant factors (d_t).[15] In our estimations we restrict the number of endogenous variables to four in order to prevent over-parameterization. Based on the Lagrangian Multiplier (LM) test for autocorrelation in the residuals, we set the lag length to three.

Since we allow for individual heterogeneity, least squares estimation of equation (4.1) would yield biased coefficients. Therefore, we apply the panel VAR technique suggested by Love and Zicchino (2006). In order to remove the country fixed effects we use forward mean-differencing (Helmert's transformation).[16] This procedure transforms all variables in deviations from forward means.[17] Moreover, it has the advantage of preserving the orthogonality between the transformed variables and the lagged regressors (see Arellano and Bover, 1995, p. 41). Thus, we are able to use the lagged regressors as instruments and to estimate the coefficients by system GMM.

To identify the currency crises shocks and to simulate the corresponding impulse response functions we assume that currency crisis shocks affect real growth, inflation, current account and private capital inflows only with a lag.[18] Moreover, ensuring that the respective crisis types have only lagged effects provides a natural way to avoid potential endogeneity problems. The alternative approach, namely to derive

[15]Since we include individual specific and time specific effects, we implicitly allow for shifts in the individual specific intercepts as well as in the time intercepts (see Baltagi, 2006, p. 177). Additionally, we have tested whether the economic impact of the three types of crises differ between "old type" and "modern type" currency crises. In particular, we have checked if the economic crisis effects as estimated in our VAR approach differ for the periods prior and after 1990 (and 1995, respectively). However, the empirical evidence (available upon request) does not indicate any structural break.

[16]Our model also allows for time specific effects. We remove these effects by subtracting the means of each variable for each period. As the employed empirical framework assumes cross sectional independence, the removing of those time effects is a simple way to mitigate potential dependencies due to common factors (see Levin et al., 2002, p. 13).

[17]Formally, the transformation is given by: $x_{it}^h = \delta_t[x_{it} - 1/(T-t)(x_{i(t+1)} + \ldots + x_{iT})]$ with $t = 1, \ldots, T-1$, and where $\delta_t = \sqrt{(T-t)(T-t+1)}$ (see, e. g., Arellano and Bover, 1995, p. 41).

[18]Furthermore, we assume that there are no effects from the macroeconomic variables to the crisis dummies. This assumption is supported by several robustness checks. They indicate that – in general – the macroeconomic performance does not increase the crisis probability (see tables 4.12 and 4.13).

restrictions on parameters and temporal correlations among the three types from a theoretical model, does not seem to be feasible as we are not aware of an adequate theoretical model concerning the interdependencies between the different types of crises.

Based on the estimated crisis coefficients of the panel VAR model given in (4.1) we simulate impulse responses of real growth, inflation, current account and private capital inflows to different shocks, namely the three types of currency crises (see figures 4.4 and 4.5 and table 4.5).[19]

As most parameters appear to be statistically significant for unsuccessful interventions, the results point to noticeable macroeconomic consequences only in case of an unsuccessful defense. In contrast, the economic development in the aftermath of immediate depreciations and successful interventions does not seem to be accompanied by severe real effects.

Regarding output, the simulation results indicate that the three types of currency crises give rise to two distinct patterns (see upper part of figure 4.4). On the one hand, the impulse response function for an unsuccessful defense shows a clear V-shaped drop (-5.1 percentage points) and recovery of real growth, implying a highly persistent impact on the output level in the aftermath of the crisis. On the other hand, successful interventions and immediate depreciations are not followed by distinct changes in output. In the case of an immediate depreciation the change in the real growth is insignificant, while the successful defense even is associated with positive, partly significant output effects.

Inflation is again characterized by different responses to the three types of crises (see lower panel of figure 4.4). Both immediate depreciations and unsuccessful inter-

[19] As recommended by Sims and Zha (1999), the interpretation of the impulse response functions presented in this paper is based on error bands with coverage .68 instead of conventional significance levels.

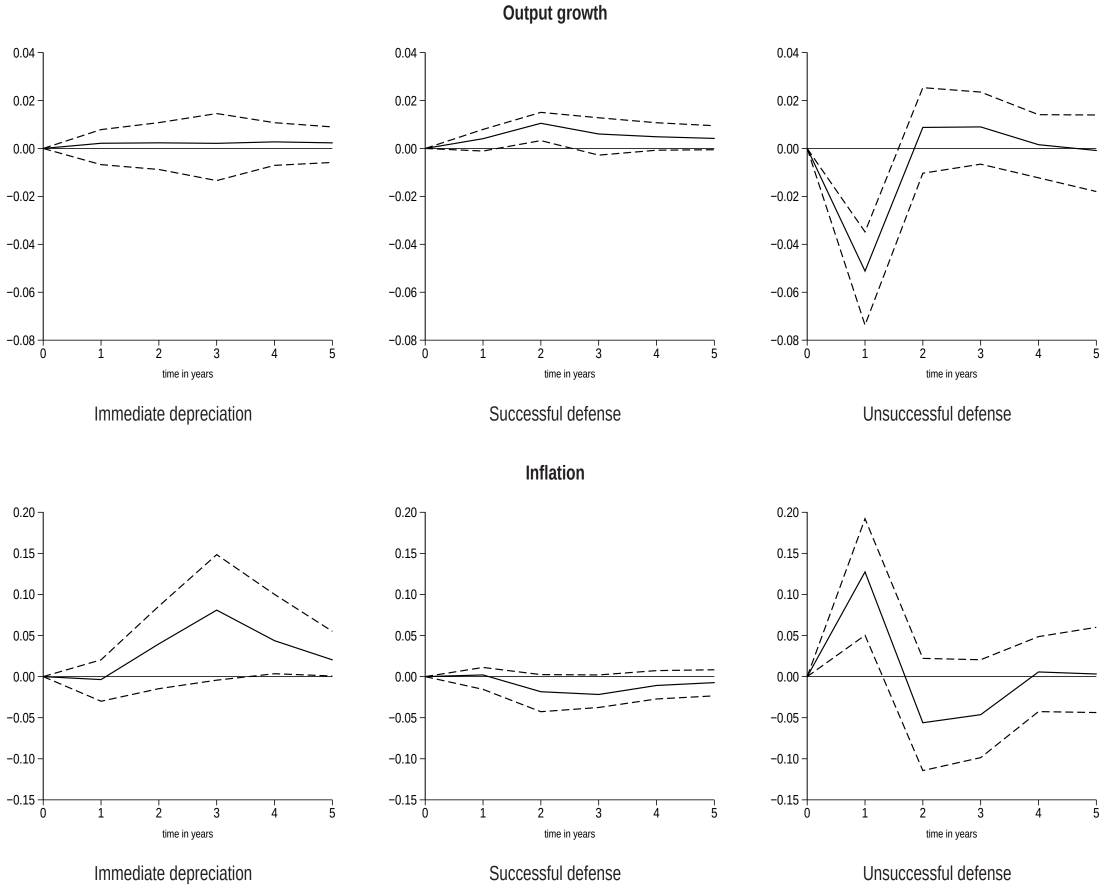

Figure 4.4: Impulse responses of output growth and inflation to currency crises

ventions appear to be associated with higher inflation during the post-crisis period. While immediate depreciations show a prolonged period of higher inflation rates of up to 8 percentage points above trend, unsuccessful defenses are followed by a strong one time inflation peak of about 13 percentage points. No significant effects are found in the case of successful interventions.

Regarding current account effects, we find a particularly strong response in the case of unsuccessful interventions (see upper part of figure 4.5). The current account improves persistently and shows the largest effect of about 4 percentage points one year after the crisis, thereby mitigating the decline in output. No changes are apparent for successful interventions and immediate depreciations.

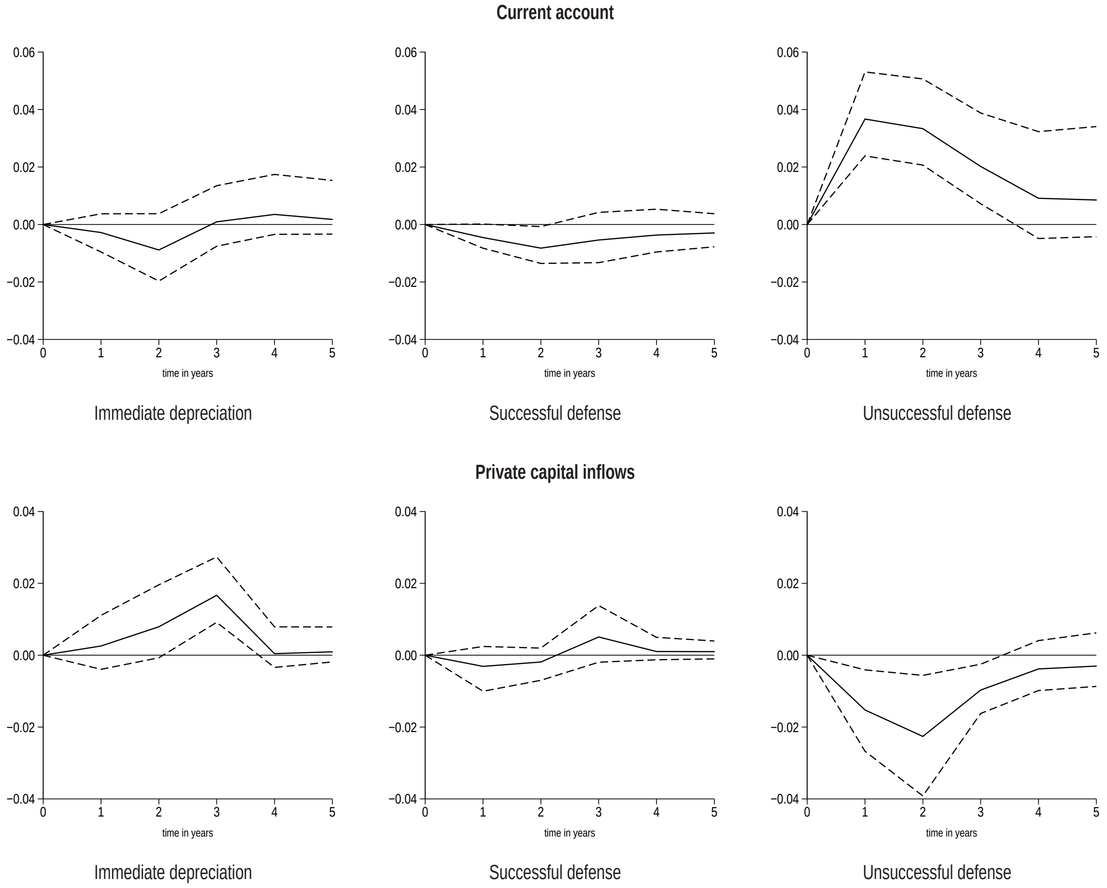

Figure 4.5: Impulse responses of current account and private capital inflows to currency crises

In the case of private capital inflows, the three types of crises again are associated with diverging developments. While capital inflows show no significant response in the case of successful interventions, they show a light positive evolution for the immediate depreciation scenario. In contrast, they strongly decline in case of unsuccessful interventions and only recover slowly – which might be related to increased uncertainty concerning the future economic development – suggesting a loss of confidence among investors (see, e. g., Radelet and Sachs, 1998).

The impulse response functions reflect the quite different policy approaches taken by central banks in the face of a speculative attack. In the case of successful defenses the central bank follows a policy that is consistent with a stable exchange rate and is thereby able to basically neutralizing the effect of the speculative attack. In the case of an immediate depreciation the central bank voluntarily abandons the exchange rate regime without intervening. Additionally, she tends to implement an expansionary monetary policy which can be inferred from the higher (tolerated) inflation rates, possibly to support real growth. This strategy may be considered as a distinct alternative monetary policy compared to defending the domestic currency. In contrast, the impulse response functions show a somewhat inconsistent monetary policy in case of an unsuccessful defense (delayed depreciation). Specifically, the intervention policies are not expansionary enough to prevent a recession and not restrictive enough to stabilize the exchange rate and/or to prevent inflation. Among speculators this inconsistency could raise expectations about future inflation as well as a potential depreciation. As a consequence, the intervention measures to defend the exchange rate turn out to be ineffective (see also Hong and Tornell, 2005, p. 77).

Taken together, the findings from the impulse response functions indicate that central banks can heavily influence the economic costs of currency crises. They have in principle two options to notably reduce the costs of currency crises, either successfully defending the exchange rate or to refrain from interventions. The decision to defend the exchange rate is risky. If the central bank intervenes she can either succeed and achieve the best result in terms of overall economic performance, or she can fail and face the worst case scenario. Abstaining from an intervention, i. e. allowing an immediate depreciation, typically results in an "intermediate" economic post-crisis development.

4.3.2 Macroeconomic dynamics of currency crises

In a next step we complement the panel VAR with a univariate panel autoregressive approach to gain further insights in the adjustment processes associated with the three types of currency crises and the potential role of central banks in mitigating the costs of currency crises. In estimating the univariate panel autoregressive model we follow Cerra and Saxena (2008), Bussière et al. (2010) and Kappler et al. (2011), and simulate impulse responses of several macroeconomic variables – in particular various components of aggregate demand – for the three different types of currency crises.

Our benchmark model is given by:

$$x_{it} = \alpha_i + \omega_t + \sum_{j=1}^{3} \beta_j x_{it-j} + \sum_{k=1}^{3} \sum_{s=1}^{3} \alpha_{ks} D_{kit-s} + \epsilon_{it},$$

where x_{it} denotes the macroeconomic variable of interest in country i in year t. The dummy variable D_{kit-s} takes on the value one if a k type currency crisis occurs in country i in year $t-s$. We additionally control for time (ω_t) and country specific effects (α_i). The i. i. d. error term is denoted by ϵ_{it}. We estimate an autoregressive model in x of order three, as we do not find any significant coefficients beyond the third lag for most indicators. Moreover, we use a common lag length for all model specifications in order to ensure a consistent basis for comparison of impulse response functions of the different macroeconomic indicators (see Kappler et al., 2011, pp. 13). Furthermore, heteroscedasticity consistent standard errors are computed. To avoid potential endogeneity problems we only allow for lagged effects of currency crises. To examine the crisis dynamics, namely the deviation from the no-crisis trend behavior, we again simulate impulse response functions to shocks of the different types of crises.

To relate the empirical results of the univariate panel autoregressive models with the panel VAR approach of the previous section 4.3.1, we start with estimating univariate panel autoregressive models for output growth, inflation, capital account and private capital inflows. Figure 4.6 reports the simulated impulse response functions which are very similar to the results from the panel VAR approach. We take these similarities as an indication that univariate panel autoregressive models are quite

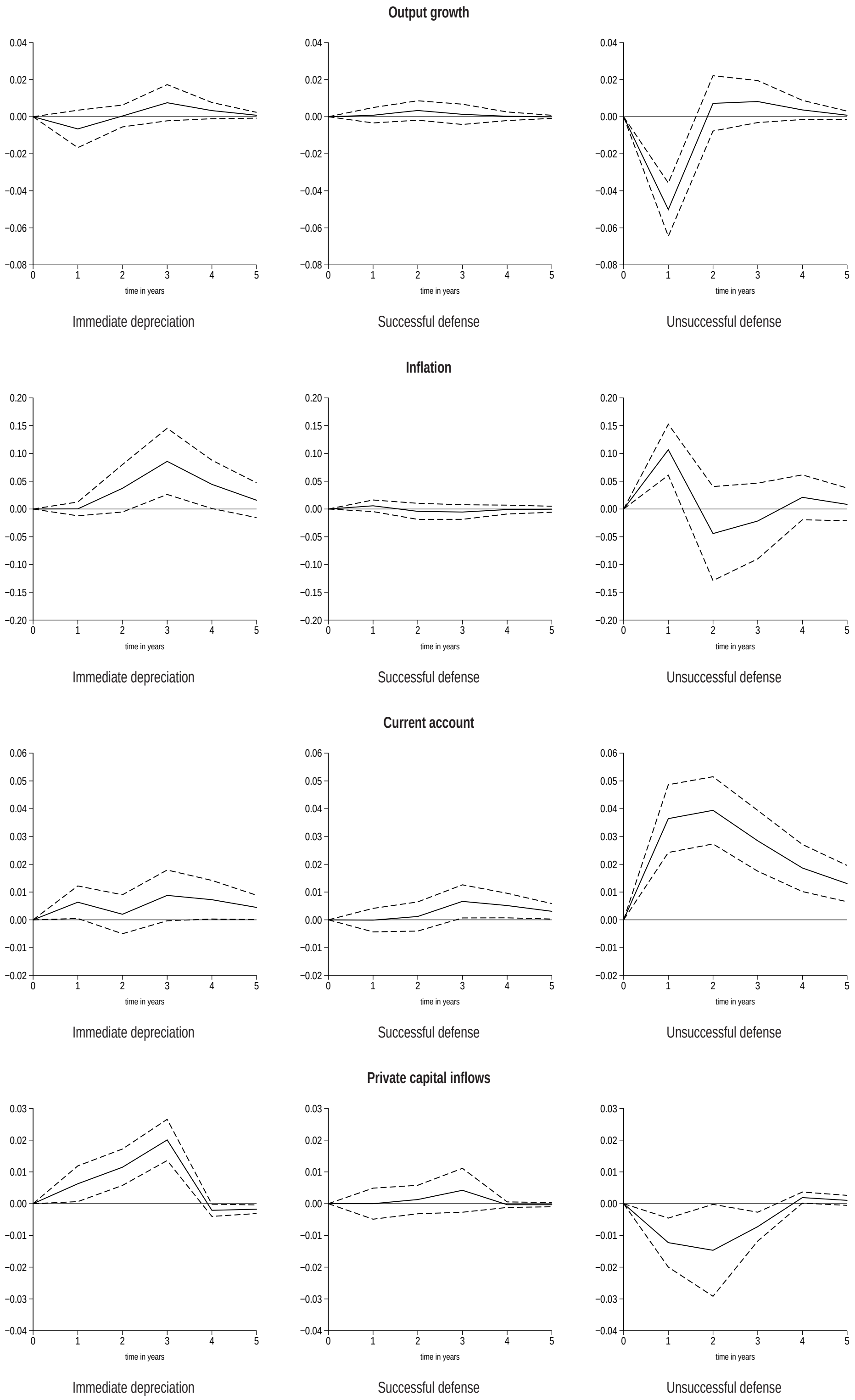

Figure 4.6: Impulse responses of output growth, inflation, current account, and private capital inflows to currency crises

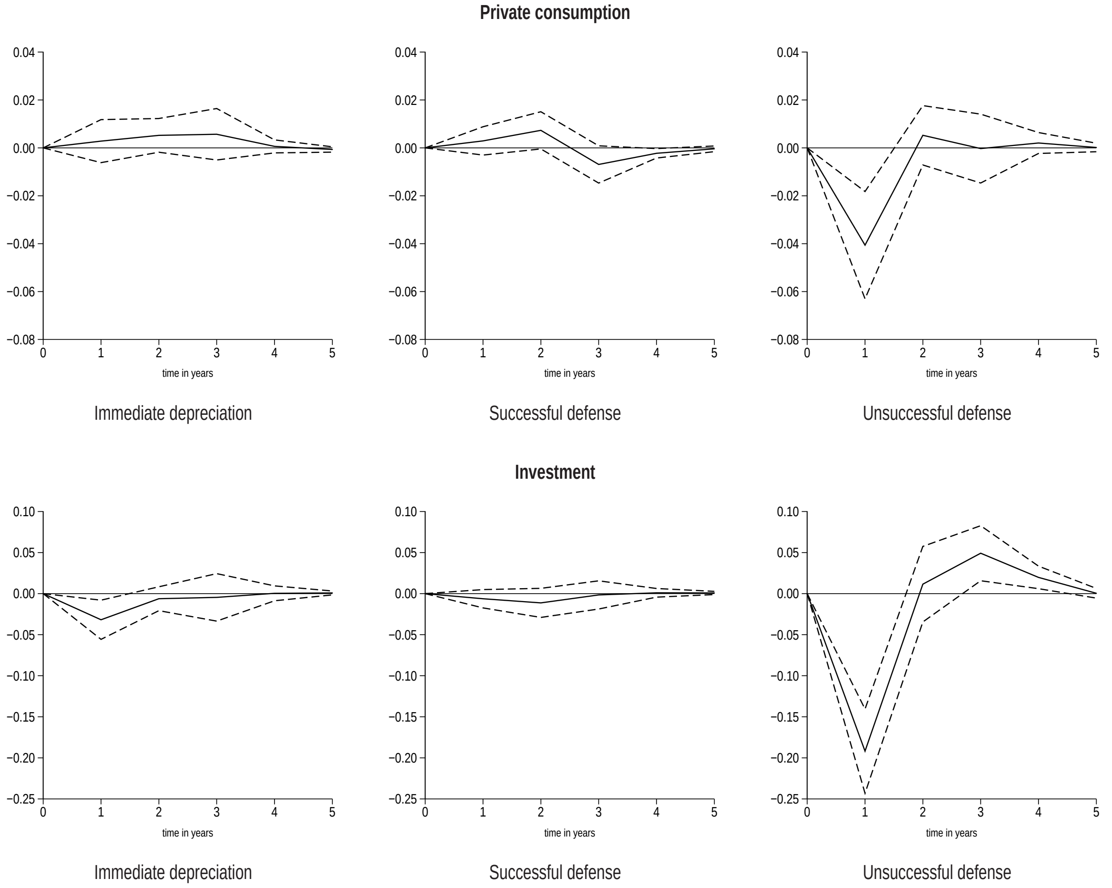

Figure 4.7: Impulse responses of private consumption and investment to currency crises

informative on the macroeconomic dynamics of currency crises and focus in the following on a number of other important macroeconomic variables, such as private consumption, investment, exports, imports, debt-to-GDP ratio, and unemployment rate.

Figure 4.7 shows that the consumption and investment effects of currency crises clearly differ between the three types and reflect the respective output effects (see figure 4.6). In particular, in case of unsuccessful interventions both consumption and investment growth fall, possibly due to increased uncertainty among households and investors. For immediate depreciations and successful interventions the consumption impulse response functions do not show any significant changes. Concerning investment growth, immediate depreciations seem to be associated with a weak decline in

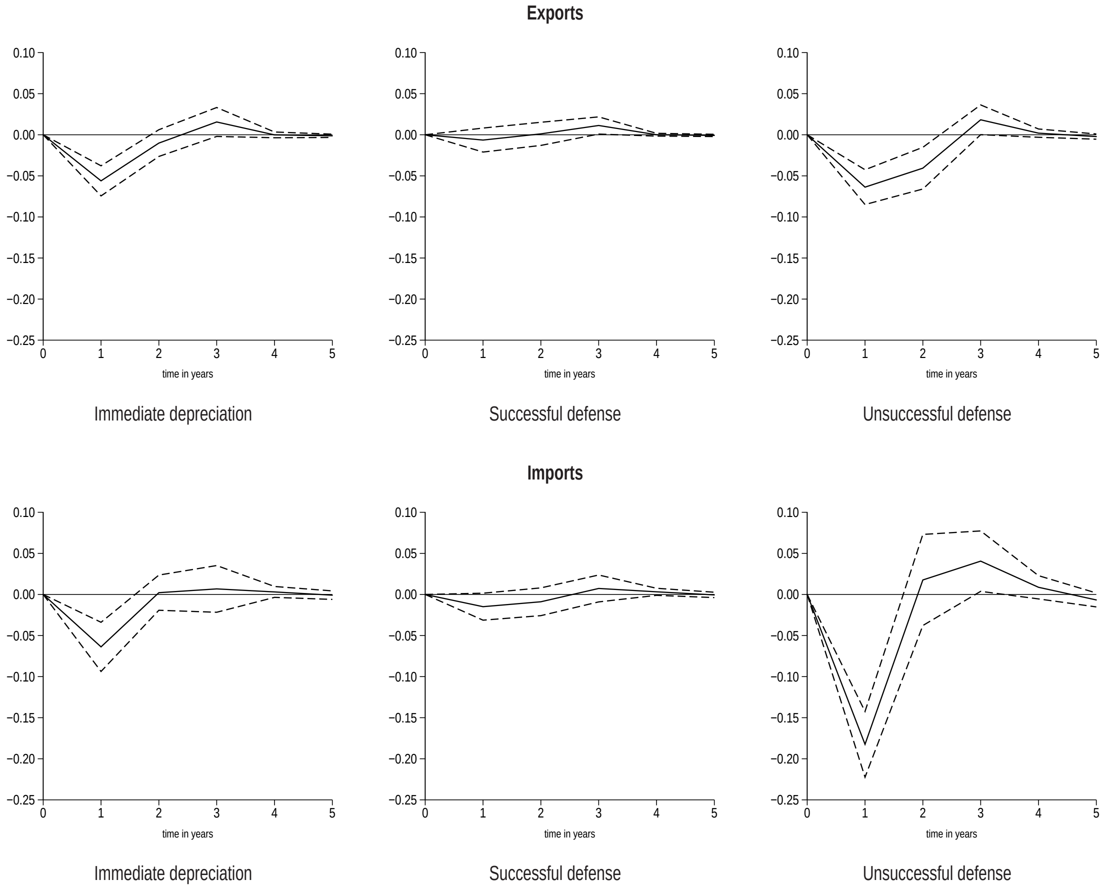

Figure 4.8: Impulse responses of exports and imports to currency crises.

investment growth in the first post-crisis year, while no significant effects are found in the aftermath of successful interventions.

In the case of export and import growth, the three types of crises are associated with diverging developments. While both exports and imports show no significant responses in the case of successful interventions, they both decline in the post-crisis period in the case of immediate depreciations and unsuccessful interventions. For immediate depreciations and unsuccessful defenses the drop in export growth is about −6 percentage points, whereas the decline in export growth seems to persist longer in the case of unsuccessful interventions (see figure 4.8). The differences in imports are even more pronounced. Import growth strongly declines by about −18.5 percentage points in case of an unsuccessful defense and by about −6.4 percentage points in the case of immediate depreciations. The decline in imports for these two depreciation events can be primarily explained by higher import prices caused by the nominal depreciation of the domestic currency (see table 4.1). Furthermore, in case of an unsuccessful defense, the decrease in output growth additionally contributes to a slow down of imports. However, it might come as a surprise that for an unsuccessful defense we also observe a decline in export growth even though the economy faces a real depreciation (see table 4.1), which should improve the economy's competitiveness. Indeed, the results indicate that the increased exchange rate volatility and the subsequently greater uncertainty which follows a depreciation event (immediate depreciation or unsuccessful defense) might lead importers and exporters to reduce their trading activities (see, e. g., Ma and Cheng, 2005).

Concerning the debt-to-GDP ratio we again find the strongest crisis impact in case of an unsuccessful defense. While immediate depreciations and successful defenses are associated with an increase between 1 and 2 percentage points, unsuccessful defenses are followed by a debt-to-GDP ratio that is up to 8 percentage points above trend in the aftermath of a crisis.[20]

The evolution of the unemployment rate in the wake of a currency crisis is also characterized by differences between the three types. Again, no significant effects are found in the case of successful interventions. On the contrary, immediate depreciations and unsuccessful interventions are both associated with higher unemployment during the post-crisis period. While immediate depreciations show a slight increase of about 0.7 percentage points, unsuccessful defenses are followed by an unemployment rate that is about 1.3 percentage points above trend.

[20]Please note that the rise in the debt-to-GDP ratio is primarily driven by the drop in output. When taking this output effect into account the increase in debt is similar for the three types of currency crises.

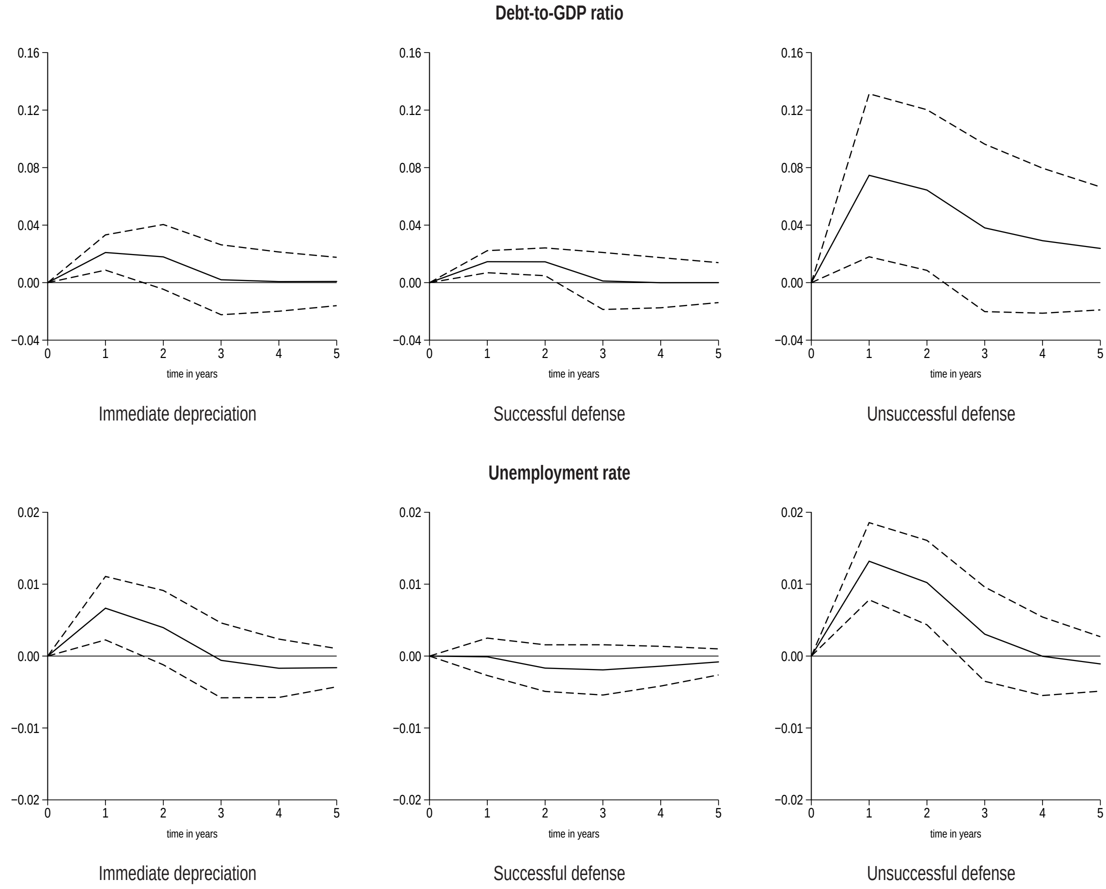

Figure 4.9: Impulse responses of debt-to-GDP ratio and unemployment rate to currency crises

Taken together, the more differentiated analysis confirms that the central bank can neutralize a speculative attack in the case of a successful defense. This type of crisis event does not seem to be associated with any economic costs. Yet, intervening to stabilize the exchange rate can not be considered a free lunch. Instead, there is the risk that the intervention is prone to be unsuccessful leading to the worst of the three scenarios with a deeper recession, higher unemployment and higher debt. If the monetary authority instead decides to let the currency depreciate without trying to defend it, the economy is likely to only face a mild recession. In general, monetary authorities that pursue a consistent policy, i. e. either implementing a credible exchange rate anchor or immediately giving in to a speculative attack, seem to fare best. Unsuccessful defenses seem to be the result of inconsistent policies, i. e. first defending the exchange rate with restrictive monetary policy and subsequently giving in to the speculative attack followed by an expansionary monetary policy. Due to negative expectational effects associated with the loss of the nominal exchange rate anchor, high economic costs are the likely result (see also Eichengreen and Rose, 2003).

4.3.3 Robustness analysis

The stylized facts presented in section 4.2 indicate that the likelihood of the different types of currency crises does not depend on the pre-crisis economic development. Only if there is no – or at least only weak – evidence that the pre-crisis macroeconomic development is fundamental for the different types of currency crises is it likely that the different post-crisis outcomes are associated with the crisis management of the monetary authority (see also Eichengreen and Rose, 2003). Therefore, we perform additional regression analyses to examine whether the pre-crisis economic development is associated with the three different types of crises. Specifically, we test whether macroeconomic fundamentals increase the probability of (i) an immediate depreciation, (ii) a successful defense, (iii) an unsuccessful defense or (iv) a currency crisis in general. Please note, that it is not the aim of this paper to explain the occurrence of a specific crisis type with respect to the underlying economic development. The occurrence of a crisis type is in particular subject to the research on early warning indicators. Interestingly, this vast empirical literature illustrated time and again, that macroeconomic variables are notoriously inapt and unreliable in predicting speculative attacks. This could in our context also be interpreted as evidence that macroeconomic fundamentals are not informative for the occurrence of the three types of currency crises and also that central banks' crisis management might play an important role for the costs of currency crises. Nonetheless, in order to further clarify this issue, we perform panel logit regressions for each type of crisis separately as well as the aggregated crisis definition. We test whether real growth, inflation, private capital inflows or current account imbalances increase the probability of either an immediate depreciation, a successful defense, an unsuccessful defense or a currency crisis in general. If the economic development does not influence the crisis probability then it is likely that monetary authority's crisis management plays a major role.[21] Tables 4.12 and 4.13 in the appendix display the estimation results. Column 1 reports the results for all crises aggregated, while columns 2 – 4 contain the results for each specific type of crisis. In general, the empirical evidence indicates that the pre-crisis macroeconomic performance does not increase the crisis probability (see table 4.12), since the lagged parameters of the different indicators in each regression are jointly insignificant. Only a few individual lags are statistically significant. When further controlling for current and forecasted economic developments (see table 4.13), we also do not find systematic differences in the occurrence of a crisis event between the three different types. All in all, the panel logit regressions seem to indicate that central banks' policies essentially determine the economic development through crises.

To further check that our results are not driven by potential correction mechanisms originating from previous crises we increase the time window concerning the singular event status of a currency crisis. In particular we make sure, that no other crisis event takes place two years before and two years after an identified currency crisis, i. e. currency crises have to be at least three years apart to be considered as a crisis event. Also, we increased the time span that determinates whether an intervention is considered to be either successful or unsuccessful from 12 to 24 months. Additionally, we checked our results if we do not apply a time window at all, i. e. we analyze every identified currency crisis. The results again depict that unsuccessful defenses are associated with severe macroeconomic consequences, while immediate depreciations can

[21] In order to avoid endogeneity problems we do not include exchange rate changes and monetary policy tools related indicators, as these variables are already mirrored by the respective crisis type.

be characterized by an "intermediate" development.[22] No remarkable macroeconomic effects can be observed in case of successful interventions.[23]

Moreover, to check the robustness of the impulse response functions, we perform a number of sensitivity checks for possible contagion either due to contemporaneous banking and/or debt crises or currency crises in other countries. As pointed out by, among others, Reinhart and Rogoff (2009) and Laeven and Valencia (2012) currency crises frequently occur together with banking and debt crises. We control for these twin and triple crises effects in order to isolate the economic consequences that can be attributed to one of the three specific currency crisis events. In our sample 36 out of 163 currency crises are accompanied by banking crises, 14 coincide with debt crises, and 7 involve both banking and debt crises. Tables 4.6 – 4.8 summarize the impulse response functions of the macroeconomic indicators of interest to the three types of currency crisis shocks when controlling for the occurrence of banking and debt crises. The empirical results indicate that successful interventions and immediate depreciations are not accompanied by noticeable negative effects. In contrast, unsuccessful defenses again are associated with a significant worsening of the fundamentals.

Another aspect that is worth controlling for are contagion effects from currency crises in other countries. Kaminsky and Reinhart (2000), Fratzscher (2003), and Dreher et al. (2006) emphasize that financial crises can be triggered by crises in other

[22]The respective estimation results are available upon request.

[23]It is worth mentioning that the employed empirical framework assumes homogeneous slope coefficients across the individuals and cross sectional independence. However, due to the occurrence of global/common as well as national shocks these assumptions could be violated, resulting in biased estimation results (see, e.g., Belke et al., 2011). To address these issues we additionally applied the Pooled Mean Group (PMG) estimator (Pesaran et al., 1999) and the Common Correlated Effects (CCE) estimator (Pesaran, 2006). The results remain qualitatively unchanged except for private capital inflows that do no longer show any significant response. However, the estimation results still confirm and underline the aspect that unsuccessful interventions are associated with high economic costs, particularly in terms of lower real growth and higher inflation. Besides those different estimators we also repeated our baseline estimations and dropped countries from our sample randomly. The obtained results again show that unsuccessful interventions are associated with high economic costs. The results are available upon request.

countries. We check our empirical results for potential contagion effects by including a dummy variable that takes on the value one if a currency crisis occurs somewhere else in the sample at the same time. Table 4.9 indicates that in general the crisis effects are somewhat weaker when taking contagion effects into account. However, qualitatively the results remain unchanged.

Moreover, we control for the influence of the exchange rate regime. For instance, it is not unlikely that the institutional arrangement in which a central bank has pursued her policy influences her reputation and the expectation of speculative traders and other economic agents and thus in turn affects future interventions. To control for this impact we include an additional dummy variable describing the exchange rate regime in place. The respective estimation results are shown in table 4.10. Again, unsuccessful interventions are characterized by distinct macroeconomic consequences, while immediate depreciations tend to be associated with an "intermediate" development. No remarkable effects can be observed for successful interventions. However, when controlling for the impact of the exchange rate arrangement with respect to the three different types of currency crises, the underlying estimation results point to weak differences.[24] The results indicate that if interventions fail the growth effects are particularly severe if the central bank tries to stabilize an exchange rate that was de facto floating during the pre-crisis period. Monetary authorities who do not pursue a consistent policy, i. e. unsuccessfully pegging a former floating exchange rate, suffer relatively high economic costs.

Finally, we additionally control for the strength of speculative attacks approximated by the attack duration. In particular we include a variable that measures the time span between the first intervention and the last intervention in case of a successful defense or between the first intervention and the significant depreciation in case of an unsuccessful defense (see table 4.11). Compared to our main results of

[24] The full results are available upon request.

section 4.3 the results are mostly identical. Taken together, the empirical results of the robustness checks (see tables 4.6 – 4.11) indicate that the results of section 4.3 are robust and remain qualitatively unchanged. Over all the robustness checks suggest a significant worsening of fundamentals particularly in case of unsuccessful interventions.

4.4 Conclusions

Currency crises can have very different economic outcomes, that range from busts – as is the typical perception of policy makers and the public – to even booms. Which development an economy takes in the course of a currency crisis seems to depend in a fundamental way on the central banks' crisis management. In case of a speculative attack the central bank can either intervene in the foreign exchange market or she can abstain from countermeasures. If the central bank intervenes she can either succeed or suspend her intervention policy giving rise to three distinct crisis events, namely immediate depreciation, unsuccessful defense and successful defense.

The empirical analysis indicates that a central bank has two options to substantially reduce the costs of currency crises, (i) an immediate depreciation and (ii) a successful defense. In case of a successful defense the central bank can even expect to completely neutralize the effect of a speculative attack without any negative side effects such as a stabilization recession. In contrast unsuccessful defenses tend to be associated with high costs in terms of output loss in the range of about -5 percentage points.

With the decision to intervene in the foreign exchange market a central bank can achieve the best result in terms of output growth if she is successful. This outcome could be referred to a real victory. However, interventions could turn into a pyrrhic victory when the stabilizing interventions are suspended, either voluntarily or – due to lack of reserves for example – involuntarily. The economy then faces the worst result in terms of output loss. If the central bank does not intervene in the case of a speculative attack, i. e. if she lets the domestic currency depreciate immediately, she can expect an "intermediate" economic development with little economic costs in terms of output loss. Not intervening and accepting the subsequent depreciation in case of a speculative attack might thus be an attractive option for a risk-averse central bank.

Our analysis also implies that to not differentiate between the different types of crises is likely to bias policy recommendations in favor of exchange rate interventions. Analyses which intermingle the different types of currency crises typically overestimate the costs of immediate depreciations as the high costs of unsuccessful defenses dominate the relatively low costs of immediate depreciations and successful defenses. Subsequently, monetary authorities are inclined to intervene "too often" rather than to immediately give in to a speculative attack.

4.5 Appendix

4.5.1 The (not-so-trivial) definition of currency crises

Our crisis differentiation is based on a stylized version of the monetary model of the exchange rate (see, e. g., Eichengreen et al., 1994; Klaassen and Jager, 2011). On the basis of significant exchange rate changes and significant interventions we identify the specific crisis events, namely immediate depreciation, successful defense and unsuccessful defense, by applying the subsequent set of rules (see Bauer et al., 2012):

1.a A depreciation is significant if it is larger than the average of the exchange rate changes during the previous 12 months plus two times the standard deviation of these changes. Additionally, the exchange rate change has to be greater than 5 %.[25] All means and standard deviations in this study are calculated time and country specific.

1.b Analogously, an intervention is considered to be significant if the INTX exceeds the average value during the previous 12 months plus three standard deviations.[26]

2.a A successful defense in year T is defined as a significant intervention in month s of year T without a significant depreciation during the subsequent 12 months.

[25] Increases of the exchange rate of less than 5 % are not classified as significant depreciations even if they exceed the standard deviation threshold, e. g. in a strictly managed exchange rate regime (see Bauer et al., 2012). In fact, a managed exchange rate regime is typically announced with a respective exchange rate band (see, for example, Ilzetzki et al., 2008).

[26] We apply a more restrictive threshold than in the case of depreciations to account for central banks' adjustments of reserve holdings that are due to portfolio alignment only and are not due to intentional intervention in the foreign exchange market.

2.b An unsuccessful defense in year T is defined as a significant intervention in month s of year T followed by a significant depreciation during the subsequent 12 months.

2.c An immediate depreciation in year T is defined as a significant depreciation without a significant intervention during the preceding 12 months.

4.5.2 Data

Table 4.2: The data

Data	**Description**	**Source**
Output growth	Growth of GDP (constant), yoy	WDI
Inflation	Change in consumer price index, yoy	WDI
Current account	Exports minus imports as a share of GDP, ratio	WDI
Private capital inflows	Foreign portfolio investments in the resp. economy as a share of GDP, ratio	IFS
Private consumption growth	Household final consumption expenditure, etc. (constant)	WDI
Investment growth	Growth of gross fixed capital formation (constant), yoy	WDI
Export growth	Growth of exports of goods and services (constant), yoy	WDI
Import growth	Growth of imports of goods and services (constant), yoy	WDI
Debt-to-GDP ratio	Central government debt as a share of GDP	WDI
Unemployment rate	Unemployment, total (% of total labor force)	WDI
Real effective exchange rate	–	WMM
Nominal exchange rate	Exchange rate LC per EUR or USD	WMM, IFS
Change in M1	Change in money stock, yoy	WMM
Change in total reserves	Change in foreign exchange reserves, yoy	WMM, IFS
Exchange rate regime	Exchange rate arrangements fine classification	IRR
Short term interest rate	–	WMM, IFS
Dates on banking and debt crises	–	RR

IFS: International Financial Statistics, IMF
IRR: Ilzetzki et al. (2008)
RR: Reinhart and Rogoff (2011)
WDI: World Development Indicators, World Bank
WMM: World Market Monitor, IHS Global Insight

Table 4.3: Panel unit root tests

Panel unit root test	ADF	PP	LLC	IPS	PESCADF
Output growth	−15.10***	−16.50***	−13.13***	−16.28***	−10.22***
Inflation	−14.22***	−18.22***	−22.78***	−17.08***	−6.55***
Current account	−7.46***	−7.60***	−5.49***	−7.28***	−4.69***
Private capital inflows	−8.72***	−13.73***	−8.05***	−9.41***	−5.70***
Private consumption growth	−15.44***	−18.60***	−14.42***	−17.22***	−10.55***
Investment growth	−15.53***	−15.68***	−12.76***	−16.15***	−12.46***
Export growth	−16.43***	−19.62***	−15.82***	−18.75***	−12.95***
Import growth	−17.22***	−20.12***	−17.50***	−19.36***	−14.87***
Debt-to-GDP ratio	−2.62***	−2.26**	−6.39***	−2.79***	−1.28*
Unemployment rate	−4.68***	−1.77**	−4.01***	−4.50***	−2.26**

Notes: Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

Table 4.4: List of countries, anchor currencies and currency crises

Country (anchor)	**Immediate depreciation**	**Successful defense**	**Unsuccessful defense**
ARG (USD)	1981, 1982, 1983, 1987	1991, 1992, **1995**, **1997**, 2006, 2007	1985, 1986, **1989**, **2001**
BRA (USD)	1964, 1965, 1968, 1981, 1986, 1987, 1988, 1991, 1999, **2001**, **2004**	**1977**, 1980, 1989, **1997**, 2000, 2002	1966, 1967, **1975**, 1979, 1982, 1985, **1993**, **2008**
BUL (EUR)	1993, 1994	**1998**, 2007, 2008	**1996**
CHI (USD)	**1979**, **2001**, **2008**, **2010**	1977, 1981, **1995**, **1998**	1982, **1984**
CHN (USD)	1986, 1994	1982, 1983, 1985, 1988, **1992**, 1995, **2010**	1984, 1989
COL (USD)	1985, 1997, **2002**, 2006, 2007	1986, 1992, 1993, 1994, 2005	1998, 2008
CZE (EUR)	**1999**	**1997**, **2004**, **2008**	
ECU (USD)	1983, 1985, **1988**, 1991	1984, 1986	1992, 1995, 1996, **1998**
EST (EUR)		**1997**, 2000, 2001, **2005**, **2007**	
HKG (USD)		**2002**, **2004**	
HUN (EUR)	1989, **1991**, 1994, **2003**	1997, 1998, **2006**, **2010**	1995, **2008**
IND (USD)	**1966**, 1972, **1993**, **1997**	**1973**, 1975, 1979, 1980, **1983**, **1988**, **1999**, **2006**	**1990**, **1995**, **2008**
IDN (USD)	**2008**	1983, 1985, 1986, **1988**, **1994**, **2001**	**1997**
KOR (USD)	**2000**	1971, 1973, **1976**, **1978**, **1984**, **1989**, 1991, 1992, **1995**, **2005**	1970, 1974, **1980**, **1997**, **2007**
LVA (USD)	**2010**	**1995**, **2005**	**2008**
LTU (USD)	**2008**, **2010**	1993, **2005**	
MAS (USD)	**1975**, 1994	**1970**, **1972**, 1982, 1983, 1984, **1986**, **1988**, 1995, **2001**, **2003**, **2005**, **2008**, **2010**	**1997**
MEX (USD)	1976, 1982	**1978**, 1986, **2006**	1981, 1985, 1987, **1994**, 1997, 1998, **2008**
PAK (USD)	1972, **1993**, 1995, 1999, **2008**	**1966**, 1970, 1971, **1979**, **1990**, 1996, **2004**, **2010**	2000
PER (USD)	**1967**, 1976, 1977, 1982, 1984, 1987	**1962**, 1991, **1998**, **2007**	1975, 1981, 1983, 1985, 1986, 1988, 1990
PHI (USD)	1986, **2008**	1987, 1989, 1990, **1992**, **2003**	**1983**, **1997**, **2000**
POL (USD)	1991, 1992, 1993, **1998**, 2000, **2008**, **2010**	**1996**, 2001, **2004**	
RUS (USD)		1995, **2001**, **2005**	1997, 1998, **2009**
SIN (USD)		**1973**, 1979, 1980, **2001**, **2004**	**1975**, **1997**
SVK (EUR)		1993, 1997, **2006**, **2008**	1998
SVN (EUR)	1992	1993, 2005, 2007	
RSA (USD)	1972, **1975**, 1983, 1985, **1996**, 2000, 2001, **2004**, **2008**	**1970**, 1973, **1988**, **1990**, **1992**	**1981**, 1984, **1998**, **2006**
SRI (USD)	**1989**, **1993**, **1998**	1980, 1981, **1983**, **1987**, **2006**, **2009**	**2000**
TWN (USD)	**1997**	**1987**, **1989**, **1995**, **2007**, **2010**	
THA (USD)	**1981**, 1984	1977, 1978, 1983, **1988**, **1995**, 2000, 2001, **2004**, **2008**, **2010**	**1997**
TUR (USD)	1986, **2001**, 2004, **2008**	**1998**, 2003	1987, **1991**, 1994, 1995, **2006**
VEN (USD)	**1984**, **1986**, **1992**, 1994, 1995, **2010**	1990, 1996, 1998, 1999, 2000, 2005, **2007**	1989, **2002**, 2004

Notes: The table reports all crisis events we found in our sample, while bold values denote those currency crises that are defined as single events and are therefore the basis for our analysis.

4.5.3 Regression results of the dynamic model

Table 4.5: Main results of a panel VAR

Responses of	Output growth	Inflation	Current account	Private capital inflows
Responses to:				
Output growth$_{t-1}$	0.553***	−0.507**	−0.209***	−0.001
	(7.81)	(−2.23)	(−2.60)	(−0.02)
Output growth$_{t-2}$	0.140**	0.213	0.027	0.058
	(2.08)	(0.69)	(0.39)	(0.64)
Output growth$_{t-3}$	0.062	−0.011	0.063	−0.003
	(0.91)	(−0.05)	(1.00)	(−0.06)
Inflation$_{t-1}$	0.012	0.624***	−0.003	0.015***
	(1.16)	(2.69)	(−0.41)	(3.07)
Inflation$_{t-2}$	−0.004	−0.197	0.002	0.005
	(−0.37)	(−1.00)	(0.48)	(1.13)
Inflation$_{t-3}$	−0.005	0.204***	0.001	0.001
	(−0.42)	(4.05)	(0.20)	(0.07)
Current account$_{t-1}$	0.194	0.248	0.793***	−0.185
	(0.85)	(0.44)	(4.58)	(−0.84)
Current account$_{t-2}$	0.000	−0.167	−0.164**	0.133
	(0.01)	(−0.58)	(−2.21)	(1.30)
Current account$_{t-3}$	−0.177	0.066	0.132	−0.153
	(−1.51)	(0.18)	(1.49)	(−1.46)
Private capital inflows$_{t-1}$	0.034	−0.002	0.108**	0.020
	(0.70)	(−0.01)	(2.52)	(0.20)
Private capital inflows$_{t-2}$	−0.140***	0.128	0.048	−0.058
	(−2.96)	(0.75)	(1.29)	(−0.67)
Private capital inflows$_{t-3}$	0.049	−0.046	−0.036	−0.012
	(0.99)	(−0.22)	(−0.78)	(−0.14)
Immediate depreciation$_{t-1}$	0.002	−0.004	−0.003	0.003
	(0.37)	(−0.16)	(−0.54)	(0.40)
Immediate depreciation$_{t-2}$	0.002	0.044	−0.006	0.007
	(0.23)	(1.06)	(−0.81)	(0.87)
Immediate depreciation$_{t-3}$	0.002	0.057	0.007	0.015*
	(0.18)	(1.27)	(0.88)	(1.73)
Successful defense$_{t-1}$	0.004	0.002	−0.005	−0.003
	(1.04)	(0.18)	(−1.29)	(−0.55)
Successful defense$_{t-2}$	0.009**	−0.016	−0.003	−0.003
	(2.23)	(−1.06)	(−0.80)	(−0.55)
Successful defense$_{t-3}$	0.001	−0.004	0.003	0.004
	(0.20)	(−0.31)	(0.55)	(0.59)
Unsuccessful defense$_{t-1}$	−0.051***	0.127**	0.037***	−0.015*
	(−3.21)	(2.00)	(3.05)	(−1.61)
Unsuccessful defense$_{t-2}$	0.029**	−0.171**	−0.004	−0.017
	(2.28)	(−1.93)	(−0.73)	(−1.44)
Unsuccessful defense$_{t-3}$	0.005	0.029	0.006	−0.006
	(0.52)	(0.65)	(0.80)	(−1.00)
Country fixed effects	Yes			
Time fixed effects	Yes			
Obs.	466			
Countries	32			

Notes: The VAR model is estimated by system GMM. Heteroscedasticity consistent t-statistics are in parentheses. Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

4.5.4 Robustness analysis

Table 4.6: Behavior of macroeconomic indicators after different crisis events controlled for twin crises effects (occurrence of currency and banking crises)

Year after crisis	1	2	3	4	5
Output growth					
Immediate depreciation	0.002	0.000	0.009	0.003	0.001
Successful defense	0.001	0.001	0.003	0.001	0.000
Unsuccessful defense	−0.038	0.006	0.012	0.003	0.001
Inflation					
Immediate depreciation	−0.011	0.005	0.069	0.058	0.017
Successful defense	−0.006	−0.010	−0.013	−0.008	−0.004
Unsuccessful defense	0.098	−0.004	−0.005	0.027	0.026
Current account					
Immediate depreciation	0.006	0.005	0.022	0.018	0.011
Successful defense	−0.003	−0.001	0.010	0.008	0.005
Unsuccessful defense	0.022	0.034	0.037	0.026	0.018
Private capital inflows					
Immediate depreciation	0.013	0.019	0.022	0.001	0.001
Successful defense	0.006	0.004	−0.001	0.000	0.000
Unsuccessful defense	−0.003	−0.009	−0.005	0.000	0.000
Private consumption growth					
Immediate depreciation	0.005	0.000	0.000	0.000	0.000
Successful defense	0.002	0.008	−0.004	−0.001	0.000
Unsuccessful defense	−0.024	0.005	−0.006	−0.001	0.000
Investment growth					
Immediate depreciation	−0.015	−0.023	−0.042	−0.011	0.001
Successful defense	−0.011	−0.016	−0.020	−0.004	0.001
Unsuccessful defense	−0.147	−0.002	0.013	0.006	0.000
Export growth					
Immediate depreciation	−0.067	−0.004	0.005	−0.002	0.000
Successful defense	−0.023	0.001	0.008	0.000	0.000
Unsuccessful defense	−0.064	−0.046	0.005	−0.003	−0.001
Import growth					
Immediate depreciation	−0.059	−0.010	−0.021	0.000	0.004
Successful defense	−0.029	−0.013	−0.002	0.003	0.001
Unsuccessful defense	−0.164	−0.001	0.007	0.008	0.000
Debt-to-GDP ratio					
Immediate depreciation	0.007	−0.008	0.001	0.001	0.001
Successful defense	0.015	0.010	0.000	0.000	0.000
Unsuccessful defense	0.044	0.016	0.018	0.016	0.013
Unemployment rate					
Immediate depreciation	0.004	0.001	0.000	0.000	0.000
Successful defense	0.001	−0.001	−0.001	−0.001	−0.001
Unsuccessful defense	0.007	0.004	0.000	0.000	−0.001

Notes: Shaded areas denote significant values at the 10 % level.

Table 4.7: Behavior of macroeconomic indicators after different crisis events controlled for twin crises effects (occurrence of currency and debt crises)

Year after crisis	1	2	3	4	5
Output growth					
Immediate depreciation	0.001	0.002	0.011	0.004	0.001
Successful defense	−0.001	0.002	0.002	0.000	0.000
Unsuccessful defense	−0.038	0.010	0.011	0.002	0.001
Inflation					
Immediate depreciation	−0.032	0.018	0.059	0.035	0.005
Successful defense	−0.003	0.006	0.001	−0.003	−0.002
Unsuccessful defense	0.058	0.004	0.003	0.020	0.019
Current account					
Immediate depreciation	0.008	0.006	0.012	0.009	0.006
Successful defense	−0.001	0.000	0.008	0.006	0.004
Unsuccessful defense	0.028	0.035	0.023	0.015	0.010
Private capital inflows					
Immediate depreciation	0.008	0.013	0.020	0.001	0.000
Successful defense	0.004	0.001	−0.001	0.000	0.000
Unsuccessful defense	−0.008	−0.014	−0.007	−0.001	0.000
Private consumption growth					
Immediate depreciation	0.005	0.003	0.008	0.001	0.000
Successful defense	0.000	0.009	−0.002	−0.001	0.000
Unsuccessful defense	−0.024	0.009	0.000	0.000	0.000
Investment growth					
Immediate depreciation	−0.023	−0.004	−0.015	−0.004	0.001
Successful defense	−0.016	−0.009	−0.014	−0.003	0.001
Unsuccessful defense	−0.158	0.021	0.041	0.013	−0.001
Export growth					
Immediate depreciation	−0.063	−0.001	0.012	−0.001	0.000
Successful defense	−0.021	0.001	0.013	0.000	0.000
Unsuccessful defense	−0.065	−0.042	0.019	−0.001	0.000
Import growth					
Immediate depreciation	−0.059	−0.002	0.002	0.003	0.000
Successful defense	−0.030	−0.010	0.004	0.003	0.000
Unsuccessful defense	−0.167	0.006	0.033	0.011	−0.004
Debt-to-GDP ratio					
Immediate depreciation	0.007	0.008	0.003	0.002	0.002
Successful defense	0.019	0.021	0.011	0.008	0.007
Unsuccessful defense	0.040	0.037	0.018	0.015	0.013
Unemployment rate					
Immediate depreciation	0.006	0.004	0.001	0.000	0.000
Successful defense	0.002	0.000	−0.001	−0.001	−0.001
Unsuccessful defense	0.009	0.008	0.001	0.000	0.000

Notes: Shaded areas denote significant values at the 10 % level.

Table 4.8: Behavior of macroeconomic indicators after different crisis events controlled for triple crises effects (occurrence of currency, banking and debt crises)

Year after crisis	1	2	3	4	5
Output growth					
Immediate depreciation	0.002	0.003	0.010	0.004	0.001
Successful defense	−0.001	0.002	0.000	0.000	0.000
Unsuccessful defense	−0.034	0.013	0.012	0.003	0.001
Inflation					
Immediate depreciation	−0.015	0.015	0.076	0.058	0.019
Successful defense	−0.005	−0.008	−0.007	−0.004	−0.002
Unsuccessful defense	0.079	0.014	0.020	0.034	0.026
Current account					
Immediate depreciation	0.008	0.005	0.011	0.009	0.006
Successful defense	−0.001	0.000	0.008	0.007	0.004
Unsuccessful defense	0.025	0.036	0.022	0.014	0.011
Private capital inflows					
Immediate depreciation	0.008	0.014	0.022	0.001	0.000
Successful defense	0.003	0.002	−0.001	0.000	0.000
Unsuccessful defense	−0.007	−0.014	−0.003	0.000	0.000
Private consumption growth					
Immediate depreciation	0.005	0.005	0.006	0.001	0.000
Successful defense	0.000	0.009	−0.004	−0.001	0.000
Unsuccessful defense	−0.021	0.011	0.002	0.000	0.000
Investment growth					
Immediate depreciation	−0.018	−0.009	−0.014	−0.003	0.001
Successful defense	−0.017	−0.013	−0.018	−0.004	0.001
Unsuccessful defense	−0.134	0.026	0.045	0.012	−0.001
Export growth					
Immediate depreciation	−0.064	−0.004	0.011	−0.001	0.000
Successful defense	−0.021	−0.002	0.012	0.000	0.000
Unsuccessful defense	−0.063	−0.036	0.019	−0.001	0.000
Import growth					
Immediate depreciation	−0.054	0.003	−0.001	0.002	0.000
Successful defense	−0.028	−0.008	0.002	0.003	0.001
Unsuccessful defense	−0.148	0.017	0.029	0.007	−0.004
Debt-to-GDP ratio					
Immediate depreciation	0.019	0.013	0.009	0.008	0.007
Successful defense	0.017	0.021	0.017	0.014	0.012
Unsuccessful defense	0.017	0.009	−0.011	−0.009	−0.007
Unemployment rate					
Immediate depreciation	0.005	0.003	−0.001	−0.001	−0.001
Successful defense	0.001	−0.001	−0.002	−0.001	−0.001
Unsuccessful defense	0.010	0.009	0.002	0.000	0.000

Notes: Shaded areas denote significant values at the 10 % level.

Table 4.9: Behavior of macroeconomic indicators after different crisis events controlled for contagion effects

Year after crisis	1	2	3	4	5
Output growth					
Immediate depreciation	−0.001	0.000	0.000	0.000	0.000
Successful defense	0.001	0.003	−0.002	−0.001	0.000
Unsuccessful defense	−0.038	0.014	0.005	0.002	0.000
Inflation					
Immediate depreciation	0.013	0.041	0.077	0.040	0.015
Successful defense	0.006	−0.005	−0.012	−0.005	−0.001
Unsuccessful defense	0.119	−0.035	−0.025	0.018	0.009
Current account					
Immediate depreciation	0.003	0.001	0.011	0.009	0.006
Successful defense	−0.001	0.001	0.009	0.007	0.004
Unsuccessful defense	0.031	0.034	0.027	0.018	0.013
Private capital inflows					
Immediate depreciation	0.005	0.012	0.021	−0.002	−0.002
Successful defense	0.000	0.001	0.005	0.000	0.000
Unsuccessful defense	−0.014	−0.015	−0.005	0.002	0.001
Private consumption growth					
Immediate depreciation	0.009	0.004	0.000	−0.001	0.000
Successful defense	0.003	0.007	−0.010	−0.002	0.000
Unsuccessful defense	−0.033	0.008	−0.003	0.001	0.000
Investment growth					
Immediate depreciation	−0.018	−0.005	−0.013	−0.003	0.000
Successful defense	−0.003	−0.013	−0.010	−0.002	0.001
Unsuccessful defense	−0.175	0.022	0.042	0.017	0.000
Export growth					
Immediate depreciation	−0.040	−0.014	0.002	0.000	0.000
Successful defense	−0.004	−0.001	0.003	0.000	0.000
Unsuccessful defense	−0.046	−0.038	0.006	0.002	−0.001
Import growth					
Immediate depreciation	−0.043	0.002	−0.012	−0.001	0.002
Successful defense	−0.012	−0.011	−0.006	0.001	0.001
Unsuccessful defense	−0.159	0.030	0.027	0.004	−0.005
Debt-to-GDP ratio					
Immediate depreciation	0.001	0.004	−0.001	−0.001	−0.001
Successful defense	0.009	0.004	−0.004	−0.004	−0.004
Unsuccessful defense	0.052	0.032	0.029	0.023	0.018
Unemployment rate					
Immediate depreciation	0.003	0.002	0.000	−0.001	−0.001
Successful defense	−0.001	−0.003	−0.002	−0.001	0.000
Unsuccessful defense	0.010	0.006	0.002	0.000	−0.001

Notes: Shaded areas denote significant values at the 10 % level.

Table 4.10: Behavior of macroeconomic indicators after different crisis events controlled for exchange rate regime effects

Year after crisis	1	2	3	4	5
Output growth					
Immediate depreciation	−0.013	0.001	0.011	0.006	0.002
Successful defense	−0.002	0.001	−0.004	−0.002	−0.001
Unsuccessful defense	−0.054	−0.003	0.003	0.005	0.002
Inflation					
Immediate depreciation	0.014	0.046	0.089	0.049	0.025
Successful defense	0.019	0.007	0.000	0.003	0.003
Unsuccessful defense	0.118	−0.048	−0.044	0.002	−0.001
Current account					
Immediate depreciation	0.012	0.017	0.019	0.014	0.009
Successful defense	0.001	0.001	0.007	0.006	0.004
Unsuccessful defense	0.037	0.042	0.026	0.017	0.013
Private capital inflows					
Immediate depreciation	0.008	0.018	0.024	−0.004	−0.003
Successful defense	0.001	0.004	0.005	−0.001	−0.001
Unsuccessful defense	−0.014	−0.013	−0.005	0.003	0.001
Private consumption growth					
Immediate depreciation	−0.005	0.000	0.012	0.003	0.000
Successful defense	−0.001	0.005	−0.010	−0.002	0.000
Unsuccessful defense	−0.048	0.004	0.004	0.007	0.000
Investment growth					
Immediate depreciation	−0.055	−0.024	−0.020	−0.002	0.002
Successful defense	−0.017	−0.020	−0.015	−0.003	0.001
Unsuccessful defense	−0.203	−0.026	0.047	0.027	0.006
Export growth					
Immediate depreciation	−0.045	0.010	0.009	−0.001	−0.001
Successful defense	0.000	0.008	0.012	0.000	−0.001
Unsuccessful defense	−0.056	−0.034	0.011	0.003	−0.001
Import growth					
Immediate depreciation	−0.085	−0.015	0.007	0.008	0.001
Successful defense	−0.025	0.001	0.009	0.003	−0.001
Unsuccessful defense	−0.200	−0.012	0.046	0.021	−0.003
Debt-to-GDP ratio					
Immediate depreciation	0.042	0.061	0.045	0.036	0.029
Successful defense	0.025	0.026	0.012	0.009	0.008
Unsuccessful defense	0.089	0.114	0.086	0.068	0.055
Unemployment rate					
Immediate depreciation	0.009	0.006	0.000	−0.002	−0.002
Successful defense	0.000	−0.003	−0.003	−0.002	−0.001
Unsuccessful defense	0.015	0.014	0.007	0.003	0.000

Notes: Shaded areas denote significant values at the 10 % level.

Table 4.11: Behavior of macroeconomic indicators after different crisis events controlled for strength effects of the speculative attack

Year after crisis	1	2	3	4	5
Output growth					
Immediate depreciation	−0.007	0.000	0.008	0.004	0.001
Successful defense	0.001	0.003	0.001	0.000	0.000
Unsuccessful defense	−0.052	0.006	0.009	0.004	0.001
Inflation					
Immediate depreciation	0.000	0.036	0.086	0.043	0.016
Successful defense	0.022	0.006	−0.004	0.001	0.003
Unsuccessful defense	0.125	−0.031	−0.017	0.023	0.012
Current account					
Immediate depreciation	0.007	0.002	0.010	0.008	0.005
Successful defense	0.000	0.002	0.007	0.005	0.003
Unsuccessful defense	0.034	0.037	0.027	0.018	0.012
Private capital inflows					
Immediate depreciation	0.007	0.011	0.018	−0.002	−0.002
Successful defense	−0.002	0.001	0.004	0.000	0.000
Unsuccessful defense	0.003	−0.016	−0.007	0.001	0.001
Private consumption growth					
Immediate depreciation	0.003	0.005	0.007	0.001	−0.001
Successful defense	0.008	0.009	−0.007	−0.003	−0.001
Unsuccessful defense	−0.060	0.001	0.000	0.003	0.001
Investment growth					
Immediate depreciation	−0.032	−0.007	−0.006	0.000	0.001
Successful defense	−0.015	−0.015	−0.001	0.002	0.001
Unsuccessful defense	−0.168	0.017	0.046	0.017	0.000
Export growth					
Immediate depreciation	−0.056	−0.009	0.019	0.000	−0.002
Successful defense	0.001	0.001	0.010	0.000	−0.001
Unsuccessful defense	−0.086	−0.042	0.019	0.002	−0.002
Import growth					
Immediate depreciation	−0.066	0.003	0.001	0.002	0.000
Successful defense	−0.024	−0.009	0.009	0.004	−0.001
Unsuccessful defense	−0.125	0.027	0.032	0.005	−0.006
Debt-to-GDP ratio					
Immediate depreciation	0.020	0.015	0.009	0.007	0.006
Successful defense	−0.012	−0.010	−0.018	−0.015	−0.012
Unsuccessful defense	0.012	0.010	−0.004	−0.005	−0.004
Unemployment rate					
Immediate depreciation	0.007	0.004	−0.001	−0.002	−0.002
Successful defense	−0.002	−0.004	−0.003	−0.002	−0.001
Unsuccessful defense	0.022	0.018	0.008	0.003	0.000

Notes: Shaded areas denote significant values at the 10 % level.

Table 4.12: Panel logit regression I

	all crises (1)	immediate depreciation (2)	successful defense (3)	unsuccessful defense (4)
Individual lags				
Real growth				
$t-1$	2.665	−8.058	8.530*	12.316
	(0.9)	(−1.5)	(1.8)	(1.6)
$t-2$	−7.663**	−8.886	−7.384	1.270
	(−2.2)	(−1.3)	(−1.5)	(0.2)
$t-3$	2.285	8.205	2.354	0.814
	(0.8)	(1.1)	(0.6)	(0.1)
All lags are zero (Chi2)	5.095	5.526	4.482	2.697
Prob.	0.165	0.137	0.214	0.441
Inflation				
$t-1$	0.842	−0.307	0.658	2.667*
	(1.4)	(−0.1)	(0.6)	(1.9)
$t-2$	−1.537	−0.159	−2.120	−5.144*
	(−1.6)	(−0.0)	(−1.0)	(−1.9)
$t-3$	0.689	0.432	0.699	1.474*
	(1.5)	(0.2)	(1.0)	(1.7)
All lags are zero (Chi2)	3.364	0.137	1.305	4.671
Prob.	0.339	0.987	0.728	0.198
Current account				
$t-1$	−2.373	−12.087*	2.454	−1.424
	(−0.7)	(−1.8)	(0.5)	(−0.2)
$t-2$	3.819	8.607	2.180	9.569
	(0.9)	(1.0)	(0.4)	(0.9)
$t-3$	0.710	1.691	0.826	−19.425**
	(0.2)	(0.3)	(0.2)	(−2.0)
All lags are zero (Chi2)	1.825	4.125	1.943	4.703
Prob.	0.610	0.248	0.584	0.195
Private capital inflows				
$t-1$	1.394	−0.733	1.911	16.107
	(0.5)	(−0.1)	(0.5)	(1.4)
$t-2$	2.739	21.573*	−0.284	−0.450
	(1.0)	(1.7)	(−0.1)	(−0.0)
$t-3$	−0.370	−5.041	3.749	−6.767
	(−0.1)	(−1.0)	(0.9)	(−0.7)
All lags are zero (Chi2)	1.186	3.632	0.894	2.294
Prob.	0.756	0.304	0.827	0.514
Country & time fixed effects	Yes	Yes	Yes	Yes
Obs.	644	259	425	233
Countries	32	20	30	19

Notes: Dependent variable: Binary variable that takes on the value one if a crisis occurs and zero otherwise. Z-values in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.10.

Table 4.13: Panel logit regressions II

	all crises (1)	immediate depreciation (2)	successful defense (3)	unsuccessful defense (4)
Individual lags				
Real growth				
$t+1$ forecast	−62.128*	−31.030	−110.348**	−120.636
	(−1.7)	(−0.4)	(−2.1)	(−1.3)
t	−4.121	−10.632	4.572	−26.287***
	(−1.3)	(−1.4)	(0.8)	(−3.4)
$t-1$	12.880**	−0.950	16.549**	21.489
	(2.3)	(−0.1)	(2.0)	(1.4)
$t-2$	−9.085**	−8.925	−10.110*	−8.397
	(−2.3)	(−1.2)	(−1.9)	(−0.9)
$t-3$	−0.185	4.043	−0.579	−3.122
	(−0.1)	(0.5)	(−0.1)	(−0.3)
Inflation				
$t+1$ forecast	−2.605	−2.041	−3.455	−11.574*
	(−1.1)	(−0.4)	(−1.1)	(−1.8)
t	0.130	−0.383	−6.051	3.259
	(0.3)	(−0.3)	(−1.5)	(1.7)
$t-1$	2.300	1.354	3.272	4.295
	(1.6)	(0.3)	(1.6)	(0.8)
$t-2$	−2.315**	−1.490	−2.195	−6.482
	(−2.0)	(−0.3)	(−1.1)	(−1.4)
$t-3$	0.990*	1.088	1.212	2.613*
	(2.0)	(0.5)	(1.6)	(1.7)
Current account				
$t+1$ forecast	30.796	27.731	34.864	18.173
	(1.6)	(0.7)	(1.2)	(0.3)
t	−8.685**	−16.508*	−6.846	−34.387***
	(−2.4)	(−1.9)	(−1.3)	(−3.6)
$t-1$	−10.278	−22.288	−9.830	13.037
	(−1.1)	(−1.1)	(−0.7)	(0.5)
$t-2$	5.632	15.967	3.712	10.814
	(1.2)	(1.5)	(0.6)	(0.8)
$t-3$	−2.790	−2.630	−1.472	−25.050**
	(−0.7)	(−0.3)	(−0.3)	(−2.2)
Private capital inflows				
$t+1$ forecast	−30.623	15.189	−70.047	−19.370
	(−0.6)	(0.1)	(−0.9)	(−0.2)
t	−9.585**	−16.974**	−9.474	−13.887*
	(−2.6)	(−2.5)	(−1.6)	(−1.8)
$t-1$	−0.199	2.385	−1.490	37.905**
	(−0.1)	(0.3)	(−0.3)	(2.5)
$t-2$	0.746	23.530	−2.952	−16.231
	(0.2)	(1.5)	(−0.6)	(−1.6)
$t-3$	0.973	−5.939	3.731	−9.420
	(0.3)	(−0.9)	(0.8)	(−0.7)
Country fixed effects	Yes	Yes	Yes	Yes
Obs.	614	239	403	222
Countries	32	19	30	19

Notes: Dependent variable: Binary variable that takes on the value one if a crisis occurs and zero otherwise. Z-values in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.10.

Chapter 5

TARGET2: How costly is buying time?

Chapter 5 is based on Erler and Hohberger (2014). I would like to thank conference participants at Prato and Bayreuth for many helpful suggestions. In particular, the very helpful comments by Bernhard Herz, Stefan Hohberger, and Matthias Kollenda are gratefully acknowledged.

5.1 Motivation

The German claims on the Eurosystem through TARGET2[1] have gained increasing attention since the beginning of the financial crisis in 2007 as well as during the twin debt and banking crisis in the euro area. Figure 5.1 shows that claims of the Deutsche Bundesbank on the Eurosystem increased from close to zero to more than 700 billion euros at the end of 2012. During 2013 the claims reduced slightly to around 600 billion euros.[2]

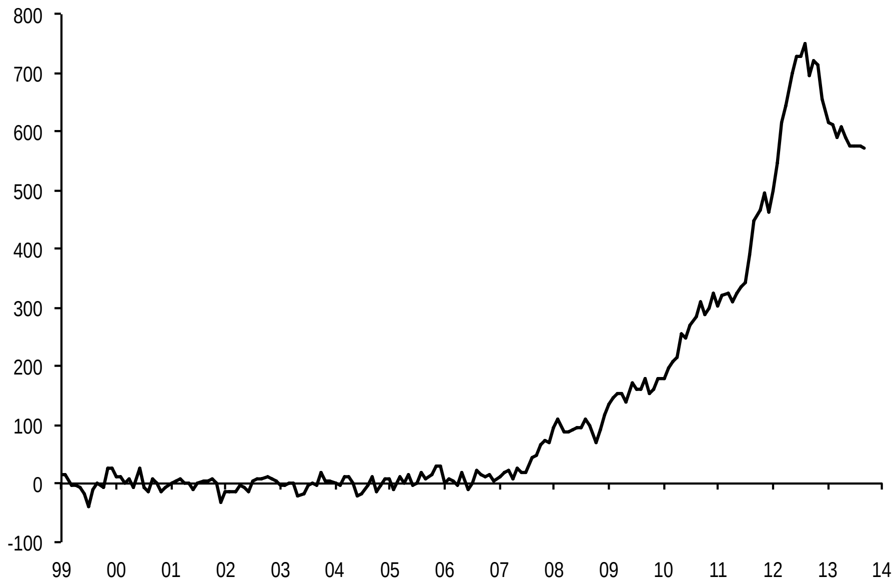

Figure 5.1: Germany's TARGET2 claims on the Eurosystem (in bn. euros)

A closer look at the TARGET2 balances within the European Monetary Union (EMU) reveals that TARGET2 imbalances are concentrated on a few member countries (see figure 5.2). Apart from Germany's almost 600 billion euros, Luxembourg,

[1] TARGET denotes *Trans-European Automated Real-Time Gross Settlement Express Transfer* and refers to the European transaction settlement system through which commercial banks make payments.

[2] For a detailed balance sheet description of the TARGET2 mechanism, see, e. g., Cecchetti et al. (2012). For a more analytical framework of the origins and development of TARGET2 positions and their potential financial risks, see Bindseil and König (2012).

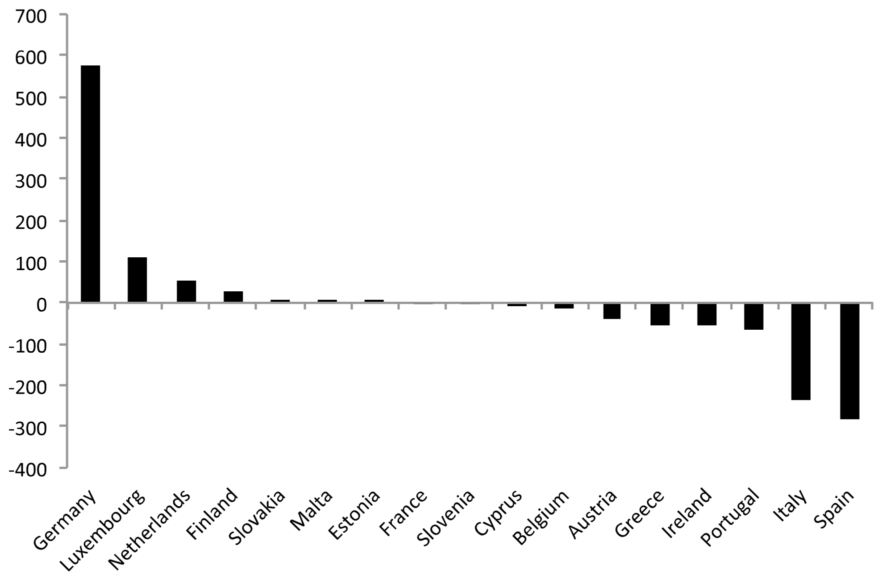

Figure 5.2: TARGET2 balances within EMU, August 2013 (in bn. euros)

the Netherlands and Finland additionally accumulated 200 billion euros of TARGET2 claims vis-à-vis Austria, Greece, Ireland, Portugal, Italy, and Spain. Italy and Spain alone are associated with TARGET2 liabilities of about 550 billion euros.

The literature on TARGET2 balances has become quite extensive over the last three years. While some authors deal with several problems at once and others with specific aspects, the academic literature on TARGET2 balances cannot easily be characterized. To highlight two main directions, one strand focuses specifically on the time period during the financial crisis in 2007 when countries like Greece and Portugal apparently financed their current account deficits through TARGET2 liabilities (see, e. g., Sinn and Wollmershäuser, 2012a,b; Cecchetti et al., 2012; Mayer et al., 2012). This interpretation is confirmed, for instance, by a panel analysis by Auer (2013). He finds that current account balances were entirely unrelated to the evolution of TARGET2 balances before the onset of the financial crisis 2007, however, in the period after 2007 a correlation of 0.808 suits well with the interpretation that current account imbalances are being financed by central bank liquidity that has replaced private capital flows.

The other strand argues that TARGET2 balances reflect a funding crisis within the euro area since 2011 (see, e. g., Buiter et al., 2011; Bindseil and König, 2012; Cecioni and Ferrero, 2012; Mody and Bornhorst, 2012). Mody and Bornhorst (2012) argue that TARGET2 mirrors a reversal of capital flows within Europe. During the European debt and banking crisis, increasing capital flows from southern European economies to Germany, which is still running a current account surplus, indicate capital flight that led to a lack of financial resources in the distressed economies. Cour-Thimann (2013) provides a comprehensive analysis and an extensive literature review of TARGET2 balances in the context of the crisis in the euro area.

These studies have in common that they focus on the dynamics of the TARGET2 system, in particular, by answering questions like, how do TARGET2 balances arise, and what are the economic implications of holding TARGET2 claims. CESifo (2014), for instance, calculates the potential losses for Germany in case of a euro area collapse and the subsequent insolvencies of the respective crisis economies. The calculation shows that holding TARGET2 claims might lead to potential losses of about 470 bn. euros. Contrary, Fahrholz and Freytag (2012) discuss potential misallocations of real resources due to the existence of TARGET2 imbalances – however, the economic costs of these misalignments are not quantified.

Summarizing, the existing literature primarily focuses on potential risks and costs, which are associated with a breakdown of the TARGET2 system, e. g. the costs in case of a euro area collapse or a member country exit. In contrast, this paper evaluates the current economic losses incurred from holding TARGET2 claims in real terms. Since TARGET2 claims and liabilities are interest-bearing and generally remunerated at the interest rate of the ECB's main refinancing operations (Deutsche Bundesbank, 2011), Germany receives, on the one hand, nominal interest gains for holding TARGET2 claims vis-à-vis the deficit countries. On the other hand, the nominal revenues have to be adjusted by price level changes over time, i. e. by the real exchange rate, to account for price differentials between EMU member countries. Due to the focus on real terms, this approach is able to shed light on the dimension of TARGET2 to a redistribution of real resources within the euro area.

Using a stylized two-period model based on the approach by Jin and Choi (2013), the paper finds that by the end of 2013 Germany has incurred accumulated losses of around 13 billion euros in real terms. Additionally, calculating the real losses and gains for every euro area member country reveals that the TARGET2 systems acts as an implicit redistribution mechanism with a cumulated distribution volume of about 30 billion euros.

The paper is organized as follows. Section 5.2 presents the stylized background of TARGET2 within the European Monetary Union. Section 5.3 describes the empirical framework, which is used to evaluate and to discuss the real losses and gains of TARGET2 balances. The main findings are summarized in section 5.4.

5.2 TARGET2 in a currency union

In order to assess the real losses and gains of Germany's TARGET2 claims we follow the approach by Jin and Choi (2013) and compare the accumulation of TARGET2 claims in a currency union with an accumulation of foreign reserves in a fixed exchange rate regime.[3] Analogously to, e. g., Homburg (2012), Neumann (2012), and Sinn and Wollmershäuser (2012b), we make use of the balance of payment identity:

[3] For further discussions about the similarities between TARGET2 balances and balance of payment crises in fixed exchange rate regimes, see, e. g., Kohler (2012) and Bernholz (2012).

$$CA + KA + \Delta S \equiv 0 \qquad (5.1)$$

where $KA = KI - KE$. The current account balance, CA, mirrors the capital account balance, KA, defined as the difference of private and public capital imports KI over capital exports KE. The term ΔS ensures that the balance of payment is balanced. In a fixed exchange rate regime the term ΔS corresponds to the changes in foreign exchange reserves.[4] Assuming a country whose current account deficit cannot be financed by capital inflows (net borrowing), the central bank sells her foreign reserves to provide domestic debtors with foreign currency to balance their liabilities. In the EMU, the foreign reserves (ΔS) are replaced by TARGET2 balances due to the loss of autonomous monetary policy and the abandonment of national currencies (see Sinn and Wollmershäuser, 2012a).

The similarity in the adjustment mechanism of foreign reserves and TARGET2 balances is illustrated in the stylized balance sheet of a central bank (see figure 5.3). We assume two current account surplus countries, one in a fixed exchange rate regime (e. g. China) and one in a currency union (e. g. Germany as member of the EMU).

Fixed Exchange Rate Regime

A		L	
Reserves	10	Base Money	100
Domestic Credit	90		
Reserves	+ 5	Base Money	+ 5

EMU

A		L	
Reserves	10	Base Money	100
Domestic Credit	90		
Target Claims	+ 5	Base Money	+ 5

Figure 5.3: Central bank's balance sheet

[4] In a floating exchange rate regime ΔS should be zero, since an appreciation or a depreciation of the exchange rate is supposed to ensure a balanced BOP.

Basically, assets like gold, government bonds, and foreign reserves (Reserves) as well as loans granted to commercial banks (Domestic Credit) are booked on the left-hand side, while the financing base (Base Money), which has been created by the central bank, is booked on the right-hand side as liability. In a fixed exchange rate regime without corresponding net private capital outflows the central bank of a current account surplus economy has to accumulate foreign exchange reserves to avoid appreciation pressure on the nominal exchange rate, thereby increasing the monetary base.[5] In the case of the EMU the accumulation of foreign reserves is replaced by creating TARGET2 claims vis-à-vis the deficit countries to substitute for private capital flows. These similarities are also discussed in Sinn and Wollmershäuser (2012a,b). The authors additionally point out that contrary to a fixed exchange rate regime there is no natural restriction in the sense of a limited stock of foreign reserves in the deficit countries. The central bank of a deficit country can incur as much TARGET2 liabilities as long as the banks of the deficit country provide sufficiently good collaterals. Since the standard of eligible collaterals can be lowered by the ECB there are de facto no limits for TARGET2 liabilities and claims.

5.3 Quantifying real TARGET2 gains and losses

As long as trade is financed by private capital flows, TARGET2 does not play an important role. Accordingly, figure 5.4 depicts that during the pre-crisis period (2002–2007) current account balances are financed by private capital flows as no clear relationship between TARGET2 balances and the current account can be observed. Since the beginning of the European debt and banking crisis in 2010 there seems to be a one-to-one relationship between current account balances and TARGET2 balances.

[5] Accompanying risks of inflation and/or required sterilizing operations by reducing domestic credit have been left out for the sake of simplicity.

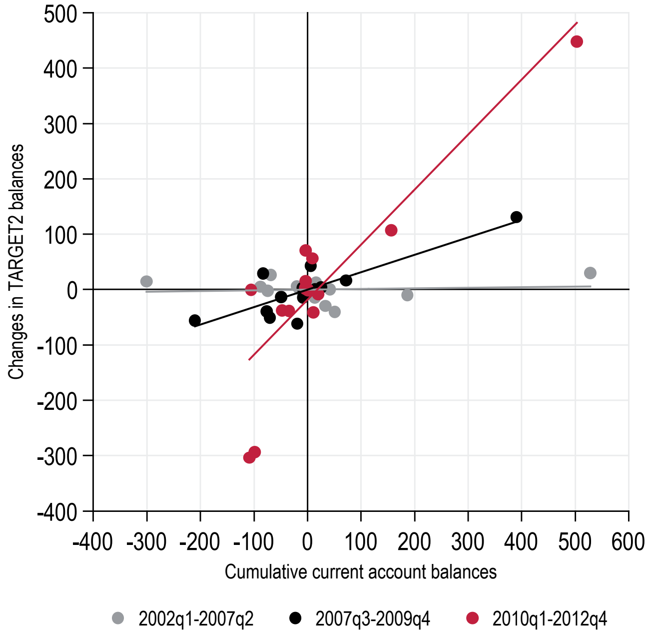

Figure 5.4: Cumulative current account balances and changes in TARGET2 balances in bn. euros (based on Cecchetti et al., 2012)[6]

This supports the assumption that private capital flows are replaced by TARGET2 balances (see, e. g., Cecchetti et al., 2012; Sinn and Wollmershäuser, 2012b).

To keep the calculation of current losses and gains as simple as possible, we analyze the dynamics of the TARGET2 mechanism in a two-period framework, following the approach by Jin and Choi (2013). In order to justify the simplification of our calculation approach, we show impulse response functions of a stylized small open economy model to gain some intuition behind the dynamics of the TARGET2 system.[7] Macroeconomic data indicate that during the last decade Germany faced a persistent real exchange rate depreciation vis-à-vis the rest of the euro area (RoEA), which boosted exports and led to a growing trade surplus. We therefore simulate

[6]Data of the national central bank TARGET2 balances were obtained from the CESifo institute and current account data from the European Commission.

[7]The simulation is based on a small open economy model within a monetary union according to Herz and Hohberger (2013). Some stylized information about the model structure and model equations can be found in the appendix. For a detailed description of the model see Herz and Hohberger (2013).

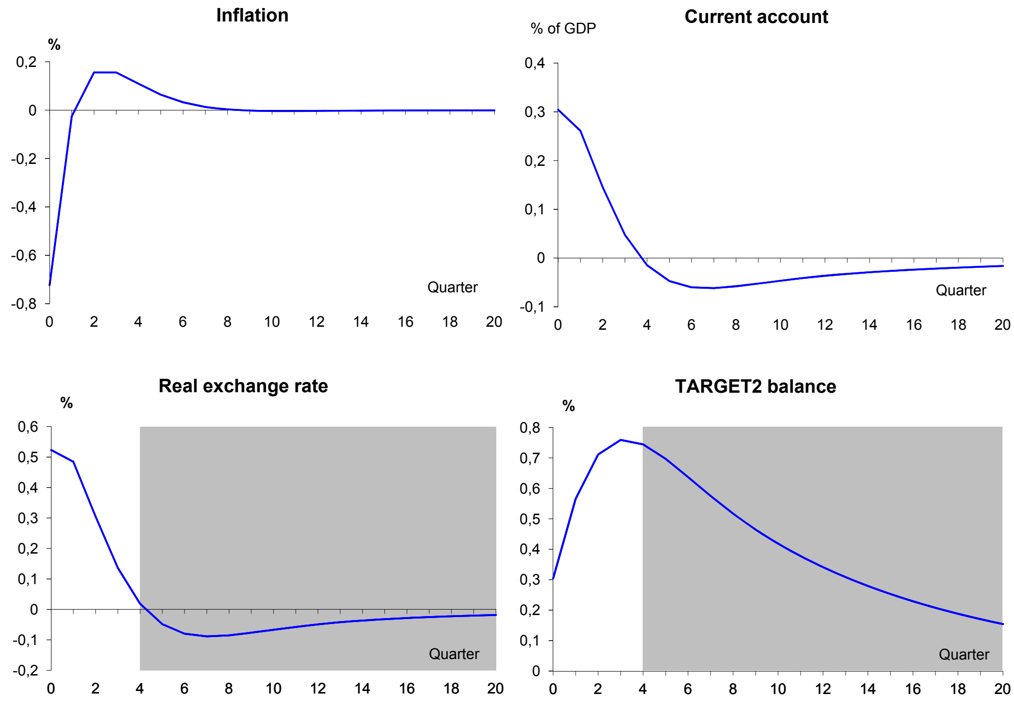

Figure 5.5: Impulse responses for a negative price shock

dynamic responses to a negative price shock in order to imitate Germany's real exchange rate depreciation.[8] Figure 5.5 shows that a decline in domestic prices depreciates (increase) the real exchange rate, implying a current account surplus through an improvement of international competitiveness. Based on our assumption that private capital flows are substituted by TARGET2 balances, an increase in the current account is accompanied by an increase in TARGET2 claims.

The crucial point for the subsequent simplification derives from the adjustment dynamics to the steady state. A future appreciation (decrease) of the real exchange rate induces a reduction of the current account surplus as well as the TARGET2 claims. Hence, a real exchange rate depreciation today must be balanced by a real

[8] A productivity shock or a risk premium shock would have similar effects on the real exchange rate (depreciation) and the current account.

exchange rate appreciation in the future to ensure stationarity in the long-run. In Figure 5.5, the first period reflects the real exchange rate depreciation and the accumulation of TARGET2 claims, the second period (shaded gray) reflects the real exchange rate appreciation and the reduction of TARGET2 claims.

5.3.1 Real gains and losses in a two-period model

Within our two-period framework, we assume that Germany's trade surplus is financed by holding TARGET2 claims as private capital flows suddenly stop between countries (see, e. g. Cecchetti et al., 2012; Sinn and Wollmershäuser, 2012b). Furthermore, we assume that trade depends on the real exchange rate (ϵ).

As baseline scenario we assume that trade is balanced ($CA_0 = 0$) at the equilibrium real exchange rate ϵ_0.[9] If the real exchange rate differs from the equilibrium rate, Germany faces a trade surplus or deficit. For example, if Germany is subject to a real exchange rate depreciation vis-à-vis the RoEA ($\epsilon_1 \uparrow$, since $\epsilon_1 = g[CA]$ with $g'[CA] > 0$), a trade surplus ($+CA$) occurs given the Marshall-Lerner-condition holds. Since trade must be balanced over two periods, Germany must have a trade deficit ($-CA$) in period 2. As private capital flows between both countries are replaced by TARGET2 balances (TB), the RoEA's trade deficit is financed through Germany's TARGET2 claims vis-à-vis the ECB, thus $TB = CA$.

Given that TARGET2 balances are remunerated at the ECB's main refinancing rate i, Germany's real trade surplus measured in foreign goods (TARGET2 claim vis-à-vis RoEA) grows to $TB(1 + r)$ in the second period, where r is defined as the difference between nominal interest rate and RoEA's inflation rate. Reversing this amount in period 2 to finance the trade deficit, it has to be adjusted by the real exchange rate in period 2 to measure the revenues in domestic goods, $TB(1 + r)\epsilon_2$, where $\epsilon_2 = g[-TB(1 + r)]$.

[9] For the sake of simplicity we assume that the equilibrium real exchange rate is unity.

Hence, the total real gains π in period 1 are:

$$\begin{aligned} \pi_1 &= TB_1((1+r_1)g[-TB_1(1+r_1)] - g[TB_1]) \\ &= TB_1(1+r_1)\epsilon_2 - TB_1\epsilon_1 = TB_1\epsilon_2 + r_1 TB_1\epsilon_2 - TB_1\epsilon_1 \end{aligned} \tag{5.2}$$

The real gains equal the "market" value of the TARGET2 balance in period 2 plus the interest rate income in period 2 stemming from holding the TARGET2 balance in period 1 less the costs of setting up the balance in period 1.

If Germany faces a real depreciation in period 1 and chooses to hold TARGET2 claims in order to finance its exports – private capital flows are no longer available – then $\epsilon_1 > 1$ and $TB_1 > 0$. Under this scenario, the development of gains and losses particularly depends on the real interest rate r. This can be seen by differentiating (5.2) with respect to TB:

$$\begin{aligned} \frac{\partial \pi}{\partial TB} &= (1+r)g[-TB(1+r)] - g(TB) \\ &\quad - TB((1+r)^2 g'[-TB(1+r)] + g'(TB)) \end{aligned} \tag{5.3}$$

Evaluating equation (5.3) at $TB = 0$, we get

$$\frac{\partial \pi}{\partial TB} = (1+r)g(0) - g(0) = r < 0, \tag{5.4}$$

which implies that π is decreasing in TB. In case of positive (negative) real interest rates, i. e. $r > 0$ ($r < 0$), Germany gains (incurs losses) by holding TARGET2 claims.

5.3.2 Cumulative real gains and losses

Since TARGET2 balances are not completely liquidated in each period, it is of particular interest to assess the cumulative gains and losses of Germany's TARGET2 claims. In order to accumulate the gains in each period, we assume that TB_i is the TARGET2 balance in period i, which is zero at the beginning of period 1. Hence, at the end of period 1, the TARGET2 balance (TB_1) equals the trade surplus ($TB_1 = CA_1$) and the corresponding TARGET2 balance in period 2 is given by $TB_2 = TB_1 + \Delta TB_2$. As Germany holds a TARGET2 balance in period 2 (TB_2) its real costs are mirrored by $TB_2\epsilon_2$. Therefore, the corresponding gains in period 2 can be formulated as:

$$\pi_2 = TB_2(1 + r_2)\epsilon_3 - TB_2\epsilon_2 = TB_2\epsilon_3 + r_2TB_2\epsilon_3 - TB_2\epsilon_2 \tag{5.5}$$

The gains of period 2 equal the "market" value of the TARGET2 balance plus the interest rate income in period 3 that stems from holding the TARGET2 balance in period 2 minus the costs of holding the balance in period 2.[10]

In order to get the real value of cumulative TARGET2 gains at the end of period 2, the gains have to be evaluated with the real exchange rate in period 3 (market value of TB_2). Additionally, the interest rate income resulting from previous TARGET2 balances and the costs of TARGET2 "interventions" in previous periods have to be considered. The cumulative gains in period 2 are given by:

$$\Pi_2 = TB_2\epsilon_3 + r_1TB_1\epsilon_2 + r_2TB_2\epsilon_3 - (\Delta TB_1\epsilon_1 + \Delta TB_2\epsilon_2) \tag{5.6}$$

[10]Analogously, the gains of period t can be expressed as follows: $\pi_t = TB_t(1+r_t)\epsilon_{t+1} - TB_t\epsilon_t = TB_t\epsilon_{t+1} + r_tTB_t\epsilon_{t+1} - TB_t\epsilon_t$.

Since $TB_0 = 0$ and $\Delta TB_2 = TB_2 - TB_1$, equation (5.6) can be rewritten as:

$$\begin{aligned}\Pi_2 &= TB_2\epsilon_3 + r_1 TB_1\epsilon_2 + r_2 TB_2\epsilon_3 - (TB_1\epsilon_1 + (TB_2 - TB_1)\epsilon_2) \\ &= TB_1\epsilon_2 + r_1 TB_1\epsilon_2 - TB_1\epsilon_1 + TB_2\epsilon_3 + r_2 TB_2\epsilon_3 - TB_2\epsilon_2 \\ &= \pi_1 + \pi_2 \qquad (5.7)\end{aligned}$$

According to equation (5.7), the cumulative real gains of holding a TARGET2 balance in period T are:

$$\Pi_T = TB_T\epsilon_{T+1} + \sum_{t=1}^{T} r_t TB_t\epsilon_{t+1} - \sum_{t=1}^{T} \Delta TB_t\epsilon_t = \sum_{t=1}^{T} \pi(t) \qquad (5.8)$$

In other words, the cumulative real gains of holding TARGET2 claims or liabilities can be obtained by adding up the real gains of each previous period.

5.3.3 Data

The calculation of real gains and losses is based on monthly data and covers the years from 1999 to 2013.

The real exchange rate between Germany and RoEA – based on seasonally adjusted HCPIs[11] – is calculated with data from the European Commission. Specifically, the real exchange rate is given by $\epsilon = P^*/P$, where P^* is the HCPI of the euro area without Germany and P is the HCPI of Germany, respectively. Both HCPIs are set to 100 in January 1999. As the RoEA's HCPI is not available by itself, it is constructed in the following way: Firstly, the monthly relative changes of the HCPI of the euro area and the HCPI of Germany were calculated. Secondly, based on the ECB's CPI weights, the German contribution to the monthly change of the HCPI

[11] Seasonally adjusted HCPIs were constructed by using the X-12 procedure.

of the euro area was removed to obtain a time series that only mirrors the monthly changes of the HCPI of the euro area without Germany. Lastly, these changes were accumulated to construct the HCPI of the rest of the euro area (RoEA).

The monthly real interest rate is computed by dividing the difference between the ECB's main refinancing rate and the RoEA's annual inflation rate by 12.

Data of the national central bank TARGET2 balances are available from CESifo institute.[12] In order to take into account price differentials between Germany and RoEA, the nominal TARGET2 balance of Germany is deflated by the HCPI of the RoEA to express the TARGET2 balance in units of foreign goods.

5.3.4 Current gains and losses for Germany

Based on equation (5.2), we calculate Germany's real monthly gains from holding TARGET2 balances. According to the implementation of the common currency in January 1999 we compute the respective gains and losses in real terms for the period $1999m1 - 2013m6$. The results for the accumulated gains in real terms are shown in figure 5.6 (solid line).

It illustrates that in the early years of the currency union the accumulated gains in real terms, namely in constant 1999 prices, were close to 0 until 2007. The gains started to increase with the beginning of the global financial crisis, reaching its peak of nearly 4 billion euros in 2010. The gains within this period are mainly driven by the accumulation of TARGET2 claims in association with positive real interest rates, and – from a German perspective – future real exchange rate depreciations.[13] However, since the end of 2011 Germany's gains declined sharply and turned into

[12] For more detailed information, see http://www.cesifo-group.de/ifoHome/policy/Spezialthemen/Policy-Issues-Archive/Target.html.

[13] More intuition regarding the driving forces of real gains and losses and the decomposition of annual gains is given below (see also figure 5.7).

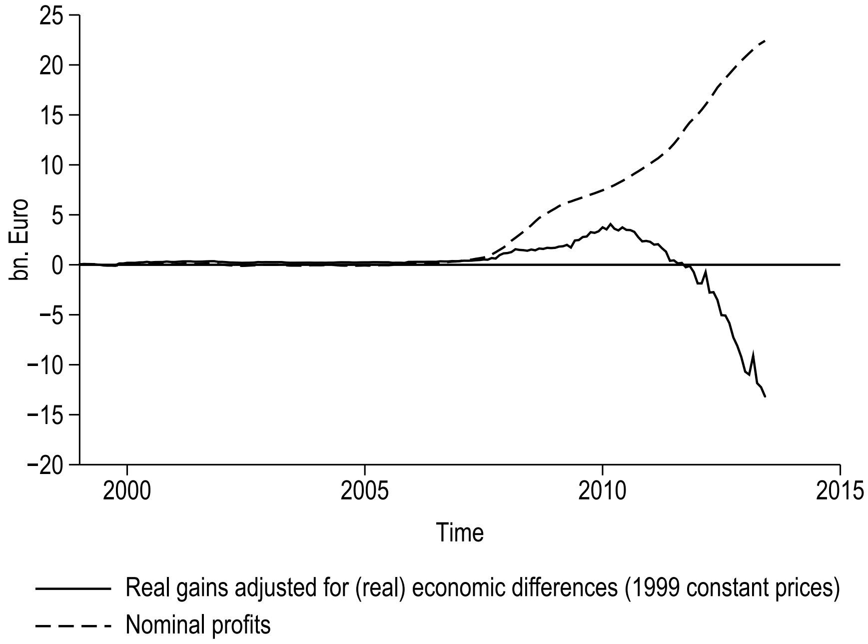

Figure 5.6: Cumulative gains and losses of Germany in bn. euros

losses. Since 2012, Germany's real losses increase to around 13 billion euros. The results underline that even without an euro area break-up or exit of one member country, holding TARGET2 claims can cause high economic costs.

Looking at TARGET2 balances in nominal terms would yield a different picture. As TARGET2 balances are remunerated at the ECB's main refinancing rate – which is still positive – and because of the absence of nominal exchange rate fluctuations, holding TARGET2 claims results in respective profits in nominal terms. Adjusting for (real) economic differences, i. e. by incorporating the real exchange rate between Germany and the RoEA, it becomes evident that holding nominal TARGET2 claims incurs losses in real terms, however (see figure 5.6).

After calculating Germany's current losses it is of particular interest to assess what future gains and losses can be expected from holding TARGET2 claims. To analyze the driving forces of gains and losses of TARGET2 balances, we differentiate equation (5.2) with respect to TB_t, r_t, ϵ_t, ϵ_{t+1}, in order to gain some intuition on the general properties concerning the development of real gains:

$$\frac{\partial \pi_t}{\partial TB_t} = \epsilon_{t+1}(1+r) - \epsilon_t - TB_t \frac{\partial \epsilon_t}{\partial TB_t} \tag{5.9}$$

$$\frac{\partial \pi_t}{\partial r_t} = TB_t \epsilon_{t+1} \tag{5.10}$$

$$\frac{\partial \pi_t}{\partial \epsilon_t} = -TB_t + (\epsilon_{t+1}(1+r_t) - \epsilon_t)\frac{\partial TB_t}{\partial \epsilon_t} \tag{5.11}$$

$$\frac{\partial \pi_t}{\partial \epsilon_{t+1}} = TB_t(1+r_t) \tag{5.12}$$

Although future gains depend on the change of TARGET2 balances (see eq. 5.9), the TARGET2 balances itself might be considered an endogenous process in the sense that a change in the trade balance is automatically accompanied by a change in the TARGET2 balance. Nevertheless, evaluating equation 5.9 at $TB = 0$ implies that the development of gains in real terms depends on the real interest rate r. For instance, in case of positive real interest rates, holding TARGET2 claims is associated with real gains and vice versa. This effect is based on the balance of payment adjustment mechanism in the currency union when private capital does not flow between member countries. Likewise, an increase in the real interest rate increases c. p. Germany's gains from holding TARGET2 claims (see eq. 5.10).

A real exchange rate depreciation ($\epsilon_t \uparrow$) due to domestic prices decreasing relative to foreign prices, lowers Germany's gains in real terms due to a deterioration of the terms of trade (see eq. 5.11), i. e. a given amount in domestic goods corresponds to a smaller amount in foreign goods. On the other hand, a future real exchange rate appreciation ($\epsilon_{t+1} \downarrow$) decreases current gains (see eq. 5.12), i. e. a given amount in foreign goods realizes a smaller amount in domestic goods.

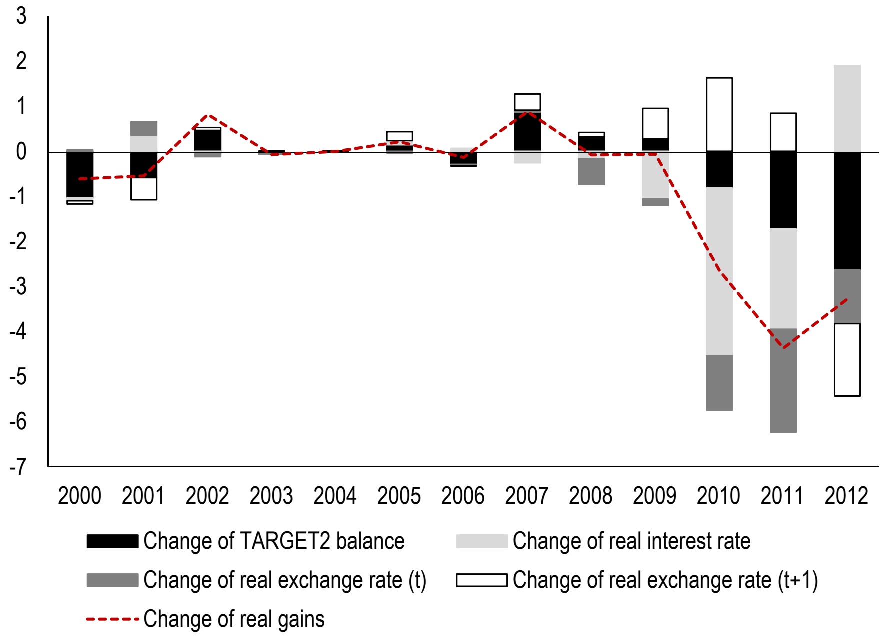

Figure 5.7: Changes of annual real gains versus previous year in bn. euros (1999 constant prices) and the approximated contribution of TB, r, ϵ_t and ϵ_{t+1} (no feedback effects are considered)

Based on the partial derivatives, we are able to decompose the respective evolution of gains of Germany. Figure 5.7 illustrates that since 2008 the decline in real gains is mainly driven by decreasing real interest rates and real exchange rate depreciations.

5.3.5 Future gains and losses for Germany

Given the current costs, what can we expect to be a likely scenario concerning the future development of gains and losses in real terms? In order to shed some light on this issue we calculate real gains and losses under 4 different scenarios within our two-period framework. Specifically, we focus on the question what would happen if Germany liquidated its TARGET2 balance in period 2.[14] We assume that the

[14]For simplicity reasons, the 4 scenarios are based on annual calculations.

German economy has TARGET2 claims in real terms of about 418.5 bn. euros in period 1 and liquidates its claims in period 2. The theoretical discussion at the beginning of this section indicates that – from a German point of view – a real appreciation is needed in order to return to a balanced current account. As the recent ratio of the German consumer price index (HCPI) to the RoEA consumer price index is 1.08, Germany is undervalued by 8 %. For the sake of simplicity, we assume a linear (symmetric) relationship between the TARGET2 balance and the real exchange rate, i. e. an appreciation rate of more than 15 % would be necessary to reduce the TARGET2 balance to zero. Thus, TARGET2 claims in real terms of about 418.5 bn. euros associated with a real exchange rate of about 1.08 in period 1 imply a real exchange rate of 0.92 in period 2 in order to liquidate TARGET2 claims completely. This hypothetical scenario, namely a future real appreciation, can basically be achieved in two ways, all other things being equal: (i) inflation in Germany (*domestic adjustment*) or (ii) deflation in RoEA (*external adjustment*).

Table 5.1 reports the expected gains and losses from the liquidation of the German TARGET2 claims in case of domestic adjustment and external adjustment (RoEA) with respect to 4 different nominal interest rate scenarios. The results indicate that both adjustment scenarios would imply different costs and highlight the sensitivity to alternative macroeconomic developments. If, for instance, Germany would liquidate its TARGET2 claims in period 2, the accumulated losses would be substantial higher in case of a German inflation compared to a deflation in RoEA. The reason is that a future real exchange rate appreciation increases current losses measured in domestic goods due to an improvement in the terms of trade, i. e. the given amount in foreign goods realizes a smaller amount in domestic goods. As monetary policy is typically interested in preventing deflation, it is in our sense more plausible to assume that the real appreciation will be attained through an increasing price level in Germany. For that reason the current German accumulated losses of about 13 bn. euros are expected to increase even further.

Table 5.1: Liquidation of the German TARGET2 balance in 4 scenarios ('99 const. prices)

Variable	Scenario (1)	Scenario (2)	Scenario (3)	Scenario (4)
Nominal interest rate	0.00	2.00	4.00	6.00
TARGET2 balance$_1$	418.50	418.50	418.50	418.50
ΔTARGET2 balance$_2$	−418.50	−418.50	−418.50	−418.50
ϵ_t	1.08	1.08	1.08	1.08
ϵ_{t+1}	0.92	0.92	0.92	0.92
Domestic adjustment				
Inflation$_{Germany}$	17.05	17.05	17.05	17.05
Inflation$_{RoEA}$	0.00	0.00	0.00	0.00
Real interest rate	0.00	2.00	4.00	6.00
Cumulative gains	−78.94	−71.23	−63.51	−55.80
External adjustment (RoEA)				
Inflation$_{Germany}$	0.00	0.00	0.00	0.00
Inflation$_{RoEA}$	−14.57	−14.57	−14.57	−14.57
Real interest rate	14.57	16.57	18.57	20.57
Cumulative gains	−22.76	−15.04	−7.33	0.38

Concerning the interest rate development, an increasing nominal interest rate would increase the gains from holding TARGET2 claims in period 1. As the current interest rate level appears to be very low in a historical context, we might expect rising interest rates that would in general contribute to increasing gains or decreasing losses, respectively. Nevertheless, it seems to be unlikely that interest rate increases might lead to gains which would outweigh the losses stemming from the real appreciation.

Table 5.1 also indicates that – in theory – it would be possible to reduce the real TARGET2 balance back to zero without incurring any losses (scenario 4, RoEA adjustment). Though, this scenario seems to be unlikely as in this situation the RoEA would face a sharp deflation accompanied by high nominal interest rates.

Summarizing the potential future developments – from a German perspective – further losses in real terms seem to be a likely scenario. Basically, the results are in line with Fahrholz and Freytag (2012). They argue that the emergence of TAR-

GET2 balances contributes to persistent real misalignments. These misalignments are in principle mirrored by our quantified TARGET2 gains and losses in real terms. Fahrholz and Freytag (2012) point out that the TARGET2 balances have been substituted for the missing private capital flows between EMU countries. Thus, the TARGET2 balances can be considered non market based subsidies. In particular they help current account deficit economies to receive the necessary capital imports, which financial markets no longer offer to these countries. As long as these capital flows are non market based they no longer reflect the decision-making process of private agents and will therefore lead to an inefficient capital allocation. Accordingly, this development will result in high economic costs, which mainly have to be borne by economies with positive TARGET2 balances such as Germany.

5.3.6 Distribution across EMU member countries

The TARGET2 system by itself is a "closed" system between EMU countries, i. e. if there is a country that incurs losses then there also has to be a country, which gains. Therefore, the question arises how the gains and losses are distributed across the EMU member countries.

Adapting the calculation approach of gains and losses to each member country of the EMU, the results indicate that the TARGET2 system can be characterized as an implicit redistribution mechanism. Figure 5.8 shows that especially surplus European countries are associated with losses, while deficit European countries benefit from the TARGET2 system. The respective gains and losses in figure 5.8 are calculated in real terms but are reported in current prices for comparison reasons. The gross redistribution volume is about 30 billion euros. Compared to all European "rescue packages" this volume appears to be relatively small. However, compared to the EU budget (payments appropriations) of about 130 billion euros in 2013, the volume seems to be quite high (nearly 25 %). To some extent the implicit redistribution mechanism

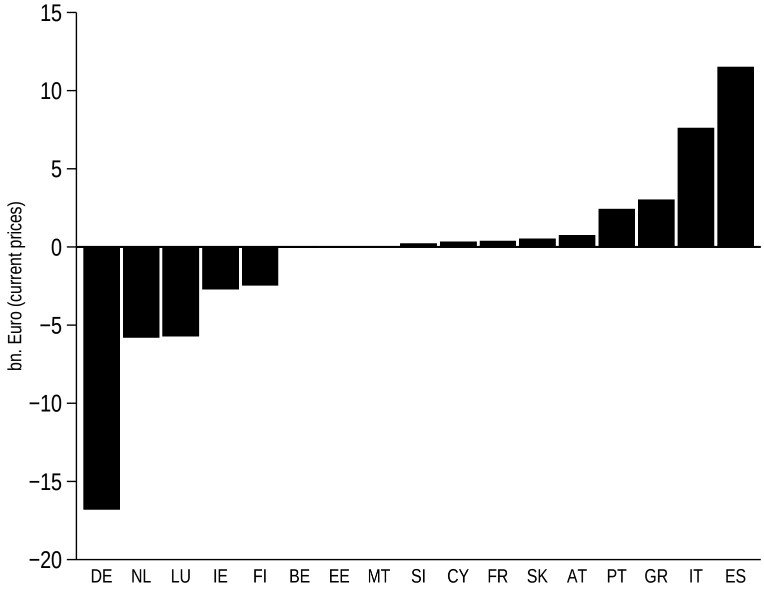

Figure 5.8: Cumulative gains and losses in bn. euros (in current prices).

of the TARGET2 system is similar to the economic effects of the introduction of Eurobonds, which would also lead to distributional effects between euro area member countries (see, e.g., Hild et al., 2014; Homburg, 2012). Through the adaption of Eurobonds, member countries with recently higher interest rates would benefit from the lower average interest rate of the Eurobond. In contrast, countries with relatively low interest rates, e. g. Germany, would face higher interest rate payments.

In line with Bindseil and König (2012), the TARGET2 system is a fundamental component of a well-functioning euro area and serves as an adjustment-buffer mechanism in the current European debt and banking crisis. TARGET2 balances might buy time to implement structural reforms that may remove the intra-European imbalances.

5.4 Conclusions

It is often stated that TARGET2 balances mirror missing private capital flows due to structural imbalances in the euro area. Economists argue that if structural imbalances will be removed, private capital flows would recover and, thus, TARGET2 balances would disappear – without causing economic costs. The existing literature focuses on potential costs and risks, which are associated with the TARGET2 system, e. g. the costs in case of a euro area collapse or a member country exit. These studies, however, seem to neglect the aspect that the TARGET2 system might be associated with current economic costs. The aim of this paper was to evaluate the economic costs in real terms and to gain insights into the distributional effects that come along with the TARGET2 system.

Since TARGET2 balances are published in current prices, it seems to be inappropriate to provide arguments concerning the TARGET2 system on a nominal basis, while price differentials between member countries are in place. Taking these imbalances reliably into account, holding TARGET2 claims can incur losses in real terms – even without a collapse of the euro area.

The paper finds that by the end of 2013 Germany has incurred losses from holding TARGET2 claims of around 13 bn. euros in real terms (in constant 1999 prices). The calculation of real gains and losses for each EMU member country indicates that the TARGET2 system can be considered an implicit redistribution mechanism. On the one hand, this mechanism might help to finance necessary (real) economic adjustments. On the other hand, as real gains and losses basically mirror real economic differences in the EMU, the TARGET2 system cannot replace necessary reforms. However, it might provide time and money, which in turn have to be used by policymakers to reduce intra-EMU imbalances.

5.5 Appendix

To illustrate the dynamics of the TARGET2 mechanism we use a small open economy approach within a monetary union in the spirit of Galí and Monacelli (2005, 2008). The specific model is based on Herz and Hohberger (2013) who analyze the potential of fiscal policy to stabilize current account imbalances. Figure 5.9 summarizes the structure of the model.

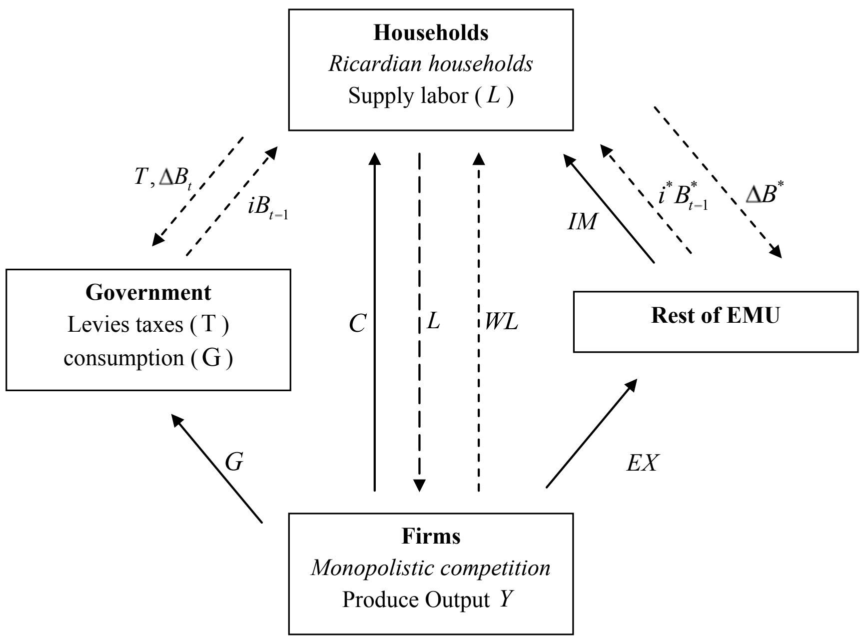

Figure 5.9: Small open economy model structure.

Given the focus on TARGET2 mechanism, the modeling of the external sector deserves more detail. The following model equations are log-linearized around a deterministic steady state, so that variables are expressed in percent deviations from their respected steady state value. The change in the real exchange rate is defined as change of CPI ratios in a common currency:

$$\Delta \epsilon_t = \Delta E_t + \pi_t^* - \pi_t, \tag{5.13}$$

Due to the same currency, we can set $\Delta E_t = 0$. Hence, an increase in foreign inflation relative to domestic inflation yields to a real exchange rate depreciation (an increase in ϵ_t). The uncovered interest rate parity condition (15) is:

$$i_t = i_t^* + risk_t \tag{5.14}$$

where $risk_t = -\chi nfa_t$ captures a time-varying country risk premium according to Schmitt-Grohe and Uribe (2005) and ensures stationarity of the foreign debt level. The real net foreign asset position evolves over time according to:

$$nfa_t = (1 + i_{t-1} - \pi_t)nfa_{t-1} + nx_t \tag{5.15}$$

where $nx_t = y_t - c_t - \alpha\Delta\epsilon_t$ are the net exports in each period. Given the evolution of assets determined by the model, we express the current account as the change in net foreign assets:

$$ca_t = nfa_t - nfa_{t-1} \tag{5.16}$$

In the current small open economy trade is financed through private capital flows (nfa_t). As we assume that private capital flows are totally substituted by TARGET2 since the beginning of the financial crisis in 2007 (see, e. g. Cecchetti et al., 2012; Sinn and Wollmershäuser, 2012b), we replace nfa_t by $target_t$ so that a trade balance surplus corresponds with a TARGET2 claim vis-à-vis the deficit country. To illustrate TARGET2 in figure 5.9, the financial flows between households and RoEA (ΔB^* and $i^* B_t^*$) can be replaced by TARGET2 balances and, hence, equation (5.15) and (5.16) can be rewritten to:

$$target_t = (1 + i_{t-1} - \pi_t)target_{t-1} + nx_t \tag{5.17}$$

$$ca_t = target_t - target_{t-1} \tag{5.18}$$

Chapter 6

Conclusions

The aim of this thesis was to analyze the role of central banks in the context of financial crises. In particular, the thesis has examined (i) the potential monetary policy's role in causing a financial crisis and (ii) the central bank's management in times of crises.

Chapter 2 has focused on US monetary policy as a cause of asset price booms. The analysis was based on an extended GMM Taylor-type monetary reaction function, which captures asset price booms in the US real estate market. The estimation results give reason to suppose that US monetary policy responds pro-cyclicly to boom phases in the real estate market. According to the analysis the Fed did not increase interest rates in response to increasing real estate prices. This interest rate setting behavior therefore seems to create an implicit expansionary monetary impulse – or, put differently, the absence of a tighter monetary policy could be a driving force for further increases in asset prices (see Meltzer, 2002). This finding indicates that the interest rate setting behavior of the US monetary policy might has contributed to the formation of an asset price bubble, and hence to the outbreak of the financial crisis in 2007.

Chapter 3 has analyzed central bank actions in the course of financial crises. In particular, this chapter has evaluated the economic costs associated with the central banks' decisions to intervene or not to intervene in case of speculative attacks. Contrary to the typical public and academic perception, currency crises can be very heterogeneous events with quite different real effects. The monetary authorities with their decisions to intervene or not to intervene seem to play an important role for the economic costs of such financial crises. In case of a speculative attack, a central bank can in principle either intervene in the foreign exchange market to defend the exchange rate or she can remain passive, i. e. abstain from an intervention. If the central bank decides to intervene she can then either succeed or fail so that the currency depreciates. This gives rise to three distinct crisis events, namely immediate depreciations, successful defenses and unsuccessful defenses.

The empirical analysis of chapter 3 indicates that a successful defense, i. e. the central bank is able to stabilize the exchange rate with her interventions, yields the best result in terms of output growth. In this case the central bank can basically counteract the speculative attack, apparently without facing any economic costs, e. g. a recession due to a restrictive monetary policy. If the central bank starts to intervene in the currency market she faces the possibility of an unsuccessful defense either because she suspends her intervention voluntarily, e. g. the benefits of a stable exchange rate no longer exceed the costs of stabilizing, or involuntarily, e. g. as the reserves are depleted. Such an unsuccessful defense seems to be associated with the worst possible outcome with an average loss of around 5 per cent of GDP. If the central bank decides not to intervene, i. e. if she lets the domestic currency depreciate right away, she can expect an "intermediate" loss, with the economy passing through a mild recession. The decision to defend therefore is evidently quite risky. Abstaining from an intervention policy could be an interesting alternative for a conservative, risk-aware central bank.

Chapter 4 has extended the analysis of the previous chapter and has focused on a number of important macroeconomic variables, such as private consumption, investment, exports, imports, debt-to-GDP ratio, and unemployment rate. The analysis has applied a panel VAR framework to explicitly examine the macroeconomic dynamics following the three types of currency crises. The findings from the impulse response functions indicate that central banks can heavily influence the economic course of a currency crisis. The impulse response functions highlight the different policy approaches taken by central banks as response to a speculative attack. In the case of successful defenses the central bank follows a policy that is consistent with a stable exchange rate and is thereby able to neutralize the effect of the speculative attack. In the case of an immediate depreciation the central bank voluntarily abandons the exchange rate regime without intervening, and at the same time she tends to implement an expansionary monetary policy – possibly to support real growth. As this strategy is associated with little economic costs in terms of output growth, it may be considered as a distinct alternative monetary policy compared to defending the domestic currency. In contrast, the impulse response functions suggest a somewhat inconsistent monetary policy in case of an unsuccessful defense. On the one hand, the intervention policies are not expansionary enough to prevent a recession. And on the other hand, they are not restrictive enough to stabilize the exchange rate. As a consequence, this inconsistency might increase uncertainty, which in turn lead to an unsuccessful defense of the exchange rate and to high economic costs.

The results also imply that to not differentiate between the different types of crises is likely to bias policy recommendations in favor of exchange rate interventions. Analyses which intermingle the different types of currency crises typically overestimate the costs of immediate depreciations as the high costs of unsuccessful defenses dominate the relatively low costs of immediate depreciations and successful defenses. Subsequently, monetary authorities are inclined to intervene "too often" rather than to immediately give in to a speculative attack.

To adequately analyze the role of the TARGET2 system within the euro area, chapter 5 has examined the dynamics of TARGET2 balances. Against the background of the European debt and banking crisis, the TARGET2 system currently acts as an implicit stabilization mechanism, as it substitutes for missing private capital flows. Economists argue that if real economic imbalances will be removed, private capital flows would recover and, thus, TARGET2 balances would disappear – without causing any economic costs. The existing literature focuses on potential costs and risks, which are associated with the TARGET2 system, e. g. the costs in case of a euro area collapse or a member country exit. These studies, however, seem to neglect the aspect that even in "normal" times the current TARGET2 system might be associated with high economic costs. Given price differentials between EMU member countries, holding TARGET2 claims can incur losses in real terms – even without a collapse of the euro area.

The analysis finds that by the end of 2013 Germany has incurred losses from holding TARGET2 claims of around 13 bn. euros in real terms (in constant 1999 prices). The calculation of real gains and losses for each EMU member country suggests that the TARGET2 system can be considered a redistribution mechanism, which might help to finance necessary (real) economic adjustments. While the TARGET2 system cannot replace necessary adjustment processes, it might provide time and money that have to be used to implement reforms and adequate policies.

In summary, this thesis highlights that central banks play an important role with respect to financial crises. Of course, the relationship between monetary policy and financial crises has many different dimensions and this thesis cannot provide a comprehensive overview of all possible transmission channels through which monetary policy may determine the economic course before and after financial crises. Nevertheless, the results of this thesis indicate that central banks' decisions may affect the economic development in fundamental ways. They can help to mitigate the negative economic consequences of financial crises, but they can also sow the seeds for financial distortions. For this very reason, the economic effects of central banks' actions inevitably needed to be thoroughly examined to subsequently support tighter control of economic consequences.

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