TECHNISCHE UNIVERSITÄT MÜNCHEN
Lehrstuhl für Volkswirtschaftslehre
– Finanzwissenschaft und Industrieökonomik –

Foreign Indebtedness and Inflation

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Vollständiger Abdruck der von der Fakultät für Wirtschaftswissenschaften der Technischen Universität München zur Erlangung des akademischen Grades eines

Doktors der Wirtschaftswissenschaften (Dr. rer. pol.)

genehmigten Dissertation.

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Prüfer der Dissertation: 1. Univ.-Prof. Dr. Robert K. Frhr. von Weizsäcker
2. Univ.-Prof. Dr. Christoph Kaserer

Die Dissertation wurde am 13. März 2014 bei der Technischen Universität München eingereicht und durch die Fakultät für Wirtschaftswissenschaften am 15. Mai 2014 angenommen.

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Abstract

This thesis analyzes the connection between a country's external debt and monetary policy. It reveals that some countries' monetary policies directly influence the distribution of real wealth across countries and discusses the adverse incentives for policy-makers that accompany these actualities.

In the first chapter, I analyze the present distribution of dollar-denominated nominal assets and quantify the effects of different inflation scenarios on U.S. national wealth. It turns out that the U.S. economy as a whole would be a major beneficiary of surprise inflation and that even small increases in the U.S. inflation rate would entail substantial redistribution of wealth from international investors to U.S. debtors.

This result motivates the theoretical discussion of time-consistent monetary policy in the presence of external nominal debt. Thus, chapter two shows that by providing incentives to induce surprise inflation, foreign indebtedness exacerbates the time-consistency problem of monetary policy. I conclude that in order to avoid the concomitant long-run inflation bias, rules and regulations in countries exhibiting external debt denominated in their own currency should assure that conservative, cosmopolitan, and far-sighted individuals are in charge of monetary policy.

The third and final chapter addresses the cohesion of external debt and monetary policy in the euro zone. After carefully examining the novel forms of intra-European debt that have come along with the European Debt Crisis, I argue that one of these forms of debt might alter national preferences on monetary policy. Using a stylized theoretical model of inflation targeting in a monetary union, I ascertain under which circumstances such a divergence of national interests in fact risks the soundness of collective decisions on monetary policy. Applying these insights to the rules and regulations of the European Central Bank leads to new proposals for reform.

Acknowledgment

I express my gratitude to my advisor Professor Robert von Weizsäcker for sparking off my interest in this topic and for encouraging and supervising my research throughout my time at his chair. Further thanks go to my colleagues Christian Feilcke, Michael Horvath, Christoph March, Oliver Nikutowski, Marco Sahm, and Mareike Schad. Their comments and questions helped to deepen my understanding of the topic and to advance my research project. Working with them has been both enjoyable and inspiring, not least because of countless, fruitful lunchtime discussions on economics and politics. I'm also grateful to all student assistants helping me with my research. Among these, Leonard Przybilla deserves to find special mention here. His efforts in collecting data and proofreading were particularly valuable. Moreover, I thank Philipp König, Technische Universität Berlin, whose remarks fostered my comprehension of the European institutional framework.

Of course, I'm also indebted to my family and friends for supporting me while I was working on the thesis. A special thanks goes to my sister Claudia, who was never tired of listening to ideas and problems related to my research. Lastly, I want to thank Arjen Robben for scoring a goal that put me into very good humor when my dissertation entered its crucial stage.

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Chapter 1

Introduction

"The dollar may be our currency but it's your problem."

John Connally,
former U.S. Secretary of Treasury (1971)[1]

This quote from the late Bretton Woods era has doubtlessly lost none of its topicality. Back then, expansionary monetary and fiscal policies in the United States put downward pressure on the U.S. Dollar (USD) on foreign exchange markets. To keep exchange rates fixed at their predetermined levels, central banks in Japan and Western Europe saw themselves forced to accumulate large sums of dollars or dollar-denominated securities. Naturally, their dollar reserves gave these countries an interest in more restrictive and less inflationary U.S. policies since further USD inflation presented them with the choice between increasing their exposure to the USD even further and accepting losses through a controlled devaluation of the greenback. However, as suggested by the quote above, U.S. policy-makers' willingness to heed foreign interests when deciding on domestic economic policies was limited at best. Eventually, the U.S. refusal to restrain domestic inflation—or foreign central banks' refusal to import U.S. inflation—resulted in the abandonment of the fixed exchange rate regime of Bretton Woods.[2] With the introduction of flexible exchange rates, the U.S. saw the expected depreciation of its currency, which caused the value of foreign official reserves and thus the value of U.S. liabilities to foreigners to decline in real terms.

Some 40 years later, "global imbalances" are back on the agenda of international politics. Indeed, there are some similarities between the situation

[1]Quoted in James (1996), page 210.

[2]For a more extensive treatment of U.S. policies in the Bretton Woods era, refer to Meltzer (1991).

in the early 1970s and today. The USD is still by far the world's most important reserve currency, enabling the U.S. to borrow significant sums from abroad in its own currency. Again, fixed exchange rates are part of the problem as China keeps its currency undervalued against the USD, thereby piling up dollar-denominated securities—just as Western European and Japanese monetary authorities did in the Bretton Woods era. Today, however, U.S. foreign indebtedness is not restricted to foreign official holdings of U.S. securities. Rather, the majority of current U.S. external liabilities are against private investors residing in countries whose currencies are floating freely against the USD. Hence, for the most part, foreign holdings of U.S. debt are the result of private decisions on capital markets rather than of government intervention. Irrespective of their origination, substantial holdings of U.S. debt expose the rest of the world (ROW) to U.S. monetary policy. In fact, comparing past and present levels of U.S. foreign indebtedness reveals a vast discrepancy in magnitudes. While U.S. external liabilities at the end of the Bretton Woods period amounted to only about 6% of U.S. GDP at that time,[3] foreign holdings of U.S. debt securities today equal about 60% of current U.S. GDP.[4] Correspondingly, foreign exposure to U.S. monetary policies today is also on a completely different level.

With today's imbalances within the European Monetary Union (euro zone), there is a second link between the Bretton Woods era and the present, which is distinct from the apparent case of current U.S. foreign indebtedness described above. In fact, comparing the problems of the late Bretton Woods era with those of the euro zone today reveals noticeable parallels. Both then and now, systematic differences in past national inflation rates accounted for different levels of competitiveness between trading partners. In spite of private capital flows not matching current account surpluses or deficits, exchange rates between trading partners could not adjust in either of the two cases.[5] Hence, monetary authorities had to fill the gap between current and capital accounts to adjust national balances of payment. While the balancing occurred by the surplus countries deliberately accumulating foreign currency reserves in the Bretton Woods era, it occurs more accidentally through the

[3] This rate is calculated based on numbers quoted in figure 1 on page 34 of Eichengreen (2004) and U.S. Bureau of Economic Analysis (2013).

[4] The derivation of this number and a further breakdown can be found in sections 2.2 and 2.3.1.

[5] In fact, as opposed to the irreversibly fixed exchange rates in the euro area, the Bretton Woods system did grant countries the opportunity to revalue their currencies against the USD under certain circumstances. However, since frequent revaluations would have undermined the credibility of the fixed exchange rate system, exchange rate adjustments were the exception rather than the norm.

creation of claims and liabilities between the participating national central banks in the European Monetary Union.[6] Just as in the historical example, creditor nations consider deflationary policies on the side of debtor nations as the best way to dissolve imbalances. This time, however, creditor countries' bargaining position seems to be strong enough to actually enforce these policies. As in the case of current U.S. foreign indebtedness, the most striking difference between past and present is the discrepancy in magnitudes of cross-border claims. With free movement of goods and capital in the euro zone, the scope of cross-border investment in Europe today is much larger than in the much-less-integrated transatlantic economy of the Bretton Woods era. Accordingly, in case of a sudden reversal in private cross-border capital flows, the potential sums that monetary authorities have to absorb far exceed those of 40 years ago.

Although this brief sketch of historical parallels demonstrates that neither external indebtedness nor exposure to foreign monetary policies are new phenomena, I argue that current circumstances are indeed unique. In previous examples, foreign debt either involved quantities dwarfed by current sums, or was not denominated in a currency controlled by the debtor nation, or both.[7] Today, however, some countries—namely the U.S. and some Southern European nations—have accumulated unprecedentedly high amounts of external debt denominated in unbacked currencies that they at least partially control. In fact, significant nominal claims or liabilities in a country's own currency challenge the neutrality of monetary policy from a national perspective, as surprising inflation must no longer be zero sum. Thus, these actualities give rise to a connection between external debt and domestic monetary policy that has been outside the realms of most traditional economic models. Examining this link between foreign indebtedness and inflation is subject of this thesis.

One way to view today's levels of foreign indebtedness is to consider them an outcome or side-effect of financial globalization. With more or less free movement of capital between industrialized countries, only investors' willingness to lend limits the amount of debt a country can accumulate in its own currency. From that perspective, the issues discussed herein can be seen as part of a larger problem, namely the dichotomy between global markets

[6] A further explanation of the development and the nature of these claims can be found in chapter 4.2.2.

[7] For instance, Germany's war reparations after World War I were denominated in so-called Goldmarks, whose value were, of course, outside of the control of German monetary authorities. Similarly, developing countries' external liabilities today are barely denominated in domestic currencies.

and national institutions. Like in other fields of economic policy—such as issues of financial or environmental regulations—decisions on monetary policies are mostly taken on a national level by institutions with a mandate to serve the national interest, although the impact of these decisions may go beyond borders.[8] Just like any other externalities, the cross-border effects of monetary policy might lead to inefficiencies from a global perspective. Thus, by shedding light on these issues, this thesis may—in the best of cases—be a first step to improve the international institutional framework.

Contrary to most studies on external debt, this thesis neither addresses the question of how current levels of foreign indebtedness evolved nor of whether the current situation can be sustained over a longer period. Instead, I take the current distribution of nominal assets across countries as given and pay attention to its potential consequences. As such, the contribution of this dissertation is threefold.

First, chapter 2 examines the connection between foreign indebtedness and inflation on empirical grounds in the U.S. More precisely, I calculate the redistributional effects of unexpected inflation in the USD. Making use of various sources of publicly available information and financial market data, I assess the effects of four inflation scenarios on the values of cross-border investment between the U.S. and the ROW. Calculating the balance in U.S. gross gains and losses from borrowing and lending in USD, I quantify the change in U.S. national wealth in the case of surprise inflation. Moreover, by breaking down the corresponding change in the ROW's financial wealth to different countries and regions, chapter 2 provides a comprehensive account of winners and losers as a result of USD inflation.

Second, chapter 3 examines the connection between foreign indebtedness and inflation on theoretical grounds. At the center of attention are the issues of whether and how the presence of nominal external debt affects the political constraints on monetary policy. Using a stylized game-theoretic model, I identify circumstances under which foreign indebtedness exacerbates the time-consistency problem of monetary policy. The results include a characterization of eligible policy-makers in indebted countries and allow the subsequent discussion of rules and regulations aimed at avoiding a long-run inflation bias.

Third, chapter 4 examines the connection between foreign indebtedness and inflation in the European Monetary Union. In particular, I address the question of whether novel forms of international but intra-European debt

[8] The European Central Bank clearly represents an exception here.

might compromise the soundness of monetary policy decisions in the euro zone. As a first step to answer this question, I thoroughly investigate the aforementioned claims and liabilities between national central banks within the Eurosystem. In a second step, the findings of the previous step are applied to a theoretical discussion of inflation targeting in a monetary union. With the insights gained therein, I arrive at a simple proposal to improve the rules and regulations of the European system of central banks.

Chapter 2

Surprise Inflation and U.S. External Debt

In this chapter, I examine the connection between unexpected inflation in the U.S. Dollar and the level of U.S. national wealth. Following traditional economic analysis, the neutrality of money implies that the internal value of a nation's currency has no direct effect on a nation's aggregate wealth. This assertion does not hold for the U.S. in today's situation. Of course, surprising inflation is still a zero-sum game from a global, albeit no longer from a national perspective. Analyzing the present distribution of dollar-denominated nominal assets, it turns out that, today, the U.S. economy as a whole were a major beneficiary of an unexpected increase in the U.S. inflation rate. Quantifying these potential gains for different surprise inflation scenarios is the main objective of this chapter.

The chapter starts with a review of the academic literature on the redistributional effects of surprise inflation. Subsequently, I present some stylized facts on the recent evolution of U.S. public and private debt—both of which are essential determinants of the potential for U.S. windfall gains. Assessing these is subject of the third and fourth section, which form the main part of this chapter. At first, in section 2.3, I further narrow down the research question and expound the approach used to derive the results. In the final section, I present the results and discuss their robustness by altering some of the calculations' critical assumptions.

2.1 Literature Review

Of all potential real effects of inflation that Fisher and Modigliani (1978) specify in their general assessment of the costs of inflation, the distributional effects are certainly among the most pervasive. In fact, the claim that unexpected inflation favors debtors at the expense of creditors comes close to a truism. Yet, surprisingly little research effort has actually been spent on quantifying this side-effect of inflation. Among the classic contributions to this topic are Bach and Ando (1957) and the updated version of this study, Bach and Stephenson (1974). They distinguish between redistributional effects on incomes and wealth and find the latter to be quantitatively more important for the U.S. post world war II. Their conclusion that unanticipated inflation directly transfers real wealth from households to the government or indirectly from government creditors to taxpayers certainly still applies. Using survey data on household income and asset holdings, Budd and Seiders (1971) go more into detail and examine the distributional effect of inflation within the U.S. household sector. They find that there are modest gains by the middle class that are at the expense of the very poor and the very rich. A few years later, Wolff (1979) studied the effects of the high inflation period of the 1970s on the distribution of wealth across U.S. households. By and large, he supports the findings of Budd and Seiders (1971) that inflation benefits middle class against upper class households as the latter are net lenders to the former. Moreover, he finds that inflation induces transfers of real wealth from old-age to middle-age households.

Over the 1980s and 1990s, this line of research did not receive much scholarly attention. More recently, however, Doepke and Schneider (2006) revived the topic. In their seminal paper, they calculate the redistributional effects of different hypothetical, but well-defined surprise inflation scenarios between U.S. sectors and within the household sector at different points in time. Amongst other things, they find that, as opposed to earlier times, surprise inflation currently is no longer a zero-sum situation for the U.S. economy. They show that, as a net debtor, the U.S. economy as a whole would have gained significantly if inflation had surprisingly increased in 2004, which is the latest date in their dataset. This result and their methodology serves as an inspiration to the work in this chapter. Although the work herein borrows inspiration from Doepke and Schneider (2006), there are a couple of differences. First, this work features different inflation scenarios at another point in time. In particular, the reference date here lies after the disruptions of the financial and economic crisis beginning in 2008, which has altered the composition of portfolio investments significantly. More importantly, the assessment of the redistributional effect here is based on a different primary data source. Since the focus here lies entirely on the redistribution of wealth between the rest of the world and the U.S., data provided by the Treasury International Capital System (TIC) can be used. With respect to cross-border portfolio investment, this data source is much more detailed than the Flow of Funds data used in Doepke and Schneider (2006), leading to more accurate estimations of net foreign losses. Furthermore, using TIC data allows to split up foreign losses by major countries and regions.

One of the scenarios discussed in this chapter features an announced, permanent increase in the inflation rate, which is equivalent to an increase in the central bank's inflation target. Quantifying the redistributional effects of such an increase thus contributes to the ongoing debate among economists on whether the inflation target should be raised or not. So far, both proponents, such as Blanchard et al. (2010) or Ball (2013), and opponents of an increase, such as Mishkin (2011), exclusively focus on the allocative efficiency of such a measure. In light of the sizable distributional effects between the U.S. and the rest of the world unfolded in this study, a complete neglect of distributional issues, however, is not acceptable when discussing the assets and drawbacks of raising the inflation target.

While a general assessment of the rest of the world's exposure to the U.S. inflation rate was lacking prior to the study of Doepke and Schneider (2006), there is an older literature on a specific channel of wealth redistribution between foreigners and the U.S., namely U.S. seigniorage income from abroad. For instance, Fisher (1982) argues that the use of the U.S. dollar as the official (or shadow) currency in developing nations—a phenomenon usually referred to as "dollarization"—leads to annual foregone seigniorage revenues of up to one percent of GDP for these nations. Of course, the ROW's foregone seigniorage revenues accrue to the U.S., which thus gains from exporting its currency. According to more recent estimates, for instance in Goldberg (2010) or Feige (2012), U.S. taxpayers' windfall gains from this source amount to almost 30 billion USD a year. Although there is a close connection to this line of research, the estimates in this study do not directly contribute to the above-cited estimates. The calculations here estimate the impact of hypothetical surprise inflation scenarios, not the impact of regular, anticipated inflation. Whether surprise inflation increases U.S. seigniorage revenues from abroad is a priori not clear. As is discussed in section 2.3.2, the answer to this question depends on the reaction of foreign holders of U.S. currency to such a scenario.

Calculating the effects of U.S. inflation on the present value of cross-border portfolio investment, this chapter is also connected to the rapidly growing literature examining the returns that countries earn on their international investments. By formalizing a country's external constraint, Gourinchas and Rey (2007b) point out that countries that manage to earn higher real returns on their foreign investment than they pay on their liabilities to foreigners enjoy a relaxation of their external constraint. They show that for countries that are well-integrated into world capital markets—i.e. nations exhibiting large cross-border asset and liability positions—this "valuation channel" of external adjustment can be very important. Indeed, several studies, such as Gourinchas and Rey (2007a) or Habib (2010), have recently attributed large parts of the puzzling discrepancy between U.S. accumulated current account deficits and its negative, but surprisingly small net foreign asset position to significant net capital gains realized by U.S. investors over the last decade. By quantifying U.S. net capital gains in case of surprise inflation, this study specifies one of several potential channels through which the U.S. could obtain capital gains. Put differently, this study reveals that surprise inflation in the USD would significantly lower the real value of U.S. liabilities to the rest of the world and thereby, *ceteris paribus*, enlarge U.S. intertemporal consumption possibilities. From this point of view, surprise inflation in the dollar would be a way to reduce global imbalances without adjusting the net flow of goods and services—yet this way of adjustment is certainly not desirable from a creditor nation's perspective.

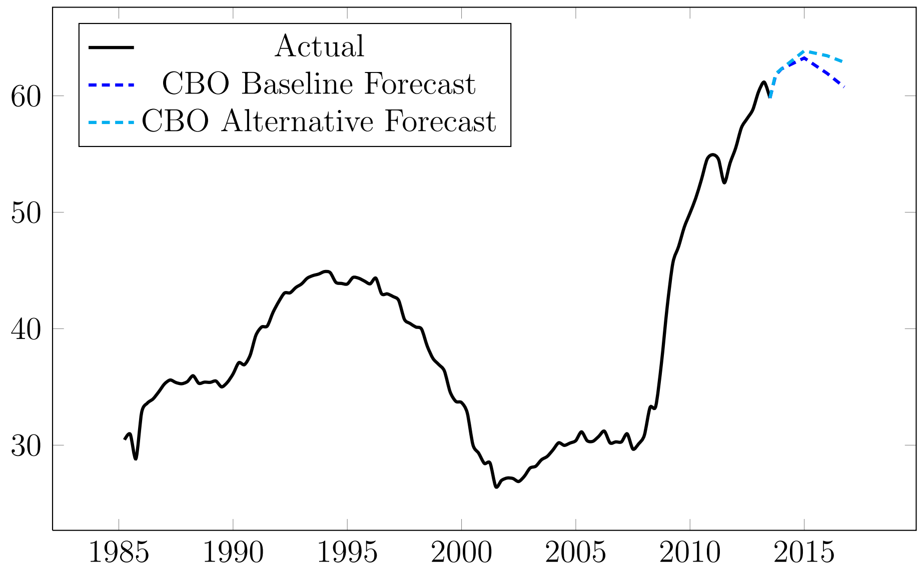
2.2 Stylized Empirical Facts

The following section lays out basic data on how important variables determining the potential for nominal wealth redistribution have evolved over the last decade. It starts with displaying recent trends in public debt and its ownership structure. Subsequently, data on U.S. private and public sector debt is aggregated to calculate the U.S. economy's net holdings of debt securities denominated in USD.

2.2.1 Government Debt

The fight against the economic crisis beginning in 2008 has entailed extraordinarily high public deficits in many countries around the world. In the U.S., tax deficits and the use of Keynesian stimulus packages resulted in the largest federal budget deficits post World War II. In the fiscal years 2009, 2010, 2011, 2012, and 2013, the federal budget deficit accounted for 10.1%, 8.9%, 8.6%, 7.0%, and 4.0% of GDP, respectively.[1] The outstanding amount of public debt has risen accordingly. Figure 2.1 shows how privately held public debt as a percentage of GDP has steadily increased over the last 15 years. In the context of sectoral redistribution of nominal wealth, this number is most relevant, since it does not include intragovernmental holdings. In particular, the Federal Reserve's sizable and rapidly growing holdings of Treasury securities are deducted from the total amount of outstanding debt. Foreign official holdings—holdings by public entities outside of the U.S.—are classified as private holdings.

Figure 2.1: Privately Held U.S. Federal Debt as a Percentage of GDP



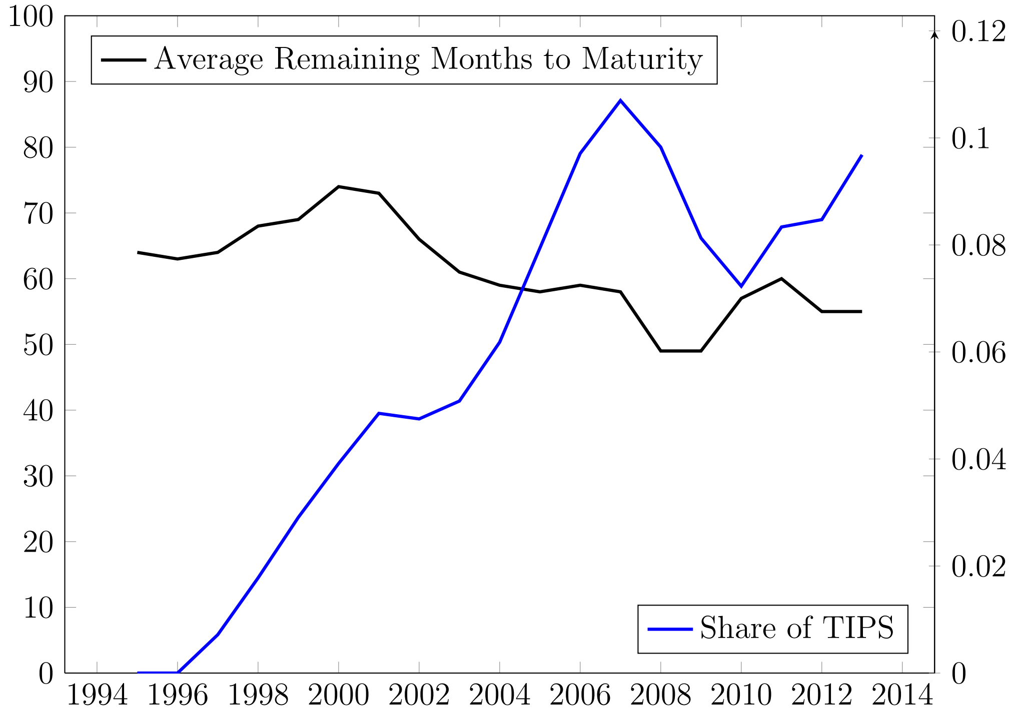
This ratio is calculated based on data from U.S. Congressional Budget Office (2013), CBO, and U.S. Bureau of Economic Analysis (2013).

The effect of the financial and economic crisis is clearly visible. While privately held public debt amounted to only about 32% of GDP in mid-2008,

[1]All figures are from U.S. Office of Management and Budget (2013), those for 2013 may be subject to revision at a later point in time.

it reached more than 60% of GDP by mid-2012. This sharp rise—the ratio almost doubled in just four years—is unprecedented in U.S. history post World War II. At least for the near future, there is little doubt among forecasters that the ratio will increase even further. For the more remote future, forecasts vary significantly due to high uncertainty about future economic performance and policy decisions. Two distinct forecasts, the Congressional Budget Office's "Baseline" and "Alternative Fiscal" scenario are depicted in figure 2.1 to illustrate the range of medium-term projections. In either case, a pronounced turnaround is not in sight and the outstanding amount of public debt is anticipated to remain at historically high levels over a long period.

Figure 2.2: Average Remaining Months to Maturity and Share of TIPS in Privately Held Public Debt



Both graphs are compiled based on data from U.S. Treasury (2013c).

The development of two further important criteria affecting the public's creditors' exposure to surges in the inflation rate is displayed in figure 2.2. The maturities of outstanding debt securities matter since the present values of payments due in the distant future are much more affected by additional inflation than those of payments due in the near future.[2] The importance of

[2]An in-depth-analysis of this relationship follows in section 2.3.2.

the share of Treasury Inflation-Protected Securities (TIPS) in total privately held public debt is evident in this regard as the real value of these securities is invariant to shifts in the inflation rate.

The black line exhibits that average maturity of government debt dropped from about six years in 2000 to about four years in 2008. Subsequently, the value stabilized between four and five years, indicating that the recent rise in debt levels has not coincided with a distinct reduction in average debt maturities.[3] At present, about 31% of all outstanding privately held federal debt securities mature within one year, about 43% mature in one to five years, about 17% in five to ten years and the remaining 9% in more than ten years.[4]

The blue line in figure 2.2 depicts the share of TIPS in total privately held public debt. After their introduction in 1997, TIPS have quickly become a popular investment and their market share increased sharply until the mid-2000s. From the middle to the end of the past decade their relative importance faded. Very recently, however, the share of TIPS rebounded a little bit to today's level of about 9.5%. Despite the slight upward trend in recent years, these numbers indicate that the vast increases in public debt levels since 2008 have, to a large degree, been carried out by issuances of conventional nominal securities.

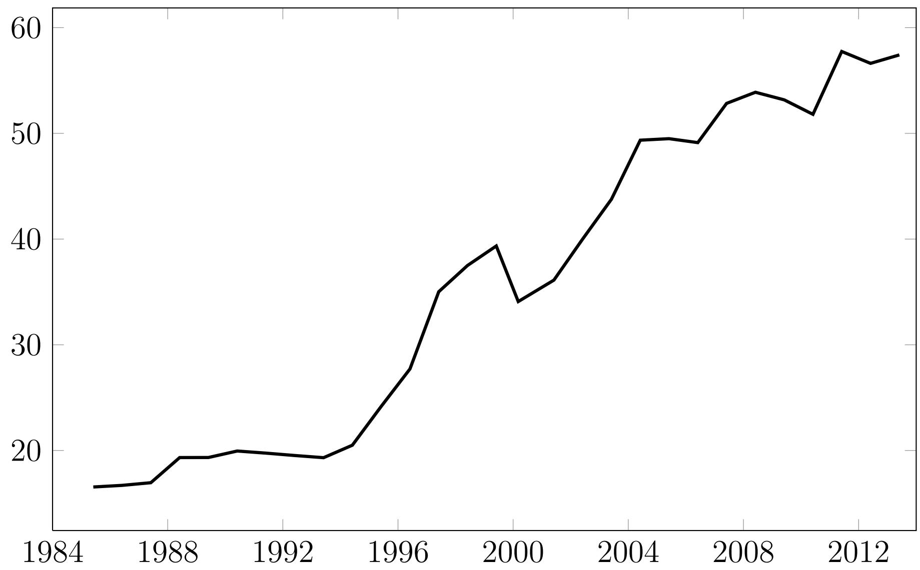
Summing up, the enormous rise in the level of U.S. public debt witnessed over the past five years, has neither be accompanied by reductions in debt maturities, nor by a significant expansion in the issuance of inflation-resistant government debt securities. Thus, the potential to reduce the real value of the public sector's outstanding debt through inflation has roughly increased in line with debt levels.

Of course, the government's windfall gain in case of surprise inflation would be at the expense of its creditors. Traditionally, the U.S. government's main creditors have been U.S. households either through direct holdings of Treasury securities or through indirect holdings via pension or other mutual funds. This pattern has changed significantly in the course of the last two decades, however, as the U.S. government has increasingly funded its deficits with the sale of debt securities to international investors.

[3]This data refers to the weighted average remaining years to maturity of *marketable* debt held by private investors. Since this comprises about 94% of total privately held public debt, average maturity of the latter should be pretty much alike.

[4]Cf. U.S. Treasury (2013c).

Figure 2.3: Foreign Ownership of Privately Held U.S. Federal Debt in Percent



The ratio is calculated based on U.S. Treasury (2013c).

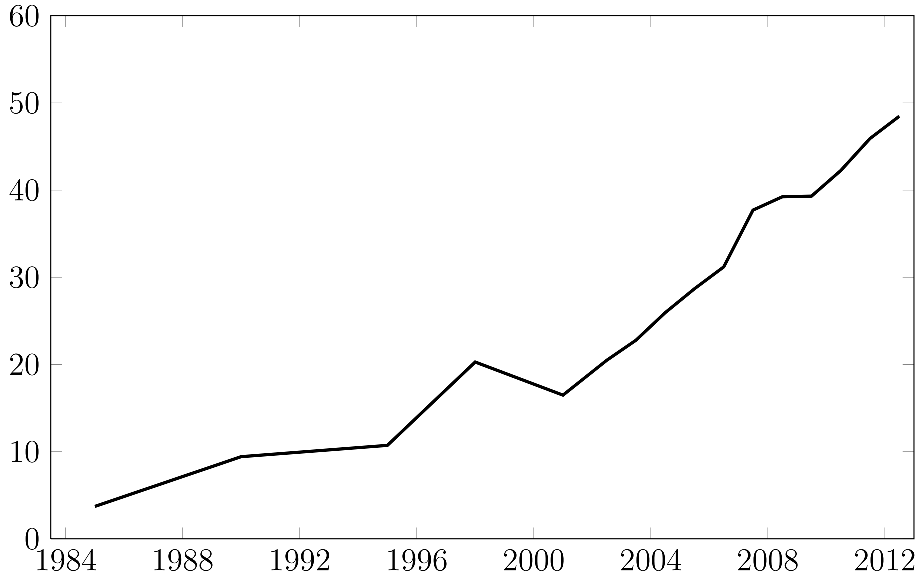
As figure 2.3 shows, the share of privately held U.S. public debt owned by foreigners has risen from about 15% in the mid-1980s to today's level of more than 57%, which equals about 5.7 trillion USD in absolute terms. Under the assumption that the share of public debt held by the rest of the world (ROW) remains constant—which seems to be rather conservative given the stable upward trend in this number over the past two decades—the above-mentioned projections of future federal debt levels imply considerable further rises in the outstanding amounts of foreign holdings over the next years.

These numbers show that, today, the U.S. government's gains in case of an unanticipated inflation in the dollar would, to a large degree, be saddled onto foreigners. Moreover, as the next section shows, U.S. government securities are not the only source of potential foreign losses in case of a surprise inflation.

2.2.2 U.S. Net Foreign Debt

Obviously, international holdings of dollar-denominated debt are not limited to Treasury securities. Foreign investors also hold substantial amounts of U.S. corporate and agency bonds as well as commercial paper and other forms of short-term debt.[5] Figure 2.4 shows that foreign holdings of dollar-denominated long-term debt securities have soared over the past two decades relative to U.S. GDP. Comparing the numbers to those in U.S. Treasury (2013c), one finds that despite featuring most prominently in the public debate, foreign holdings of Treasury securities accounted for only about 63% of total foreign holdings of dollar-denominated U.S. debt in June, 2012. This share went up from about 40% prior to the Great Recession, mirroring foreign investors' reluctance to lend to the U.S. private sector in the aftermath of the financial crisis of 2008.[6] This substantial shift in the composition of foreign investors' portfolios is usually refered to as a "flight to security," indicating that U.S. government securities are perceived to be a "safe haven" in times of high uncertainty. Regarding the broad trend of foreign lending to the U.S. economy as a whole, the crisis's impact is much less pronounced, as figure 2.4 illustrates.

Figure 2.4: Gross Foreign Holdings of Dollar-Denominated Long-Term U.S. Debt as a Percentage of U.S. GDP



The ratio is calculated using data from U.S. Treasury (2013b) for foreign holdings of U.S. debt securities and U.S. Bureau of Economic Analysis (2013) for data on U.S. nominal GDP. Securities with an original time to maturity of one year or above are classified as long-term.

Starting from almost negligible values in the mid-1980s, foreign holdings of dollar-denominated U.S. debt securities rose to about 48% of U.S. GDP by

[5] For detailed information on the classification of various assets classes, refer to the appendix on page 170 and the following.

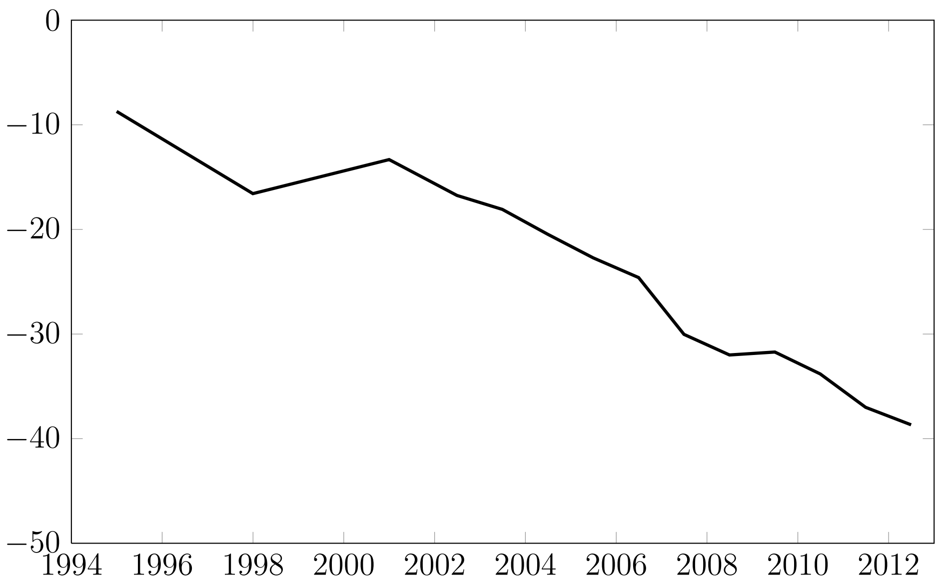
[6] The quoted numbers are calculated on the basis of U.S. Treasury (2013b).

June, 2012. This sharp increase reflects both the continuous current account deficits the U.S. has been running since the early 1980s and the financial globalization underway at the same time.

For the purpose of quantifying the rest of the world's exposure to surges in the U.S. inflation rate, data on foreign holdings of U.S. securities is not sufficient. This is due to the fact that foreign companies and countries also borrow in USD from the U.S., that is to say that there are positive gross holdings of dollar-denominated foreign debt for the U.S. economy. While the government's long position in these assets is insignificant, that of U.S. private investors is not. Hence, these holdings have to be subtracted from gross foreign holdings of U.S. debt in order to analyze the U.S. economy's *net holdings* of dollar-denominated long-term debt.

$$\begin{aligned} &\text{U.S. Net Holdings of Debt in USD} = \\ &\text{U.S. Gross Holdings of Foreign Debt in USD} \\ &-\text{Foreign Gross Holdings of U.S. Debt in USD} \end{aligned} \tag{2.1}$$

Figure 2.5: U.S. Net Holdings of Dollar-Denominated Long-Term Debt as a Percentage of U.S. GDP



To compile the ratio, data from U.S. Treasury (2013b) on foreign holdings of U.S. debt securities is augmented with data on U.S. holdings of foreign securities from U.S. Treasury (2012).

Figure 2.5 illustrates the development of the U.S. economy's net holdings of dollar-denominated long-term debt relative to U.S. GDP over the last 17 years. Taking into account U.S. holdings of dollar-denominated foreign debt lowers the ROW's nominal position. By June, 2012, net foreign holdings of dollar-denominated debt amounted to about 39% of U.S. GDP, which is about nine percentage points lower than gross foreign holdings. Yet, the overall picture remains unchanged, as is evidenced by a comparison of figures 2.4 and 2.5. In fact, the graph in the latter figure is nearly mirror-inverted to the one in the former figure. Summing up, the ROW is not just a large gross but also a large net nominal creditor to the U.S., and there is a broad trend of ever increasing U.S. foreign indebtedness in both gross and net terms.

This section exposed that the United States' net holdings of dollar-denominated debt securities have deteriorated significantly over the past two decades. By June, 2012, the U.S. economy has accumulated more than six trillion in net dollar-demoninated long-term debt, facilitating large potential wealth transfers in case of unanticipated inflation in the U.S. currency. By employing the numbers presented above, these wealth transfers are quantified for four hypothetical inflation scenarios in the following.

2.3 Data and Methodology

As a first step towards assessing the redistributional effects of different inflation scenarios, a uniform measure of wealth transfers has to be specified. Pivotal for the quantification is the choice of a reference day and a reference unit of account. Here, the reference day is June 30, 2012, which is, by the time of writing, the latest date on which detailed information on the ROW's holdings of U.S. assets is available. The reference unit of account is the value of one USD on the reference day, i.e. wealth transfers are measured in 2012 USD or as a percentage of nominal U.S. GDP in the second quarter of 2012.

Referring to the dollar as the unit of account for foreign losses might appear inappropriate at first sight. It does make sense, however, for various reasons. First, changes in the real value of nominal payments in USD imply that a foreign investor can exchange his nominal claims against fewer U.S. goods and services. His purchasing power in the U.S. diminishes. Second, a foreign investor suffers losses of the same magnitude even if he is solely interested in the amount of goods and services he can buy with his entitled payment streams at home. Since there is no reason why an increase in the U.S. price level should, *ceteris paribus*, affect real exchange rates, the nominal USD exchange rate will depreciate by the same proportion the U.S. price level increases.[7] Put differently, the dollar's external value changes in line with its internal value, leading to losses in the purchasing power of one USD both inside and outside of the U.S. Remembering that surprise inflation leads to a mere redistribution of total wealth, it becomes evident that U.S. gains must correspond to foreign losses of the same amount, no matter what unit of account is used.

In short, this chapter intends to answer the following question. How would the present value of U.S. national wealth have changed if a certain inflation scenario materialized on June 30, 2012?

Answering this question requires three basic steps. First, data on the ROW's long and short position in various asset classes has to be collected and consolidated (section 2.3.1). Second, I specify four different inflation scenarios and explain how each of these affect the present values of different types of assets (section 2.3.2). In the third and final step, the results of the previous two steps are brought together to calculate the ROW's net gains or losses. Of course, the calculated change in foreign wealth caused by an accelerated U.S. inflation rate is tantamount to a change in U.S. wealth of the same magnitude, albeit with opposite sign.

2.3.1 Data

This section expounds the sources of raw data on cross-border holdings of nominal assets. After a brief discussion of data classification issues, the consolidated cross-border investments in dollar-denominated nominal assets are presented.

Data Sources

The main data sources are the *Report on Foreign Portfolio Holdings* (U.S. Treasury (2013b)) and the *Report on U.S. Portfolio Holdings of Foreign Securities* (U.S. Treasury (2012)), both jointly edited by the Department of the Treasury, the Federal Reserve Bank of New York, and the Board of Governors of the Federal Reserve System. They are part of the *Treasury International*

[7]Consider the definition of the real exchange rate $\epsilon \equiv e\frac{P}{P^*}$ with P being the U.S. price level and e being the nominal exchange rate quoting the units of foreign currency one can exchange for one dollar. Keeping in mind that both the foreign price level P^*, and the real exchange rate ϵ are constant, it immediately follows from differentiating the equation with respect to time that $\frac{\dot{e}}{e} = -\frac{\dot{P}}{P}$.

Capital System (TIC), which intends to cover all U.S. cross-border portfolio investments. The two reports present the consolidated results of annual surveys, in which all financial institutions and custodians in the U.S. have to report their customers' international investment positions. By the time of writing, the latest figures on foreign portfolio holdings are of June 30, 2012, those of U.S. holdings of foreign securities are of December 31, 2011. Data on outstanding amounts are extrapolated to June, 2012 using estimations of monthly holdings of long-term securities (U.S. Treasury (2013a)), which are also provided by the TIC system.

TIC data incorporates all international cross-holdings of debt and equity securities but explicitly excludes holdings of currency, deposits, and loans. For these assets and liabilities, complementary information from the Federal Reserve's Flow of Funds Statistics (U.S. Federal Reserve Board (2013)) is accessed. In contrast to TIC numbers, these positions are quoted at par instead of market values. For these asset classes, however, par values are unlikely to differ significantly from unknown market values.

As is explained in section 2.3.2, assessing the market value change of securities under some inflation scenarios also requires information on securities' interest rate sensitivities. These are collected from Thomson Reuters Datastream (Datastream (2013)) and the bond index database of Bank of America Merrill Lynch.[8]

Data Classification: Nominal versus Real Assets

Although the dollar inflation rate can, in principle, have an effect on the real value of all assets denominated in USD,[9] only those that are directly affected are taken account of. Inflation has a direct effect on the value of all *nominal* claims, i.e. the present values of all assets containing fixed payments are sensitive to changes in the inflation rate.[10] The specific timing of fixed payment streams is irrelevant for the dichotomy of nominal and real instruments at this step of the procedure. For instance, cash and checkable deposits can be interpreted as securities with one fixed payment stream equaling their face

[8]Cf. Bank of America Merrill Lynch (2013f), Bank of America Merrill Lynch (2013g), Bank of America Merrill Lynch (2013e), Bank of America Merrill Lynch (2013k), Bank of America Merrill Lynch (2013h), Bank of America Merrill Lynch (2013i), and Bank of America Merrill Lynch (2013d).

[9]The real values of securities denominated in currencies other than USD are, *ceteris paribus*, not affected by the U.S. inflation rate. Thus, those assets are not considered in the calculations.

[10]More detailed information on the classification of particular assets can be found in the appendix on page 170 and the following.

value and are thus classified as nominal assets, although their maturity is zero.

All assets that do not include fixed payments are classified as real and left aside in the calculations. This means that their values are assumed to be invariant to changes in the inflation rate. Among the group of real assets held by foreigners, direct investment and equity are most important. The effect of inflation on the real values of these assets is ambiguous. Both assets constitute a claim on U.S. businesses. Whether these claims increase or decrease in value due to an increase in the inflation rate primarily depends on these businesses' net holdings of nominal assets.[11] If a foreign investor holds equities of a U.S. corporation whose nominal assets exceed its nominal liabilities, his shares should theoretically decline in value when the inflation rate increases. On the other hand, if a foreign investor holds shares in a U.S. business with a negative nominal position, his equity should theoretically increase in value when price increases accelerate. The omission of these indirect effects can thus lead to either an under- or an overestimation of the redistributive effect.

Assessing indirect effects would require lacking information on the net holdings of nominal assets of partly foreign-owned U.S. businesses for each asset class. Moreover, it is far from clear to what extent a company's potential gains or losses would be passed on to its shareholders as variable components of salaries and taxes might dilute the occurring effects. In any case, these potential indirect effects on the ROW's net wealth are dwarfed by the direct effects calculated in the following section.[12]

Data Classification: The Rest of the World

Another pivotal question is how foreign holdings of securities are distinguished from domestic holdings. In this regard, the classification of the main data sources is adopted. Both the TIC system and the FoF accounts classify investments according to the residency of investors, that is to say, a security is allocated to the ROW if its holder resides outside the U.S.[13] Using the

[11] There can be various dynamic effects of inflation on the real value of a company's earnings. For instance, if the adaptation of salaries lags the inflation rate, additional inflation temporarily enhances profits. All such dynamic effects are even more speculative than the effects on the business sector's existing assets and are thus ignored.

[12] Doepke and Schneider (2006) estimate the indirect effects through foreign ownership of U.S. equity to be close to zero after taking a number of simplifying assumptions.

[13] As is explained in greater detail in the appendix on page 174, cross-border security holdings of corporations are treated equally to holdings of indivuals, i.e. these holdings are attributed according to the registered offices of the corporations involved.

investor's residency as the criterion of distinction is the standard procedure in national accounting, which is, for instance, also used to calculate national income.

There are some caveats when investors hold securities indirectly through investment intermediaries residing in different countries. Holdings of this kind show up as holdings of the investment intermediary's country of residence, although the actual owner of the security resides somewhere else. Most of these difficulties only affect the attribution within the ROW, which is analyzed in section 2.4.2.[14] It cannot be ruled out, however, that some holdings of U.S. securities are falsely attributed to the ROW. In particular, holdings of U.S. securities assigned to Caribbean financial centers, such as the Cayman Islands, are likely to partly reflect actual holdings of U.S. citizens. While these holdings are attributed entirely to the ROW in the baseline configuration, as part of the robustness checks in section 2.4.3, the overall effects are also calculated net of all holdings of Caribbean financial centers.

U.S. Nominal Liabilities to the Rest of the World

Goal of this step of the procedure is to apportion the ROW's holdings of nominal securities as detailed as possible. For this purpose, various information on the distribution of foreign investment have to be aligned with each other. When information is lacking, additional assumptions are taken.

In U.S. Treasury (2013b), foreign holdings of U.S. debt are split up into two main categories, short- and long-term securities. All securities with an original time to maturity of one year and above are classified as long-term, all below as short-term. Within both categories, there is a further division in three different types of issuer, namely in Treasury, agency, and corporate debt securities. Agency debt includes all securities issued by a U.S. government agency other than the Treasury and those of government-sponsored enterprises.[15] In the case of long-term securities, holdings for each type of issuer are also subdivided into two types of assets. Holdings of Treasury securities are split up into holdings of conventional debt and TIPS, whereas holdings of corporate and agency debt are each divided into conventional and asset-backed securities (ABS). Both subdivisions are essential for the

[14] A more detailed discussion of these and other potential difficulties in TIC data can be found in Warnock and Cleaver (2003).

[15] In particular, this subcategory includes state and municipal debt and debt issued by the three real estate financiers known as "Fannie Mae," "Freddie Mac," and "Ginnie Mae."

calculation of foreign losses. By construction, the present values of TIPS are invariant to changes in the inflation rate, which is why these holdings are classified as entirely real and are thus not included in the further calculations. Differing ABS from conventional bonds is also important for three of the inflation scenarios discussed here, as the payment streams of ABS might differ significantly from conventional bonds of the same maturity, leading to different inflation sensitivities.

Moreover, U.S. Treasury (2013b) provides a breakdown of foreign holdings into those denominated in USD and those in other currencies for each of the three intermediate categories. Of course, in this context, holdings denominated in currencies other than USD are irrelevant. Unfortunately, information on the currency composition of foreign holdings by issuer *and* type of asset is lacking. In case of agency and Treasury debt, this does not cause any problems as these securities are almost entirely denominated in USD. For corporate bonds, however, the share of dollar-denominated assets in ABS and non-ABS securities has to be specified by an assumption.

Figure 2.6: Total (Dollar-Denominated) Foreign Holdings of U.S. Debt Securities as of June 30, 2012, in Billion USD

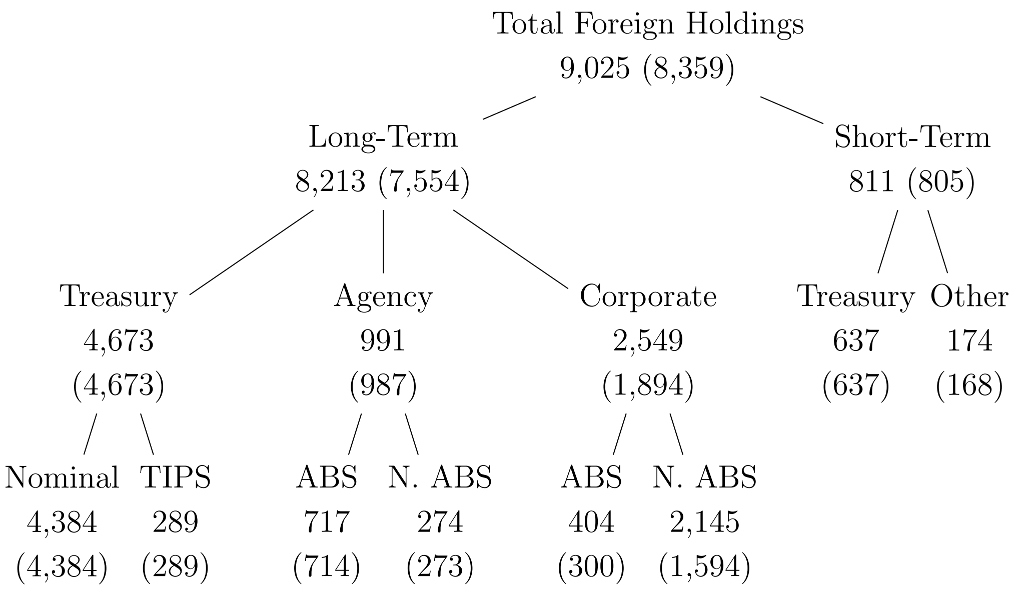


Figure 2.6 provides an overview of the ROW's gross holdings of U.S. debt securities by issuer, asset class, and currency composition.[16] Under the baseline assumption, the share of dollar-denominated securities is equal

[16]A further breakdown by major country for each category can be found in the spreadsheets supplementing this thesis.

for the two types of corporate debt. An alternative segmentation of dollar-denominated corporate debt is discussed in section 2.4.3.

To arrive at a more complete breakdown of foreign holdings of U.S. nominal securities, holdings by asset class have to be matched with information on the maturity distributions of foreign holdings of long-term debt. The latter comprises maturity distributions for each of the three subcategories of long-term debt—Treasury, agency, and corporate debt. Since these distributions refer to total instead of dollar-denominated holdings, specifying the maturity distribution of dollar-denominated corporate debt requires an additional assumption, namely that the maturity distributions of dollar- and foreign-currency-denominated debt are equal. Another problem is that maturity distributions by subcategories are not provided. For instance, the maturity distributions of foreign holdings of TIPS and nominal Treasury securities are unknown. Likewise, in the case of agency and corporate debt, the maturity distributions of ABS and non-ABS are also not enlisted separately. Under the baseline assumption, the maturity distributions of all subcategories equal those of their respective categories. Again, section 2.4.3 discusses alternations of these assumptions.

Table 2.1 displays the consolidated breakdown of foreign holdings of nominal U.S. securities under the baseline assumptions. Foreign gross holdings are heavily concentrated in Treasury securities, particularly in those with short to medium remaining times to maturity. The second-most important asset class is conventional (non-ABS) corporate bonds. With a total volume of about three-quarters of a trillion USD, holdings of agency ABS come in third. Compared to holdings of Treasury securities, holdings in the latter two categories are more centered on longer maturities.

Table 2.1: Foreign Holdings of Nominal U.S. Securities by Asset Class and Remaining Years to Maturity as of June 30, 2012, in Billion USD

Maturity	Treasury	Agency		Corporate		Total
		ABS	N. ABS	ABS	N. ABS	
ST	637	20	8	56	80	805
<1y	601	51	20	26	137	835
1-2y	802	52	20	27	143	1,044
2-3y	666	32	12	27	143	880
3-4y	399	17	7	28	147	598
4-5y	561	21	8	26	137	753
5-6y	285	9	4	20	107	425
6-7y	281	6	2	18	96	403
7-8y	175	4	2	11	69	261
8-9y	189	4	2	17	89	301
9-10y	145	4	1	12	62	224
10-15y	61	24	9	12	65	171
15-20y	44	9	3	11	56	123
25-30y	162	392	150	24	126	854
>30y	0	4	2	13	70	89
Total[a]	5,021	714	273	300	1,594	8,070

[a] Numbers may not add up to totals due to rounding.

Apart from portfolio investment in U.S. nominal assets, the ROW also possesses substantial amounts of U.S. currency, checkable and time deposits, and loans to U.S. businesses. Data on these positions is derived from U.S. Federal Reserve Board (2013) and displayed in table 2.2.

Table 2.2: Foreign Holdings of Non-Marketable Nominal U.S. Assets as of June 30, 2012, in Billion USD

Currency	Checkable Deposits	Time Deposits	Loans
422	74	285	166

Holdings of U.S. currency are the largest component of foreign investment in non-marketable U.S. debt.[17] These positions reflect the dollar's special role as the world's lead currency. In many countries around the globe, USD bills are used as substitutes to domestic money—especially in regions where the purchasing power of domestic money is volatile. Foreign investments in time and checkable deposits at U.S. financial institutions and loans granted to U.S. corporations are also significant. For the calculations, these positions are assumed to be entirely denominated in USD. Since the ROW's holdings of these assets are tiny compared to its holdings of marketable securities, this assumption plays a very minor role for the results of this chapter.

U.S. Nominal Claims against the Rest of the World

Another consequence of the dollar's central role in the world economy, is its use in the financing of foreign governments and businesses. In fact, most of the debt contracts between the U.S. economy and the ROW refer to the USD as unit of account. Thus, the U.S. economy does not just borrow from the ROW in USD, but also lends to the ROW in USD. Regarding these positions in isolation, the U.S. economy suffers losses in case of surprise inflation. These potential losses have to be offset against potential gains from the ROW's holdings of U.S. debt.

As in the case of the ROW's holdings of U.S. nominal assets, detailed information on U.S. holdings of foreign marketable assets can be found in data provided by the TIC system. In turn, all relevant information found in U.S. Treasury (2012) are brought together to arrive at the most detailed possible segmentation of U.S. holdings.

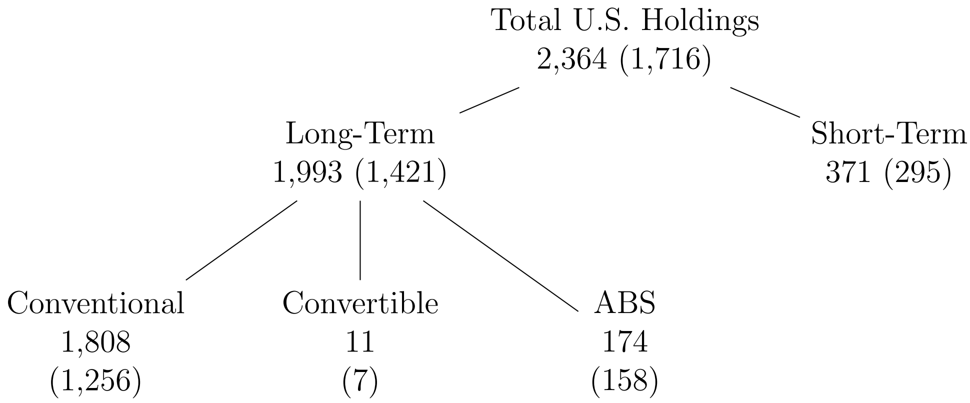
A first problem is that data in U.S. Treasury (2012) refers to end of December, 2011 instead of June, 2012. Thus, U.S. holdings have to projected from end-2011 to mid-2012 using preliminary estimations of U.S. holdings of long-term debt from U.S. Treasury (2013a).[18] With respect to data on maturity and country distributions, no further alignments are made.

Splitting up U.S. holdings of marketable securities into different subcategories, one faces similar problems as in the case of foreign holding of U.S. securities. For instance, U.S. Treasury (2012) divides holdings of long-term

[17]The exact amount of U.S. currency held outside of the U.S. is unknown. The number quoted here is the Federal Reserve Board's estimate for June, 2012. According to Feige (2012), this number is rather conservative compared to alternative estimates brought forward by scholars working on this subject.

[18]The procedure of the projection can be found in the appendix on page 174.

Figure 2.7: Total (Dollar-Denominated) U.S. Holdings of Foreign Debt Securities as of June 30, 2012, in Billion USD



debt into three different asset classes (conventional, convertible, and asset-backed securities) and into dollar- and foreign currency-denominated debt. Yet, the USD share for each of the three asset classes is not quoted. However, holdings by currency and asset class are broken down for different countries. Putting these two sources of information together, the implied currency distribution for each of the three types of debt securities can be calculated.

Figure 2.7 gives an overview of the consolidated U.S. holdings of marketable debt securities by type of asset and currency. With a total of about 1.7 trillion USD, U.S. nominal claims against the ROW only amount to about one-fifth of foreign holdings of U.S. nominal assets. As is pointed out in section 2.4, this immense discrepancy gives rise to a substantial potential for wealth redistribution in case of unexpected inflation.

The vast majority of U.S. holdings are in conventional dollar-denominated bonds. Although the share of dollar-denominated securities is higher for ABS than for conventional securities, USD holdings in the latter are still about nine times as large as USD holdings of foreign ABS. The third category, convertible bonds, is quantitatively of very minor importance.

Similarly to the procedure in the case of foreign holdings of U.S. debt, information on the maturity distribution of total U.S. holdings is used to subdivide holdings by asset class and remaining time to maturity. Since the maturity distributions for different asset classes are not enlisted separately, assumptions on these have to be made. Table 2.3 exhibits the breakdown of U.S. holdings of long-term securities under the baseline assumption that maturities do not differ across asset classes. Section 2.4.3 discusses an alternation of this assumption.

Table 2.3: U.S. Holdings of Foreign Nominal Securities by Asset Class and Remaining Years to Maturity as of June 30, 2012, in Billion USD

Maturity	Conventional	Convertible	ABS	Total[a]
ST	295	0	0	295
<1y	141	0.8	18	160
1-2y	118	0.7	15	134
2-3y	131	0.6	16	148
3-4y	95	0.6	12	108
4-5y	107	0.4	13	120
5-6y	73	0.3	9	82
6-7y	56	0.4	7	64
7-8y	63	0.4	8	71
8-9y	75	0.5	10	86
9-10y	89	0.3	11	100
10-15y	59	0.3	7	66
15-20y	45	0.3	6	51
20-25y	54	0.3	7	61
25-30y	79	0.5	10	90
>30y	70	0.4	9	79
Total[a]	1,551	7	158	1,716

[a] Numbers may not add up to totals due to rounding.

U.S. holdings of marketable foreign debt securities are roughly spread evenly across maturity clusters, with a slight bias towards maturities up to five years. Thus, average remaining years to maturity of U.S. nominal claims exceeds that of U.S. nominal liabilities against the ROW.

In addition to their holdings of marketable securities, U.S. citizens and corporations also possess non-marketable nominal claims against foreign entities. These predominantly comprise time and checkable deposits at foreign banks and loans granted to foreign businesses. Data on these are from the Federal Reserve's Flow of Funds statistics. Unfortunately, FoF accounts neither provide separate numbers for time and checkable deposits nor do they divide holdings into dollar- and foreign-currency-denominated claims. This lack of data requires taking additional assumptions. In the baseline configuration, the USD share of the aforementioned non-marketable asset classes is 75%, which roughly equals those in marketable securities. With respect to U.S. deposits abroad, the baseline assumption is that these are split up evenly into checkable and time deposits.

Table 2.4: U.S. Holdings of Foreign Non-Marketable Nominal Assets as of June 30, 2012, in Billion USD

	Checkable Deposits	Time Deposits	Loans
Total	385	385	193
Denominated in USD	289	289	144

As table 2.4 shows, the magnitudes of these positions are smaller than those of marketable securities. Comparing U.S. claims with U.S. liabilities in these asset classes, which are displayed in table 2.2, one finds that—in contrast to its net position in marketable securities—the U.S. economy's net position in non-marketable nominal assets is approximately balanced.

2.3.2 Inflation Scenarios

In the second step, the quantitative effect of surprise inflation episodes on the present values of nominal assets is specified. For this purpose, the following section lays out four specific inflation scenarios and presents the respective formulas that are used to calculate the changes in the present values of nominal assets.

As far as possible, redistributional effects are measured by hypothetical changes in the outstanding debt instruments' market values.[19] In principle, neither creditors nor debtors necessarily have to be concerned about the present market value of the underlying payment obligations, which remain unaltered. If an investor plans to hold a security until its maturity, fluctuations of the instrument's market price are irrelevant to him as long as his income from this security stays the same in real terms. This, however, is not the case if the change in market prices stems from a change of future (expected) inflation. Provided that expected inflation equals realized inflation, changes in current market prices exactly reflect the present values of

[19]The only exception to this approach applies to scenario III, which is discussed on page 35 and the following.

actual real-term losses or gains that creditors and debtors face in the future. In any other case, changes in current market prices can be seen as the best estimate for future real-term gains and losses. Thus, changes in the outstanding instruments' market prices constitute a reasonable measure of the redistributional effects of surprise inflation.

Of course, changes in the market or present values of nominal assets depend on the magnitude and length of the surprise inflation episode. The effect of the latter parameter can be gauged by comparing the results of the first, second, and fourth inflation scenario. In addition to the length of the surprise inflation episode, the amount of wealth redistribution also depends on how fast investors adapt their expectations to the new inflation path. Comparing the results of the second and third scenario allows a broad assessment of the scope of different expectation adjustments.

All four inflation scenarios represent very moderate episodes of surprise inflation. Under each scenario, the future inflation rate exceeds the previously anticipated inflation rate by exactly one percentage point, yet for different time intervals and different modes of adapting inflation expectations. Focusing on small amounts of surprise inflation bears the advantage that the assessments' inaccuracies due to the non-linear relationship between a payment stream's present value and future inflation rates are within an acceptable range. Moreover, a sudden outburst of rapid inflation seems rather unlikely in the present U.S. situation.

Scenario I

In scenario I, the USD inflation rate increases by one percentage point for one year. More precisely, scenario I implies that beginning on June 30, 2012, the U.S. inflation rate exceeded the previously anticipated rate by one percentage point for one year. To describe this and the following scenarios formally, I define π_t as the annual rate of inflation in period t (i.e. from point $t-1$ to point t) and Π_t as the accumulated rate of inflation from $t = 0$ to t. In continuous time, the accumulated rate of inflation is

$$\Pi_t = e^{\sum_{t=0}^{t} \pi_\tau} - 1.^{20} \tag{2.2}$$

[20]As it is assumed that the inflation rate is constant between periods, it is convenient to express the exponent as a sum of annual rates instead of the integral over the function of inflation rates of infinitesimally small periods.

Under this scenario, the first-year inflation rate increases by one percentage point ($\pi_1^I = \pi_1 + 0.01$), while all other annual inflation rates remain unaltered. This increase leads to a new accumulated inflation rate (Π_t^I) of

$$\Pi_t^I = e^{\sum_{t=0}^{t}(\pi_\tau)+0.01\min(1,t)} - 1 = e^{0.01\min(1,t)}(1+\Pi_t) - 1. \tag{2.3}$$

For all periods of one year or above, the new inflation factor, $(1+\Pi_t^I)$, is $e^{0,01}$ times the previous inflation factor, $(1+\Pi_t)$. For periods shorter than one year, the inflation factor increases by the factor of $e^{0,01t}$.

To evaluate how such an increase in the inflation rate affects the prices of nominal assets, one needs to make an assumption on the reaction of investors to the changes. In scenario I, it is assumed that investors—although they did not anticipate the surge in inflation prior to its occurrence—immediately understand the new inflation path and react correspondingly. This scenario is thus equivalent to a surprising announced increase in the inflation rate of one percentage point for one year. As investors understand that inflation is going to be higher in the following year, they instantenously adapt their inflation expectations. This means that inflation expectations increase in line with the inflation rate. Under the assumption that the surge in inflation expectations does not lead to a change in (expected) real interest rates, it immediately follows from the Fisher-equation relationship that nominal interest rates change in line with inflation expectations. In analogy to equation (2.2), the nominal interest rate from $t-1$ to period t is defined as f_t (forward rate) and the accumulated nominal interest rate from $t=0$ to t as

$$S_t = e^{\sum_{t=0}^{t} f_\tau} - 1. \tag{2.4}$$

By defining R_t^e as the accumulated expected real interest rate, the Fisher equation can be stated as

$$1 + S_t = (1+R_t^e)(1+\Pi_t^e). \tag{2.5}$$

Since R_t^e does not change, the inverse discount factor, $(1+S_t)$, changes in line with $(1+\Pi_t^e)$. In turn, as the increase in inflation is tantamount to an increase in expected inflation in this scenario, it follows from equations (2.3) and (2.5) that the discount factor under scenario I is

$$DF_t^I = \frac{1}{1+S_t^I} = \frac{1}{e^{\sum_{t=0}^{t} f_\tau + 0.01\min(1,t)}} = \frac{1}{(1+S_t)e^{0.01\min(1,t)}} = DF_t e^{-0.01\min(1,t)}. \tag{2.6}$$

For payments due in one year or more ($t \geq 1$), the new discount factor, DF_t^I, is $e^{-0.01}$ times the old discount factor, DF_t; for payments due within the next year ($t < 1$), it is $e^{-0.01t}$ times the old discount factor. Scenario I thus leads to an increase of the rate at which future payments are discounted. As a consequence, the present values of all assets featuring nominally fixed future payments decline. Starting from the basic formula expressing a security's price on the reference date, P_0, as the sum of its discounted payment streams ($P_0 = \sum_{t=0}^{T} C_t DF_t$), the price of a security under scenario I, P_0^I can be stated as

$$P_0^I = \sum_{t=0}^{T} C_t DF_t^I = \sum_{t=0}^{T} C_t DF_t e^{-0.01 \min(t,1)}. \tag{2.7}$$

The present value of a security consisting entirely of payments due in one year or more is $e^{-0.01}$ times the previous present value. Thus, the price change of nominal assets whose cash flows due in one or more years account for most of its present value can be reasonably approximated by multiplying the previous price with the factor $(e^{-0.01} - 1)$.[21] The price change is smaller for securities whose cash flows due in the near future account for a larger part of its previous price. For assets consisting entirely of cash flows due in less than one year, scenario I is equivalent to an upward shift of the entire yield curve by one percentage point. Hence, these securities' durations D can be used to calculate the change in prices.

With the definition of the duration as the weighted average maturity of cash flows

$$D = \frac{\sum_{t=0}^{T} t C_t e^{-\sum_{t=0}^{t} f_\tau}}{P},^{22} \tag{2.8}$$

the price change of a security maturing within one year approximately is $(e^{-0.01D} - 1)$ times the previous price. Which of the two factors is used for

[21]One way to assess the price change of a security is to divide its price into two components: $P = P_A + P_B$. P_A stands for the present value of cash flows due in less than one year and P_B stands for the present value of cash flows due in one or more years. The total price change can also be divided into these two categories: $\Delta P = \Delta P_A + \Delta P_B = (e^{-0.01t} - 1)P_A + (e^{-0.01} - 1)P_B$. If the present value of cash flows due in one or more years exceeds that of less distant cash flows by far ($P_B >> P_A$), the total price change can be approximated using $\Delta P = (e^{-0.01} - 1)P$. Put differently, $\Delta P \rightarrow (e^{-0.01} - 1)P$ if $\frac{P_B}{P_A} \rightarrow \infty$.

[22]As continuously compounding is used to express security prices, *Macaulay duration* and *modified duration* are equal, i.e. the duration measures both the weighted average maturity of cash flows and the absolute value of the partial derivative of the bond price with respect to its yield divided by P. To see this, it is useful to express the discount factor in period t as e^{-tf}, with f being the average annual forward rate. With that, a bond's price is $P = \sum C_t e^{-tf}$. Thus, $\frac{\partial P}{\partial f} = -\sum t C_t e^{-tf} = -\frac{D}{P}$.

a particular security depends on the security's duration.[23] Securities with a weighted average maturity of cash flows exceeding one year are treated as if their cash flows were entirely due in one year or more. Securities with a duration below one year are treated as if their cash flows were entirely due within the next year. Combined in one equation, the formula used to assess the impact of scenario I on the present value of dollar-denominated nominal assets is

$$\Delta P^{I} \approx P_0(e^{-0.01\min(1,D)} - 1). \tag{2.9}$$

Approximately, the present values of securities with a duration of one year or more decrease by about one percent of their previous present values. With about D percent, the approximated, hypothetical market price change of securities exhibiting a shorter duration is even smaller.

Price changes calculated with equation (2.9) are subject to some inaccuracies. First, using continuous instead of discrete compounding—for most marketable securities denominated in USD, interest is compounded semi-annually—leads to a slight overestimation of price changes. Given the very low interest rate environment on the reference date, however, the inaccuracies caused by this procedure are neglible. Second, the omission of higher order effects of interest rate changes (i.e. neglecting the convexity of the instruments) also leads to a slight overestimation of price changes. As the interest rate change considered in this and the following scenarios is only one percentage point, however, second and higher order effects are very small and their inclusion would not alter the results significantly. A third source of inaccuracies stems from lacking information on the exact timing and distribution of cash flows of cross-border investment positions. As was explained above, scenario I affects cash flows due within one year and those due in one or more years differently. Equation (2.9) implies that securities are either treated as if they entirely consisted of cash flows due in one or more years, or as if they entirely consisted of cash flows due within one year. This procedure leads to noticeable inaccuracies for securities featuring large cash flows in the near *and* the distant future. In the case of conventional bonds, which

[23]Since real-world securities are not priced using continuous compounding, distinguishing Macaulay duration from modified duration is necessary. The latter is used as the criterion of distinction and to calculate price changes using equation (2.9). Applying data on modified durations calculated for securities with discretely compounded yields in a formula expressing continuously compounded yields is actually inconsistent. The implied inaccuracies of this inconsistency, however, are very minor. Moreover, they have the positive side-effect of partly offsetting another minor source of inaccuracies, namely that originating from the omission of higher order effects of interest rate changes on security prices.

account for the most part of cross-border holdings of nominal assets, these inaccuracies are not significant as the repayment of principal at maturity dwarfs previous coupon payments in a low interest rate environment such as that on the reference day.[24]

The main advantage of this formula is its simplicity and universality. In fact, it can be applied to assess the price change of all nominal assets under scenario I. For instance, the duration of cash or checkable deposits is zero leading to no change in these assets' present values. Remembering that the real interest rate on all payments that are not fixed in advance is assumed to remain constant under this scenario, this result is apparent. Indeed, holders of cash or bank money do not necessarily lose in case of a surprising rise of inflation expectations. If they manage to switch their holdings in these asset classes into holdings of securities whose nominal returns exactly compensate for the rise in expected inflation—thereby keeping the real interest rate on these assets on its previous level of $-\pi_t\%$—the additional amount of inflation does not lead to a redistribution of wealth with respect to these asset classes. In other words, the assumption of immediate and perfect adaptation to the new inflation path by (foreign) investors implies that U.S. seigniorage revenues at the expense of foreigners do not change as a result of an increase in expected inflation.[25] In light of the limited substitutability of U.S. cash from the perspective of foreign holders, this procedure is very likely to underestimate true foreign losses when the USD inflation rate increases.

More generally, the assumption that there are no losses on future cash flows that are not fixed at the time the inflation surprise occurs, leads to rather conservative estimates or—as Doepke and Schneider (2006) put it—yields a "lower bound" on the actual losses investors in nominal assets suffer in case of surprise inflation. Compared to those in case of longer lasting increases in the inflation rate, potential losses on reinvested cash flows in this scenario, for instance, on coupons payed within the first year, are small. Thus, an alternative assumption on the reaction of investors to an increase in the U.S. inflation rate is only discussed for scenario II, which is described in the next paragraphs.

[24]For this and the other scenarios, "true" and approximated changes of the market values of hypothetical bonds are contrasted with each other in the appendix on page 181 and the following.

[25]This implies that the seigniorage-Laffer-curve, depicting U.S. seigniorage revenues from abroad as a function of the U.S. inflation rate, is expected to have had a slope of zero on June 30, 2012. Put differently, the inflation elasticity of foreign currency holdings had been -1 on this date.

Scenario II

In scenario II, the USD inflation rate increases by one percentage point for five years. More precisely, scenario II implies that beginning on June 30, 2012, the U.S. inflation rate exceeded the previously anticipated rate by one percentage point for five years. Each of the annual inflation rates of the five-year period beginning on the reference date increases by one percentage point. Expressed formally, this means

$$\pi_t^{II} = \pi_t + 0.01 \; \forall \; t \in [1, 5]. \tag{2.10}$$

In analogy to equation (2.3), the accumulated inflation rate under scenario II can be expressed as

$$\Pi_t^{II} = e^{\sum_{t=0}^{t}(\pi_\tau)+0.01\min(5,t)} - 1 = e^{0.01\min(5,t)}(1 + \Pi_t) - 1. \tag{2.11}$$

For all periods of five or more years past the reference date, the inflation factor is $e^{0.05}$ times the old inflation factor. For periods within the next five years, the inflation factor increases by a factor of $e^{0.01t}$.

Apart from the different length of the surprise inflation episode, scenario II does not differ from scenario I. In particular, the reaction of investors to the outburst of inflation is equal under both scenarios. Likewise, investors immediately understand the new inflation path and accordingly update their inflation expectations. Although the annual inflation rate is shifted upwards for an interval of five years, only the initial hike comes at a surprise to investors. Thus, just like scenario I, scenario II examines the effects of a one-time surprise as opposed to repeated inflation surprises. As was explained in the previous paragraphs, under the assumption of a constant real yield curve, the implied increase in inflation expectations gives rise to an increase in nominal interest rates. The increase in nominal interest rates, in turn, alters the vector of factors at which future cash flows are discounted to assess their present values. Under scenario II, the discount factor in period t is

$$DF_t^{II} = \frac{1}{1 + S_t^{II}} = \frac{1}{(1 + S_t)e^{0.01\min(5,t)}} = DF_t e^{-0.01\min(5,t)}. \tag{2.12}$$

As a result of the increase in nominal interest rates, all future payments are discounted at higher rates, i.e. the discount factor decreases. For payments due in five or more years, the new discount factor is $e^{-0.05}$ times the old discount factor. Future payments due within the period of accelerated inflation are multiplied by $e^{-0.01t}$ times the old discount factor to arrive at their present values. Analogous to equation (2.7), the price of a security under scenario II can be stated as

$$P_0^{II} = \sum_{t=0}^{T} C_t DF_t^{II} = \sum_{t=0}^{T} C_t DF_t e^{-0.01\min(5,t)}. \tag{2.13}$$

The present values of all payments due in five or more years past the reference day decrease by $(e^{-0.05} - 1)$ times their previous present values, or about five percent. Cash flows maturing in less than five years lose a smaller share of their previous present values, namely $(e^{-0.01t} - 1)$. Unfortunately, data on cross-border security holdings do not reveal the composition of cash flows by maturities, which is why the price change of securities consisting of payments of both of the two maturity categories can not be calculated exactly under scenario II. Applying the same procedure as in scenario I, securities exhibiting a duration of less than five years are treated as if they solely consisted of payments due within five years past the reference date. Those securities whose weighted average maturity of cash flows exceeds five years are treated as if they entirely comprised cash flows due in five or more years past the reference date. This procedure leads to an equation to assess the price changes of nominal assets that is very similar to that under scenario I, stated in equation (2.9). The approximated change of the market value of nominal assets under scenario II is

$$\Delta P^{II} \approx P_0(e^{-0.01\min(5,D)} - 1). \tag{2.14}$$

As in the case of scenario I, approximated price changes are subject to some inaccuracies.[26] Since the episode of surprise inflation in scenario II lasts longer than in scenario I, payments due in more than one year past the reference day exhibit a larger decrease in present value. As a result, creditors entitled to nominal payments in the more distant future suffer higher losses than under scenario I. On the other hand, debtors that have concluded long-lasting credit contracts with their creditors gain more than under scenario I, as the present value of their future payment obligations declines.

In a scenario of this kind, in which the additional amount of inflation only initially surprises investors, the duration of credit contracts is a pivotal determinant of the amount of wealth redistributed from creditors to debtors.

[26] These inaccuracies are discussed in the appendix on page 181 and the following

This parameter forfeits its importance if the additional amount of inflation comes at recurrent surprises, as is the case in scenario III.

Scenario III

With respect to the magnitude of additional inflation, scenario III is equivalent to scenario II. The annual inflation rates in the five-year period beginning on the reference date increase by one percentage point, i.e.

$$\pi_t^{III} = \pi_t + 0.01 \; \forall \; t \in [1, 5]. \tag{2.15}$$

Thus, the accumulated inflation rate under this scenario is

$$\Pi_t^{III} = e^{\sum_{t=0}^{t}(\pi_\tau)+0.01\min(5,t)} - 1 = e^{0.01\min(5,t)}(1 + \Pi_t) - 1. \tag{2.16}$$

As in scenario II, the inflation factor under scenario III, $(1+\Pi_t^{III})$, is $e^{0.05}$ times the previous inflation factor for periods of five or more years past the reference date. For periods shorter than five years past the reference date, the inflation factor only increases by the factor of $e^{0.01t}$.

With respect to the reaction of investors to the outburst of inflation, however, scenario III diametrically differs from scenario II. In the latter, investors immediately understand the new inflation path and are thus able to avoid any losses on non-fixed payments. In contrast, in scenario III, it is assumed that the rise in inflation does not alter inflation expectations at all. This means that over the entire surprise inflation episode, investors do not realize that inflation is systematically higher than previously anticipated. They are recurrently surprised by the additional amount of inflation as it occurs. Recurrent surprises do not mean that investors are unable to realize that inflation has been higher than anticipated ex post. Rather, recurrent surprises imply that investors perceive realizations of additional inflation as random deviations from the path of inflation they have anticipated. Consequently, they do not draw conclusions from the realization of higher than expected inflation and do not react to these news at all. Thus, neither nominal yields nor market prices would have changed on the reference date under this scenario.

Nevertheless, a surprise inflation of this form also leads to a redistribution of wealth from creditors to debtors. However, redistribution here is not a result of discounting future payments at a higher rate. Instead, redistribution occurs as the future purchasing power of all nominal claims declines. Knowing that the future purchasing power of nominal claims declines and that future real values are discounted by the same discount rates—nominal interest rates do not change—implies that today's real value of nominal claims must also decline.

One way to understand creditors' losses under such a scenario of recurrent inflation surprises is to consider how the real interest earned on nominal assets is affected. Since all nominal interest rates remain unaltered, the annual real interest rate on all nominal assets, r, declines by one percentage point in each period in which there is additional inflation. Accumulated over the entire period of surprise inflation, the present value of the foregone real profit ($-\Delta\tilde{P}^{III}$) from the perspective of creditors thus is

$$\Delta\tilde{P}^{III} = P_0(e^{\sum_{t=0}^{t}\Delta r_\tau}-1) = P_0(e^{\sum_{t=0}^{t}-(\pi_\tau^{III}-\pi_\tau)}-1) = P_0(e^{-0.05}-1).^{27} \quad (2.17)$$

Under this scenario, the present value of the accumulated future real yield earned on all nominal assets—irrespective of their maturities—decreases by the factor of $e^{-0.05}$. Economically, a loss of future earnings is tantamount to an actual or realized loss, which is why this scenario is de facto equivalent to an instantenous increase in the price level by the factor of $e^{0.05}$. Since investors do not react to the additional increases in prices under this scenario—each additional increase comes at a surprise to them—their losses are as high as if the entire increase in prices occurred in one surprising jump. As was explained above, market prices of nominal assets would not change under this scenario as investors do not realize that the path of inflation has changed. Thus, investors' losses here can only be stated as implied losses, $\Delta\tilde{P}$.

Another way to grasp the losses of creditors is to reframe the scenario slightly. Not understanding the new inflation path is equivalent to understanding it, but being unable to react to it. Hence, the implied losses that investors suffer under this scenario are equivalent to those of investors who understand that the inflation rate is higher than previously anticipated but face returns on their assets that are fixed throughout the surprise inflation episode. Since nominal returns are fixed in both cases, the nominal value of

[27] Again, P_0 refers to the previous (nominal) present value of a nominal asset. The nominal value of the asset increases with the nominal interest that is earned on it over time ($P_t = P_0 e^{\sum i_t}$). The real interest earned on P_t in period t is the real interest rate in that period multiplied by the nominal value of the asset $(e^{r_t}-1)P_t$. Expressed in present values, this real interest is $(e^{r_t}-1)P_t e^{\sum -i_t} = (e^{r_t}-1)P_0$. Thus, the present value of the foregone real interest is the accumulated loss of real interest multiplied by the previous present value of the nominal asset, $(e^{-0.05}-1)P_0$.

these assets at $t = 5$ would not be altered. However, with the knowledge that accumulated inflation over the period increases by the factor $e^{0.05}$, an informed investor would discount this nominal value at a higher rate. More precisely, an informed investor's discount factor for cash flows due at the end of the inflation episode, DF_5^{III}, would be $e^{-0.05}$ times his previous discount factor for that time interval. Thus, from the perspective of an informed investor, the present value of all nominal assets would decline by $(e^{-0.05} - 1)P_0$, which confirms the result of equation (2.17). In this version, it becomes clear that investors' losses under scenario III are the sum of those under scenario II and additional losses on nominal assets with non-fixed pay-offs.

The main difference between the amount of wealth redistribution under this and the previous scenario arises from those nominal assets whose returns are not fixed over the inflation period. While investors do not suffer any losses on these claims under scenario II, they suffer losses that are as high as if their claims were fully fixed under scenario III. For instance, foreign holders of U.S. currency are not affected by the additional amount of inflation under scenario II, since rational investors could—at least theoretically—avoid losses on these positions by instantenously switching into real securities. In contrast, under scenario III, foreign holders of U.S. currency do not change their investment decisions at all, implying that these holdings are fully affected by the increase in inflation. Thus, for this scenario, the assessed present value loss is fictional. It equals the present value of additional U.S. seigniorage revenues from abroad earned over the period of surprise inflation. Put differently, the inflation elasticity of foreign holdings of U.S. currency is assumed to be zero under this scenario—as opposed to -1 under scenario II.

Since investors do not understand that inflation is systematically higher for a period of time, their losses due to the acceleration of price increases are particularly high. In the words of Doepke and Schneider (2006), applying the assumption of recurrent surprises thus leads to an "upper bound" on actual losses in case of a surprise inflation episode of this magnitude. Neither the assumption of scenario II, that investors are fully able to avoid losses on non-fixed cash flows, nor that of scenario III, that they are completely unable to avoid losses on these positions, is realistic. Yet, comparing the amount of wealth redistribution between scenarios II and III allows the reader to get a picture of the broad range of the actual amount of wealth redistribution when inflation increases unexpectedly by a certain amount for a certain time.

Scenario IV

The fourth and last inflation scenario features a permanent increase of the inflation rate. Beginning on the reference day, all future annual inflation rates increase by one percentage point. Expressed formally, this means

$$\pi_t^{IV} = \pi_t + 0.01 \; \forall \, t, \tag{2.18}$$

which leads to an accumulated inflation rate of

$$\Pi_t^{IV} = e^{\sum_{t=0}^{t}(\pi_\tau)+0.01t} - 1 = e^{0.01t}(1 + \Pi_t) - 1. \tag{2.19}$$

Under this scenario, over the entire investment horizon, the difference between the old and the new inflation factor increases with time. Since prices permanently rise at a faster rate, accumulated inflation diverges from its previous levels with distance to the reference day.

As in scenarios I and II, the public is assumed to understand the new inflation path immediately. Investors instantenously adapt their inflation expectations and react to the acceleration of price increases by demanding higher nominal interest rates on all newly formed credit contracts. Therefore, this scenario is equivalent to a surprising and credible announcement that inflation is going to be one percentage point higher than previously expected. In fact, this scenario analyzes what would have happened if the Federal Reserve had raised its inflation target by one percentage point at the reference day. With prominent economists recently advocating a raise in the inflation target to four percent[28]—which is twice as high an increase as discussed here—this scenario is certainly not beyond all question.

Since investors are fully informed about the new inflation path, they accordingly raise their inflation expectations, which, *ceteris paribus*, leads to an increase in nominal interest rates on the reference day. Since the expected inflation rate increases over the entire investment horizon, annualized nominal interest rates for all maturities also increase by one percentage point. Thus, this scenario is equivalent to an upward shift of the USD yield curve by one percentage point on the reference day. As a consequence, the time value of money changes. The new vector of discount factors used to assess the present value of a cash flow in period t is

$$DF_t^{IV} = \frac{1}{1 + S_t^{IV}} = \frac{1}{(1 + S_t)e^{0.01t}} = DF_t e^{-0.01t}. \tag{2.20}$$

[28] Cf. Blanchard et al. (2010) or Ball (2013).

All future payments are now discounted at a higher rate, depressing today's value of nominal assets. While the present value change of cash flows due in the near future is small, that of payments due in the remote future is considerable. For example, a cash flow due in one year loses about 1% in value under this scenario. In contrast, the present value of a cash flow due in twenty years decreases by more than 18%. Correspondingly, holders of nominal securities with long remaining times to maturity suffer most under this scenario.

Since all nominal interest rates increase by one percentage point under this scenario, the price change of all securities can be approximated using their durations. Expressed in terms of its previous market value, a security's price change under scenario IV approximately is

$$\Delta P^{IV} \approx P_0(e^{-0.01D} - 1).^{29} \tag{2.21}$$

Price changes calculated with equation (2.21) are not exact. However, the inaccuracies for this scenario are very minor as one formula applies to all cash flows. In particular, as opposed to scenarios I and II, no additional assumptions on the distribution of cash flows have to be taken, which eliminates the most important source of inaccuracies.

Summing up, scenario IV features an initially surprising, permanent increase of annual inflation rates. Under this setting, the maturities of cash flows play a pivotal role in assessing the amount of redistributed from creditors to borrowers, as securities with long remaining times to maturity are most sensitive to increases in nominal interest rates.

Among scenarios I, II, and IV, the latter leads to the largest redistributional effects. In fact, since the length of the surprise inflation episode increases from scenario I to II and from II to IV, the amount of wealth redistribution under scenario I is a subset of that under scenario II, which in turn is a subset of that under scenario IV. Comparing the latter to scenario III, however, it is a priori unclear which of the two scenarios yields larger magnitudes of wealth redistribution. To facilitate the reading of the next section, the scenarios' most important features and formulas are recapitulated in table 2.5.

[29] Again, modified duration is used to assess the price changes of marketable securities, as these are not priced with continuous compounding.

Table 2.5: Scenarios I-IV at a Glance

Scenario	Length of Surprise Inflation Episode	Adaptation of Expectations	Approximated Price Change
I	1 year	Immediately	$P \cdot (e^{-0.01 \min(1,D)} - 1)$
II	5 years	Immediately	$P \cdot (e^{-0.01 \min(5,D)} - 1)$
III	5 years	Never	$P \cdot (e^{-0.05} - 1)$
IV	Enduring	Immediately	$P \cdot (e^{-0.01D} - 1)$

2.4 Assessing Redistributional Effects

With the results of the first two steps—the consolidated cross-border holdings of nominal assets and the equations used to assess the price changes of nominal assets under certain scenarios—calculating the amount of wealth redistribution entailed by the four inflation scenarios in the third step is not too difficult an undertaking. The formulas derived in the previous section are simply applied to data on foreign holdings of U.S. nominal securities and on U.S. holdings of foreign securities. Setting off U.S. gross gains against U.S. gross losses leads to figures on U.S. net gains for each of the four inflation scenarios. As none of these actually materialized on the reference date, the calculations represent an exercise in counterfactual thinking. Nevertheless, the obtained results are on no account irrelevant from today's perspective. In view of the rather sluggish behavior of most of the underlying parameters, the calculated effects, in fact, constitute reasonable benchmarks for the impact of moderate inflation episodes beginning today or in the near future.

This section starts by presenting quantitative estimates on U.S. net gains for each scenario, which are the main results of the calculations under the baseline assumptions. Subsequently, as far as possible, foreign losses are split up into different countries and regions. Finally, to discuss the robustness of the results presented before, the calculations are repeated for various alternations of the assessment's critical assumptions.

2.4.1 U.S. Net Gains

Applying the above-described formulas to consolidated data on U.S. long and short positions in dollar-denominated nominal assets allows the calculation of U.S. gross and net gains for each scenario. Table 2.6 shows the results under the baseline assumptions,[30] both in absolute terms and as percentages of U.S. GDP on the reference day.

Table 2.6: Changes of U.S. National Wealth in Billion USD (as Percentages of U.S. GDP)

Scenario	Gross Gains	Gross Losses	Net Gains
I	73 (0.45)	17 (0.11)	56 (0.35)
II	235 (1.45)	54 (0.33)	181 (1.11)
III	440 (2.72)	119 (0.74)	321 (1.99)
IV	330 (2.04)	78 (0.48)	252 (1.56)

Under the first scenario, the U.S. economy gains about 56 billion USD or 0.35% of GDP. Given that inflation only increases by one percentage point for one year—which is about a standard deviation of average U.S. inflation rates over the last 15 years—a wealth gain of 56 billion USD is substantial. As expected, U.S. net gains are even larger for longer periods of surprise inflation. Under scenario II, in which inflation rates exceed the previously anticipated ones by one percentage point for five years, U.S. net wealth increases by about 181 billion USD. Remembering that this number is calculated under the strong assumption that foreign investors react optimally to the increase in inflation, a net gain of this magnitude is even more striking. Comparing this number with U.S. gains under scenario III, the importance of the adaptation of expectations becomes apparent. If investors do not react to the increase in the dollar inflation rate—for instance, because they perceive additional inflation as a random deviation from their expectations—the ROW's net loss amounts to 321 billion USD, which is almost 2% of U.S. GDP. Hence, realizing that inflation is going to be higher for five years saves foreigners about 140 billion USD. These 140 billion USD, i.e. values between 181 and 321 billion USD, can be interpreted as a broad range of the amount of wealth redistribution between the U.S. and the ROW in case of a surprise inflation of this magnitude. For longer periods of additional inflation, or stronger increases in the inflation rate, expectations play an even more major role.

[30] A list of all assumptions made under the baseline calculation can be found in the appendix on page 184.

Interestingly, the amount of wealth redistribution under scenario IV is smaller than under scenario III. To comprehend this result, it is useful to compare the two scenarios starting from the amount of wealth redistribution under scenario II. On top of this, there are losses on cash flows due within the five years of surprise inflation under scenario III. In contrast, the ROW suffers additional losses on cash flows that are fixed for more than five years past the reference date under scenario IV. A higher amount of wealth redistribution under scenario III than under scenario IV thus means that the ROW's additional losses on its net holdings of short- and medium-term securities under the former exceed the additional losses on long-term securities under the latter. Hence, due to the concentration of foreign investment in U.S. short- and medium-term securities, U.S. gains in case of a period of recurrent inflation surprises are more pronounced than those in case of an only initially surprising, but permanent increase in inflation. Nonetheless, with U.S. net gains of more than 1.5% of GDP, the amount of cross-border wealth redistribution under scenario IV is far from being insignificant. In fact, net wealth gains of this magnitude would be an explosive side-effect of an increase in the inflation target by the Federal Reserve.

The numbers displayed in table 2.6 refer to the total amount of wealth that would have been redistributed from the ROW to the U.S. economy if the respective inflation scenario materialized on the reference date. Knowing the ROW's holdings of Treasury securities and U.S. currency, it is possible to split U.S. gains up into those by the federal government and those by the rest of the economy. For this calculation, it is assumed that the federal government does not hold significant amounts of foreign dollar-denominated debt. Thus, the government's gross gains at the expense of foreigners equal its net gains at the expense of foreigners. The amount of wealth redistributed from the ROW to U.S. private sectors (including U.S. agencies other than the federal government) is then simply calculated as the difference between the U.S. economy's net gain and the federal government's net gain at the expense of the ROW. It is important to note that these figures measure the sectors' gains at the expense of the ROW, not the total gains of these sectors. Distinguishing these two measures is necessary, since surprise inflation also leads to sectoral redistribution of wealth within the U.S. economy. In particular, U.S. private investors' substantial holdings of U.S. public debt instruments would lead to further gains by the government sector. Assessing redistributional effects of surprise inflation within the U.S. economy, however, goes beyond the scope of this thesis.

Table 2.7: Wealth Redistribution from the ROW to U.S. Sectors in Billion USD

Scenario	U.S. Net Gains Total	Net Gains Federal Government	Net Gains Rest of the Economy
I	56	43	13
II	181	136	45
III	321	265	56
IV	252	176	76

The calculations show that large parts of the U.S. economy's total net gains would accrue to the federal government. Depending on the scenario, the federal government's gain in real wealth accounts for 70-82% of the U.S. economy's net gains. There are two main reasons for this result. First, foreign investment in U.S. Treasury securities dwarfs that in all other forms of nominal debt; Treasury securities comprise more than 60% of the ROW's total holdings of marketable nominal U.S. securities. Second, the federal government's gross holdings of foreign dollar-denominated debt securities are negligible.[31] Thus, the U.S. economy's gross losses from its exposure to foreign nominal bonds entirely pertain to the private sector, which holds all of the U.S. economy's foreign nominal assets. Hence, in spite of borrowing substantial amounts from the ROW, the U.S. private sector would gain comparatively small amounts in case of surprise inflation. A large part of the private sector's gross gains from borrowing from the ROW would be offset by its losses from lending to the ROW.

Even compared to the U.S. federal government's total budget, these gains are substantial. For instance, the Treasury's gains under scenario IV—which is equivalent to a permanent increase of the inflation target by one percentage point—would amount to 176 billion USD, which is more than 7% of the federal government's total revenues in 2012.[32] Raises in the inflation target are thus a powerful tool to effectively tax foreign investors' holdings of U.S. debt securities. Economically, such an increase would be equivalent to a one-time capital levy on holdings of nominal securities, with implicit tax rates

[31]The Federal Reserve is the only agency within the U.S. federal government that holds siginificant amounts of foreign debt securities. However, these debt securities are not denominated in USD and are hence not directly affected by U.S. inflation.

[32]This number is calculated using data provided by U.S. Office of Management and Budget (2013).

varying with the maturity structure of an investor's portfolio of nominal securities.

Ascertaining that the U.S. federal government would take on the most prominent place on the part of the beneficiaries of surprise inflation raises the question of how foreign losses would be distributed across regions and countries. Shedding light on this issue is the goal of the next section.

2.4.2 A Geographical Breakdown of Foreign Losses

For marketable securities, both U.S. Treasury (2013b) and U.S. Treasury (2012) break down cross-border holdings by major investing country. Thus, it is possible to attribute foreign gross and net losses from cross-border holdings of marketable securities to different countries and regions. Since the amount of wealth redistribution induced by international lending through marketable securities accounts for the vast majority of total wealth redistribution, most of the ROW's losses can, in fact, be assigned to different countries. For non-marketable securities, reliable information on the geographical distribution of holdings is not available. The inaccuracies entailed by this lack of information are very minor, however, for scenarios I, II, and IV. Only in scenario III, under which the ROW suffers substantial losses on its holdings of U.S. currency, the amount of unassigned foreign losses is significant.

In this section, the ROW is divided into four regions, Asia, Europe, America, and the rest (i.e. Australia and the Pacifics form this region together with Africa). Within each region, there is a further subdivision into the largest holders of U.S. nominal securities. In Asia, these include China,[33] Japan, Taiwan, and the Middle East oil-exporting countries.[34] In Europe, the most important creditors to the U.S. are the United Kingdom, Switzerland, Russia, and the euro zone. Positions of the individual member states of the euro zone are not specified separately, since the high degree of capital market integration in the euro zone would lead to unreliable results for individual countries. For instance, according to TIC data, Belgium and Luxembourg are the largest creditors to the U.S. within the euro zone. It is very likely, however, that large parts of these claims are falsely attributed to these nations, since many financial intermediaries are based in these countries. By treating the euro zone as one single item, most of these problems

[33]Hongkong and Macau are included.

[34]These include the nations Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.

can be avoided. Of course, similar problems exist with respect to holdings attributed to the UK and particularly Switzerland, as these countries are also major banking centers. Hence, the results for these two countries need to be interpreted with caution. In America, the most important creditors to the U.S. are Brazil and the Caribbean banking centers.[35] Similar to the cases of Belgium and Luxembourg, holdings attributed to small island countries in the Caribbean are likely to represent actual holdings of investors from other parts of the world, particularly from the U.S. itself. Thus, as part of the robustness checks in section 2.4.3, the ROW's total losses are also calculated under the assumption that holdings of these countries do not represent cross-border holdings at all. Other countries on the American continent do not exhibit a significant exposure to nominal U.S. assets, which is why these countries are combined in one item.[36]

Summing up, foreign net losses are split up into those by 15 individual countries or groups of countries, respectively. These results are presented in table 2.8. Under each scenario, China and Japan suffer the highest losses. Depending on the scenario, the losses of each of the two creditor nations comprise between one-fifth and one-fourth of the ROW's total losses. In light of the public debate on this issue being predominantly focused on China's exposure to the USD, the result that Japanese losses in case of a surprise inflation are almost as high as Chinese might come at a surprise. Under scenario IV, estimated Japanese losses even surpass Chinese losses by half a billion USD. The reason for this is that the share of U.S. corporate debt in Japan's portfolio of U.S. securities is higher than in China's portfolio, which is heavily biased towards U.S. Treasuries. Since these, on average, exhibit lower maturities than corporate securities, Japan's losses in case of a long-lasting period of inflation are comparatively high, while those of China are comparatively low.

[35] These include the nations Bahamas, Bermuda, British Virgin Islands, Cayman Islands, Netherlands Antilles, and Panama.

[36] Canada's gross holdings of U.S. debt securities are substantial. However, the Canadian economy also borrows large amounts in USD from the U.S., which roughly counterbalance its lending. Thus, Canada's net exposure to inflation in the USD is small.

Table 2.8: Net Foreign Losses by Countries and Regions in Billion USD

Country or Region	Scenario			
	I	II	III	IV
China	14.2	44.7	75.0	58.7
Japan	13.2	42.8	69.9	59.2
Taiwan	2.3	7.2	11.8	9.4
Middle East Oil Exporters	1.5	4.3	10.8	5.7
Other Asia	3.6	10.9	20.9	15.6
Euro Zone	9.5	31.6	56.2	46.6
Switzerland	2.2	7.5	12.1	10.9
United Kingdom	1.4	5.3	6.0	8.4
Russia	1.4	4.6	7.6	5.9
Other Europe	1.4	4.4	7.7	5.6
Carib. Banking Centers	3.1	10.3	21.1	16.3
Brazil	2.0	6.3	10.9	8.0
Other America	0.2	0.2	1.1	1.8
Other	0.1	0.2	-1.4	0.0
Unknown	0.2	0.4	11.0	0.4
Total ROW[a]	56.3	180.7	320.9	252.5

[a] Numbers may not add up to totals due to rounding.

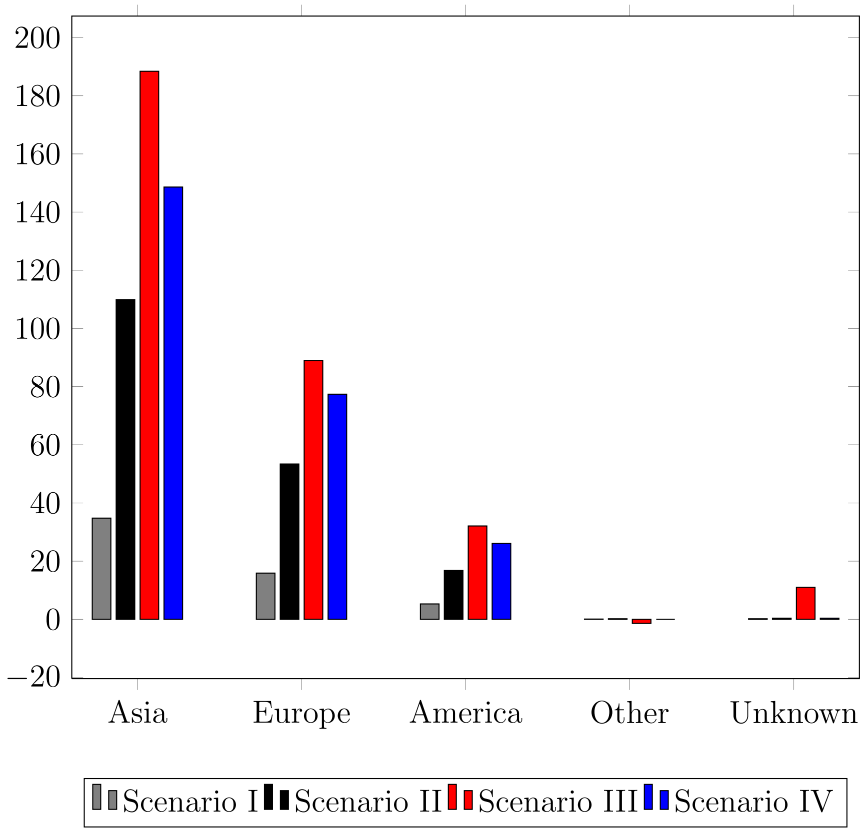
About one-sixth of the ROW's losses under all scenarios are borne by the economies forming the euro zone. Given the economic size of the euro zone and the high degree of capital market integration between the U.S. and Western Europe, it is not surprising that the euro zone is exposed to inflation in the USD. The magnitude of this exposure, however, is surprising. For instance, a permanent increase in the U.S. inflation target would cost the euro zone about 47 billion USD, which is only about 12 billion USD less than Chinese or Japanese losses under this scenario. Even for an economic area as large as the euro zone, losses of this magnitude are not negligible. Indeed, the calculations reveal that the euro zone's stake in U.S. nominal assets is substantial. Thus, just as investors from East Asia, euro-zone investors should concern themselves with U.S. monetary policies.

The remaining foreign losses are fragmented into many small parts. Although small in absolute terms, losses of some other nations are also substantial relative to the size of their economies. Examples for small economies exhibiting high levels of exposure to USD inflation are Taiwan, Switzerland, and island states in the Caribbean. Drawing conclusions from the assessed losses for Switzerland and, particularly, Caribbean financial centers, however, is not advisable, since those losses might, in fact, accrue to investors residing in other countries.

With one exception, all countries or groups of countries enlisted in table 2.8 suffer losses in case of surprise inflation in the USD. That one exception is the category "other" under scenario III, in which this group of countries gains by about 1.4 billion USD at the expense of the U.S. economy. Behind this oddity are U.S. investments in short-term Australian government securities denominated in USD. Gains on this form of borrowing are only substantial under scenario III, in which these gains exceed the losses on investment in U.S. securities from the perspective of these countries. However, neither net losses under scenarios I, II, and IV nor net gains under scenario III are quantitatively important for Australia and the other countries within this category.

Employing the data presented in table 2.8, figure 2.8 provides a broad geographical breakdown by continent for scenarios I to IV. With about 60%, Asian countries bear the lion's share of foreign losses. U.S. net gains at the expense of European nations are also substantial and account for about 30% of total foreign losses. The remaining 10% are mostly losses attributed to other nations on the American continent. Under scenario III, in which investors do not react optimally to the outburst of additional inflation, a net loss of about 11 billion USD remains unattributed. This sum is the U.S. economy's net gain from net borrowing in non-marketable securities, for which country-specific information is not available.

Figure 2.8: Net Foreign Losses by Continent in Billion USD



2.4.3 Robustness Checks

So far, all of the quoted redistributional effects were calculated under a number of baseline assumptions.[37] Most of theses assumptions either barely affect the results, or are not critical, or both. For instance, the assessed durations of non-marketable nominal assets are highly uncertain. However, these asset classes barely contribute to the total amount of wealth redistribution, which is why alternations of these assumptions are not discussed. Another example is the assumption that foreign holdings of U.S. assets are distributed according to outstanding market values within maturity categories. Alternations of this assumption would affect the calculated redistributional effects significantly. However, since aggregate cross-border holdings consist of numerous single cross-border investments, it seems unlikely that there is a systematic discrepancy between the ROW's portfolio and the market portfolio within these narrow asset classes.

[37] A list of all assumptions made in the baseline calculation can be found in the appendix on page 185.

Some of the baseline assumptions are critical and influence the results significantly. Repeating the calculations for alternations of these assumptions sheds light on the robustness of the previously presented results. Table 2.9 provides an overview of assumptions that are both uncertain and of some quantitative importance for the calculations.

Table 2.9: List of Critical Assumptions

Assumption	**Concerned Scenarios**
Holdings of Caribbean banking centers attributed to ROW	I, II, III, IV
Maturity structure of foreign holdings of TIPS equals that of conventional Treasury securities	I, II, IV
USD share in foreign holdings of U.S. corporate ABS equals that of U.S. corporate non-ABS	I, II, IV
Maturity structure of ABS equals that of non-ABS in respective category	I, II, IV
Interest rate sensitivities of cross-border ABS holdings equal those of market portfolios in these asset classes	I, II, IV
USD share in holdings of U.S. corporate debt equal for all countries	I, II, III, IV

By replacing them with alternative specifications, the assumptions enlisted in table 2.9 are briefly discussed in the following. To check the robustness of the results, rather extreme and unlikely variations are chosen. Since the assessed redistributional effects are intended to constitute conservative estimates of cross-border wealth redistribution, a particular focus is on variations leading to lower magnitudes of wealth redistribution.

Holdings of Caribbean Banking Centers

The first critical assumption concerns the classification of holdings attributed to small island states in the Caribbean. As tax havens, these countries are home to many financial intermediaries, particularly hedge funds and subsidiaries of international banking companies. These companies manage funds for investors from all parts of the world, leading to substantial holdings of nominal securities attributed to Caribbean island states. In parts, these holdings surely reflect actual holdings of U.S. investors and are thus falsely attributed to the ROW. Hence, it is worth calculating the ROW's total losses under the alternative assumption that all assets and liabilities of these countries are treated like U.S. domestic claims. Put differently, Caribbean financial centers are reclassified as U.S. territory in this counterfactual setting. Table 2.10 contrasts U.S. net gains under the baseline assumption with those under this alternative assumption.

Table 2.10: U.S. Net Gains Excluding Holdings of Caribbean Banking Centers in Billion USD (as Percentages of U.S. GDP)

Scenario	Baseline	Excluding Caribbean Financial Centers
I	56 (0.35)	53 (0.33)
II	181 (1.12)	170 (1.05)
III	321 (1.99)	300 (1.86)
IV	252 (1.56)	236 (1.46)

Deducting gains at the expense of Caribbean financial centers reduces U.S. net gains by 5-7%, depending on the scenario. Thus, even under the extreme and unlikely assumption that all holdings attributed to Caribbean financial centers reflect holdings by U.S. citizens, the results do not change very much. Hence, despite adding some uncertainty, it is fair to say that the overall results do not critically depend on these classification issues. U.S. net gains are substantial—regardless of the treatment of Caribbean holdings.

Maturity Structures of TIPS and Conventional Treasury Securities

The second critical assumption concerns the maturity distribution of foreign holdings of nominal Treasury securities. While U.S. Treasury (2013b) provides the maturity distribution of the ROW's total holdings of Treasury securities, separate distributions for the ROW's holdings of TIPS and conventional securities are lacking. In contrast to conventional Treasury securities, the prices of TIPS are invariant to inflation, irrespective of a security's remaining time to maturity. Price changes of conventional bonds, however, do vary with a bond's remaining time to maturity in the case of one-time inflation surprises. Thus, the maturity distribution of TIPS plays a role in assessing the amount of wealth redistribution under scenarios I, II, and IV.

In the baseline specification, the maturity distribution of TIPS equals that of conventional securities. Thus, to arrive at the ROW's holdings of nominal Treasury securities in each maturity category, total holdings are simply reduced by about 6.6%, which equals the share of TIPS in the ROW's total holdings of Treasury securities according to U.S. Treasury (2013b). To get a sense of the quantitative impact of this assumption, the redistributional effects are calculated for the alternative specification that foreign holdings of TIPS feature the longest possible remaining times to maturity. This means that the 289 billion USD that foreign investors hold in TIPS are attributed to the five longest maturity categories. Since foreign investors' holdings in TIPS exceed their total holdings of Treasury securities with a remaining time to maturity above 15 years, all holdings of this category are assumed to be non-nominal. As a result, weighted average remaining time to maturity of conventional Treasury securities is expected to be smaller under this setting than under the baseline assumption. Of course, this reduction of maturities also entails a reduction of durations and, thus, a reduction of inflation sensitivities. The effect of this alternative assumption can be detected in table 2.11, which opposes U.S. net gains under this setting to those under the baseline assumption.

Table 2.11: U.S. Net Gains with Minimum Maturities of Conventional Treasury Securities in Billion USD (as Percentages of U.S. GDP)

Scenario	Baseline	Minimum Maturities
I	56.3 (0.35)	56.1 (0.35)
II	180.7 (1.12)	175.4 (1.09)
III	320.9 (1.99)	320.9 (1.99)
IV	252.5 (1.56)	223.4 (1.38)

The effects of this alternation strongly differ across scenarios. While there are no effects under scenario III and only a very small effect under scenario I, the results under scenarios II and, particularly, IV do change significantly. Under the latter, U.S. net gains are reduced by about 29 billion USD compared to the baseline assumption. This difference stems from the much lower weighted average maturity of conventional Treasury securities and the correspondingly lower foreign losses on these positions under this assumption. Since it is very unlikely that none of the substantial outstanding amounts of conventional Treasury securities with remaining times to maturity of 15 years and above are held by foreigners, the results calculated under this alternative assumption can be seen as a lower bound rather than a best guess on actual U.S. gains. Although the unknown maturity distribution of foreign holdings of TIPS adds considerable uncertainty to the redistributional effect under scenario IV, the main results remain unchallenged.

USD Share of ABS and Non-ABS

Similar issues apply to foreign holdings of corporate debt. While the share of dollar-denominated corporate debt securities is known, that of the two subcategories, ABS and non-ABS, is unknown. Distinguishing between these two forms of debt securities is necessary since they exhibit different inflation sensitivities. In contrast to conventional bonds, most asset-backed securities feature repayments of principal before maturity. Thus, weighted average time until cash flows are received—which is the definition of a security's duration—is smaller for ABS than for non-ABS of the same remaining time to maturity. Consequently, the prices of dollar-denominated ABS are less sensitive to one-time inflation surprises than those of dollar-denominated non-ABS. Hence, the larger the USD share of ABS opposed to that of non-ABS, the less sensitive to inflation are foreign positions in U.S. corporate bonds.

Under the baseline assumption, the USD share is assumed to be equal for both types of securities. If the true share of USD in corporate ABS were higher, this assumption would lead to an overestimation of foreign losses. To assess the quantitative importance of this potential bias, the calculations are repeated under the alternative assumption that foreign holdings of ABS are entirely denominated in USD. Hence, foreign holdings of dollar-denominated conventional corporate bonds are assumed to be lower than in the baseline setting. How this alternation affects the overall redistributional effect of surprise inflation can be read from table 2.12.

Table 2.12: U.S. Net Gains with Minimum Amount of Nominal Conventional Corporate Bonds in Billion USD (as Percentages of U.S. GDP)

Scenario	Baseline	ABS all USD
I	56.3 (0.35)	56.1 (0.35)
II	180.7 (1.12)	179.0 (1.10)
III	320.9 (1.99)	320.9 (1.99)
IV	252.5 (1.56)	248.7 (1.54)

Again, the effect of this variation differs across scenarios. On the one hand, since durations do not play a role at all under scenario III, this alternation does not lead to changes in the assessed effects under this scenario. On the other hand, this alternation leads to appreciable changes under scenario IV, in which durations play a particularly prominent role in determining the amount of wealth redistribution. However, even for this scenario, the extreme assumption that there are no corporate ABS denominated in foreign currencies does not change the estimated amount of wealth redistribution from the ROW to the U.S. economy by a large amount. With a maximum margin of error of only about 1.5%, the results can be deemed to be fairly robust against alternations of this assumption.

Maturity Structures of ABS and Non-ABS

Further uncertainties relating to holdings of ABS and non-ABS exist with respect to the maturity distributions of these subclasses. As opposed to the above-discussed issue of unknown USD shares,[38] this problem does not only concern foreign holdings of corporate debt but also foreign holdings of agency debt and U.S. holdings of foreign debt. Again, distinguishing between ABS and non-ABS matters due to the different inflation sensitivities of the two asset classes. The difference in inflation sensitivities is particularly distinct for securities with a long remaining time to maturity. Thus, potential differences in the maturity distributions of ABS and non-ABS play a role in the assessment of international wealth redistribution.

Under the baseline assumption, ABS and non-ABS are assumed to share the same maturity distribution. This assumption leads to an overestimation of gross foreign losses (and gross U.S. losses) if holdings of ABS, on average, exhibit longer maturities than holdings of non-ABS. To check whether this potential bias is quantitatively important, the calculations are repeated under the alternative assumption that cross-border holdings of ABS exhibit the longest possible remaining times to maturity, i.e. holdings of non-ABS exhibit the shortest possible remaining times to maturity. For instance, in the case of foreign holdings of U.S. agency debt, this implies that all holdings with a remaining time to maturity of nine years and above are exclusively ABS, whereas all holdings of securities with eight or less remaining years

[38] The uncertainties relating to the USD share of U.S. holdings of foreign ABS and non-ABS are minor. This stems from the possibility to calculate reasonably accurate implicit USD shares of ABS and non-ABS using data on country-specific USD shares and holdings by asset class for each country.

to maturity are non-ABS. For the other two concerned asset classes, U.S. corporate debt and foreign debt, the impact of this alternation is smaller as the share of ABS in these asset classes is lower. Table 2.13 shows how this assumption alters the estimations' results.

Table 2.13: U.S. Gains with Minimum Maturities of Non-ABS Securities in Billion USD (as Percentages of U.S. GDP)

Scenario	**Baseline**		**Minimum Maturities**	
	Gross Gains	Net Gains	Gross Gains	Net Gains
I	73 (0.35)	56 (0.35)	73 (0.35)	56 (0.35)
II	235 (1.45)	181 (1.12)	226 (1.40)	174 (1.08)
III	440 (2.72)	321 (1.99)	440 (2.72)	321 (1.99)
IV	330 (2.04)	252 (1.56)	283 (1.75)	217 (1.34)

Since foreign losses on U.S. securities and U.S. losses on foreign securities are concerned, table 2.13 shows how both U.S. gross and net gains change with this variation. Under each scenario, U.S. gross and net gains change by approximately the same proportion. The magnitudes of the changes depend on the inflation scenario. As in the case of the previous two alternations, the results under scenarios I and III are not or barely affected, while those under scenarios II and IV change significantly. Again, the most profound effects can be found for scenario IV, in which durations play a particularly prominent role in determining the amount of wealth redistribution. Assuming that cross-border holdings of non-ABS exhibit the lowest possible remaining times to maturity and, thus, the lowest possible durations, reduces U.S. net gains in case of a permanent increase in the inflation rate by about 35 billion USD. A potential error of this magnitude is substantial. However, remembering that it is calculated under the extreme and unrealistic assumption that cross-border holdings of ABS and non-ABS differ diametrically with respect to maturities puts this result into perspective. In any case, the uncertainties regarding the maturity distributions of ABS and non-ABS do not challenge the results qualitatively.

Inflation Sensitivities of ABS

Further uncertainties concern the price changes of asset-backed securities. Due to embedded options in many of these securities, stemming from prepayment rights held by debtors in the underlying credit contracts, future cash flows are not known. Thus, assessing such a security's inflation or interest rate sensitivity is not straightforward. It requires some method to model future cash flows.[39] Assessing how the prices of ABS change due to a hike in market interest rates, one cannot just discount expected future cash flows at a higher rate but must also predict how future cash flows themselves change due to increasing interest rates. Put differently, interest rates influence the value and the timing of cash flows for ABS. For instance, a rise in interest rates, *ceteris paribus*, lowers borrowers' propensity to prepay their debt, which, in turn, decreases expected near-future relative to distant-future cash flows. This property is often referred to as "negative convexity," meaning that the price-yield relationship of ABS is concave.

In addition to these embedded options, ABS also differ from conventional bonds with respect to the timing of principal redemption. As opposed to the former, most ABS are amortizing, i.e. the face values of these securities decrease with time. Thus, there is no close connection between remaining time to maturity and interest rate sensitivity (measured by duration) for these securities. Due to the limited informative values of conventional bond ratios, other ratios have been established for ABS. For instance, *average life*[40] is used instead of remaining time to maturity and *effective duration*[41] is used instead of (modified) duration. As both of these ratios critically depend on the timing of future cash flows, they cannot be compiled objectively using publicly available information. For this reason, Datastream (2013) does not offer these or other interest rate sensitivity measures for individual ABS. Hence, assessing capitalization-weighted average durations for each maturity subcategory is not possible.

Instead, the baseline results are calculated using effective durations for broad market indices of ABS.[42] This is tantamount to assuming that foreign holdings of agency and corporate ABS exhibit the same interest rate sensitivities as the market portfolio in these categories. Although it seems

[39] An overview of different approaches used to value and analyze ABS and, particularly, mortgage-backed securities can be found in Fabozzi et al. (2005).

[40] Average life measures the weighted average time until principal is repaid.

[41] Effective duration measures expected price changes following an interest rate change. Indirect effects on a security's price through changes in cash flows are included.

[42] For agency ABS, "The BofA Merrill Lynch US Mortgage Backed Securities Index" is used. For U.S. corporate ABS, the referred index is called "The BofA Merrill Lynch US Asset Backed Securities & Commercial Mortgage Backed Securities Index." For U.S. holdings of foreign dollar-denominated ABS, "The BofA Merrill Lynch Global Collateralized Index" is used. Further information on these indices and the methodology used to calculate the relevant ratios can be found in the appendix on page 178 and the following and the additional sources cited therein.

rather unlikely that cross-border and total holdings of ABS differ strongly with respect to interest rate sensitivities, there are good reasons to check how robust the results are to alternations of this assumption. For instance, true price changes in case of an unanticipated increase in interest rates might be different from those predicted by the models used by the issuer of the indices. Moreover, it is worth examining how robust the results are to alternations of this assumption even if inflation sensitivities of cross-border ABS holdings on the reference day can reasonably accurately be grasped using market indices. Due to the options embedded in most ABS, their interest rate sensitivities are much more volatile than those of conventional bonds. For instance, when the current level of interest rates is lower than previously anticipated, many debtors are expected to prepay and refinance their loans, which leads to low average lives and, thus, also to low effective durations of ABS. Generally, interest rate sensitivities of ABS vary significantly with the bond market environment. Hence, one has to be cautious in drawing conclusions to foreign investors' current or future inflation exposure from the snapshot of ABS interest rate sensitivities on the reference day.

To test the robustness of the overall redistributional effects to different inflation sensitivities of cross-border ABS holdings, the calculations are repeated for two alternations. In the first one, it is assumed that effective durations of all ABS segments were 50% lower than those assessed for the respective market indices on the reference day. In the second alternation, the assumption is that effective durations of ABS were 50% higher than those assessed in the baseline calculation. How these variations affect U.S. net gains under the four scenarios can be read from table 2.14.

Table 2.14: U.S. Net Gains with Different Inflation Sensitivities of ABS in Billion USD (as Percentages of U.S. GDP)

Scenario	**Effective Durations -50%**	**Baseline**	**Effective Durations +50%**
I	55.8 (0.35)	56.3 (0.35)	56.5 (0.35)
II	171.0 (1.06)	180.7 (1.12)	188.9 (1.17)
III	320.9 (1.99)	320.9 (1.99)	320.9 (1.99)
IV	242.8 (1.50)	252.5 (1.56)	262.0 (1.62)

Again, the quantitative effects of these variations strongly differ across inflation scenarios. While there is no effect on the amount of wealth redistribution under scenario III, those under scenarios II and IV are somewhat sensitive to the alternations. For instance, U.S. net gains under scenario IV are reduced by about 10 billion USD if effective durations of ABS on the reference day were 50% lower than those under the baseline calculation. On the other hand, they increase by about the same amount if effective durations of ABS are assessed 50% higher than in the baseline configuration. Thus, even those rather extreme variations only lead to a fluctuation range of about 5% around the values calculated under the baseline assumption. In light of these numbers, the uncertainties concerning the inflation sensitivities of ABS do not pose major challenges for the overall results.

USD Share of Corporate Debt by Country

The final critical assumption discussed herein concerns the currency denomination of foreign holdings of U.S. corporate debt. TIC data provides separate breakdowns by currency and by country but not a breakdown by country *and* currency. Thus, there are uncertainties on the amounts of dollar-denominated securities attributed to different countries and regions. The total USD share of foreign holdings in this asset class, however, is not in question. Hence, alternations of this assumption only affect the distribution of foreign losses, whereas the total amount of U.S. gains remains unaltered.

The baseline assumption is that the share of dollar-denominated securities is equal for all countries in this asset class. Thus, countries' gross losses from U.S. corporate debt are directly proportional to their holdings in this asset class. This procedure leads to an overestimation of losses for countries that hold disproportionately high amounts of U.S. corporate debt denominated in foreign currencies. It seems likely that this applies to countries in whose currencies U.S. companies borrow significant sums. For example, the share of U.S. corporate bonds issued in Japanese yen is presumably higher in Japan's portfolio of U.S. bonds than in those of other parts of the ROW. Aside from Japanese yen, the only other foreign currencies in which U.S. corporations borrow significant amounts in international capital markets are the euro, the British pound, and, to a somewhat lesser extent, the Swiss franc.[43] Thus, under the baseline assumption, losses of Japan, the United Kingdom, and particularly, the euro zone might be overestimated. To quantify the potential

[43] A distribution of U.S. borrowing by currency can be found in table 18a in U.S. Treasury (2013b).

overassessment for these countries, the calculations are repeated under the alternative assumption that all foreign-currency-denominated U.S. corporate debt is held by the country issuing the respective currency. That is to say that foreign holdings of euro-denominated securities are entirely attributed to the euro zone, foreign holdings of yen-denominated securities are entirely attributed to Japan and so on. Consequently, this assumption leads to a reduction of USD shares for the aforementioned countries or regions. On the contrary, since the total USD share remains constant, implied USD shares rise for those nations, in whose currencies the U.S. economy does not borrow significant amounts. The results under this assumption can be read from table 2.15.

Table 2.15: Net Foreign Losses by Countries and Regions with Country-Specific USD Shares in Billion USD

Country or Region	**Scenario**			
	I	**II**	**III**	**IV**
China	14.2	44.9	75.4	59.1
Japan	12.9	41.6	68.2	57.4
Taiwan	2.3	7.5	12.1	11.0
Middle East Oil Exporters	1.5	4.4	11.0	6.0
Other Asia	3.7	11.4	21.6	16.3
Euro Zone	8.1	26.5	48.9	38.8
Switzerland	2.4	8.3	13.2	12.1
United Kingdom	2.1	4.3	4.1	6.8
Russia	1.4	4.6	7.6	5.9
Other Europe	1.6	4.9	8.5	6.4
Carib. Banking Centers	4.0	13.5	26.0	20.9
Brazil	2.0	6.3	10.9	8.1
Other America	0.5	1.1	2.5	3.2
Other	0.3	1.1	-0.1	1.4
Unknown	0.2	0.4	11.0	0.4
Total ROW[a]	56.3	180.7	320.9	252.5

[a] Numbers may not add up to totals due to rounding.

To get a sense of the impact of this alternation, one has to compare the numbers in table 2.15 to those in table 2.8. The alternation affects all of the four scenarios. Under each scenario, a part of the losses formerly attributed to Japan, the United Kingdom, and the euro zone are now attributed to other foreign holders of U.S. corporate debt. In absolute terms, the effects are most pronounced for the euro zone, as the euro is, by far, the most important foreign currency in which U.S. corporations borrow. For instance, compared to the baseline calculation, the euro zone's net losses under scenario III are reduced by about 7 billion USD. Relative to the assessed losses under the baseline assumption, the change for the United Kingdom is most significant. Its losses decline by about one-third, albeit absolute numbers for the UK are not very large. On the other hand, losses attributed to Caribbean banking centers increase by about 5 billion USD under this alternative assumption for scenario III. This stems from these nations being the most important holders of U.S. corporate debt outside of Europe, which is why the implied increase in the USD share of their holdings in this asset class has a particularly distinct impact. Since losses attributed to these nations might, in fact, not be losses of foreign investors at all, one can argue that the uncertainties relating to the country attribution of foreign currency debt also indirectly concern the total amount of U.S. gains.

Summing up, this section reveals that, in spite of some uncertainties, the main results do not critically depend on the assumptions that need to be made as a result of lacking data. The results of scenarios I and III prove to be particularly robust since interest rate sensitivities do not play a major role in these. The results of the other two scenarios are somewhat more sensitive to the above-discussed assumptions. Yet, with potential biases of the order of 10% or less, none of the presented alternations challenges the results qualitatively. Keeping in mind that aggregate data, and all calculations based on it, is always subject to some inaccuracies, uncertainty ranges of this magnitude are not serious problems.

This chapter's main contribution is to quantify U.S. net wealth gains in case of moderate surprise inflation in the USD. Those turn out to be substantial. For instance, a one-time hike in the inflation rate of one percentage point would lead to an increase in U.S. national wealth of at least 0.35% of U.S. GDP. If the period of surprise inflation lasted five years, U.S. net gains would be in the range of 1.12-1.99% of U.S. GDP, depending on how fast investors react to the new inflation path. Lastly, an announced increase of the U.S. inflation target would lead to net gains for the U.S. economy of about 1.56% of GDP.

These figures exemplify that, in the current situation, the U.S. economy as a whole would be major beneficiary of surprise inflation in its own currency. This opportunity to realize short-term gains at the expense of other countries has surely not remained unnoticed by U.S. policy-makers. Thus, it is worth discussing under which circumstances opportunities of this kind conflict with the long-term goals of monetary policy. The following chapter intends to shed light on this issue from a theoretical perspective.

Chapter 3

Time-Consistent Monetary Policy and External Debt

As was shown for the U.S. example in chapter 2, inflation today must no longer be a zero-sum situation from a national perspective. In fact, countries whose nominal liabilities exceed their nominal assets in their own currency gain in case of surprise inflation. In other words, the national wealth of countries who have borrowed from the rest of the world in their national currency increases when the value of their currency diminishes. Moreover, given the huge amount of cross-border portfolio investment in today's globalized capital markets, magnitudes of wealth redistribution from creditor to debtor countries in case of inflation are large. Naturally, this raises the question of whether and how sound monetary policies can be warranted in countries that are heavily indebted in their own currency. Answering these questions is the main objective of this chapter. For this, I introduce a basic version of a game between a policy-maker and the public and discuss how the presence of nominal external debt alters the outcome of this game. With the focus lying on the time-consistency problem, this chapter discusses the political economy of monetary policy, thereby neglecting all practical and theoretical issues of how monetary policy operates.

The chapter starts with a review of the literature on incentives to inflate and time-consistent monetary policy in section 3.1. Subsequently, I introduce the basic model that is used to discuss the effects of nominal external debt in section 3.2. To further enrich the analysis, two variations of the basic framework are presented in section 3.3. Finally, a discussion of the main results and policy implications ends the chapter.

3.1 Literature Review

Discussing the time-consistency of monetary policy in the presence of external debt, the work in this chapter is connected to several branches of the academic literature. First, it adjoins to the rich theoretical literature on the time-consistency problem of monetary policy. Second, it contributes to related studies examining policy-makers' incentives to inflate and thereby the primary sources of the time-consistency problem. Third, by analyzing the effectiveness of reputational forces in the presence of external debt overhangs in section 3.3.1, there is also a connection to theoretical studies dealing with the repudiation of external debt. Fourth and finally, by providing a new argument in favor of currency unions, this chapter supplements the theoretical papers discussing the assets and drawbacks of currency unions.

All of these literature branches are briefly reviewed in the following. Owing to the vast quantity of publications in these fields, the review is restrained to seminal contributions and those that are most closely related to the work herein. For more thorough reviews of specific subquestions, references to literature surveys are provided.

Since the widespread adoption of rational expectations in macroeconomic modeling in the 1970s, an extensive amount of literature has dealt with the time-consistency problem of monetary policy.[1] The early contributions following the pathbreaking paper of Kydland and Prescott (1977), e.g. Barro and Gordon (1983a) or Lucas and Stokey (1983), concluded that in order to avoid a permanent inflation bias, formal rules should substitute for discretion. An alternative way of avoiding the inflation bias was introduced in a pioneering paper by Barro and Gordon (1983b), which also forms the basis of the analysis in this chapter. By formalizing the interaction between a policy-maker and the public as a simple repeated game, they show that reputational considerations can help mitigating the time-consistency problem for policy-makers with a sufficiently long planning horizon. Since then, numerous subsequent studies have shed light on the existence and nature of reputational equilibria under various settings. For instance, Canzoneri (1985) discusses cases in which the central bank possesses private information impeding the ex-post appraisal of monetary policy and hence the formation of reputational equilibria. Similar problems arise if there is uncertainty about the objective function of the policy-maker in charge, as Backus and Driffill (1985) point out. At the same time, Rogoff (1985) suggested a famous alternative to

[1] A survey of this literature can, for instance, be found in Walsh (2010), chapter seven.

overcome the time-consistency problem. By modeling a trade-off between inflation and employment stabilization, he shows that in order to meet the goals of low inflation and stable employment, monetary policy should be delegated to an individual that is more inflation-averse than society. A couple of years later, Persson and Tabellini (1993) and Walsh (1995) introduced a fourth way to mitigate the inflation bias, namely by optimally designing the contracts of central bankers to achieve the long-term goals of society. Since the work in this chapter neither provides the reader further insights into the technicalities of the time-consistency problem—e.g the existence of multiple equilibria etc.—nor offer a novel solution to this general problem, it does not directly contribute to this part of the literature. Instead, I point to a potential new source of inconsistent policies and discuss how that alters the outcome and the solutions of the standard Barro-Gordon model.

Since the problem of time-consistency only arises if the policy-maker has an incentive to induce surprise inflation ex post, i.e. after expectations have been formed, it is worth going back one step to examine what benefits of surprise inflation exist. Identifying these benefits allows for a discussion of first-best solutions to the time-consistency problem, which is excluded in the above-cited studies. In most of the literature, authors refer to two positive effects of surprise inflation. First, following the original example of Kydland and Prescott (1977), it is commonly assumed that surprise inflation temporarily increases real economic activity or decreases unemployment, respectively. This effect, the expectational Phillips-Curve relationship, foots on the assumption that, due to nominal rigidities in wages, surprise inflation temporarily shifts the marginal productivity of labor above the real wage, making it profitable for firms to increase production and employment. Removing this source of time-inconsistent policies required a widespread adoption of inflation-indexed wage contracts. Second, policy-makers are assumed to find surprise inflation appealing as it increases real government revenue. Indeed, the devaluation of outstanding government debt provides a well-known incentive for policy-makers to inflate, which has been recognized by academics as early as in Bach and Musgrave (1941). However, in a closed economy, it is not straightforward why a policy-maker would embrace such a redistribution of wealth from the private to the public sector. The argument brought forward in the theoretical literature—e.g. Calvo (1978), Bohn (1988) or more recently Díaz-Giménez et al. (2008)—is that the ex-post devaluation of government debt can be regarded as a non-distortionary tax on capital, which is given preference over all kinds of conventional, distortionary taxes by a benevolent social planner.[2] Of course, this argument ceases to exist if one assumes that other forms of lump sum taxation are available to policy-makers. Even if these do not exist, by reducing the distortions of alternative taxes, the devaluation of government debt only has a second-order effect on public welfare in the closed economy. By contrast, as recently argued by Aizenman and Marion (2011), the incentives to devalue outstanding government liabilities are much stronger when the public's creditors are foreigners. Similar to the optimal taxation approach, they build a general equilibrium model in which a benevolent policy-maker maximizes a representative household's utility given an initial debt overhang by choosing tax and inflation rates. The key trade-off is between the deadweight-losses associated with these two policy instruments. Calibrating their model to fit U.S. historical data, they find policy-makers' temptation to inflate away some of the debt burden today to be similar to that at the end of World War II. Surprisingly, they focus entirely on public debt, thereby drawing an incomplete picture of the true redistributive potential of an unexpected rise in inflation. Generally, the incentives that arise when a country is net debtor in its own currency have been paid only little attention to in the literature. The simple reason for this is that countries with a high level of external debt have traditionally not been able to borrow in their own currency. This certainly changed over the last decades when the U.S. accumulated huge amounts of foreign debt in USD. Remarkedly, one of the few treatments of this subject dates from 1991, a time when U.S. external debt was only a tiny fraction of today's level. In fact, with regard to contents, Bohn (1991) is the study that is most closely related to this chapter. In contrast to the work here, Bohn (1991) focuses on showing how the existence of nominal foreign debt might drive a wedge between the first-best and the discretionary inflation rate and does not discuss possible solutions to the problem. Thus, in spite of some differences in the modeling approach—Bohn (1991) derives his result from a general equilibrium as opposed to a reduced form model—the work in this chapter can be seen as complementary to Bohn (1991).

While a debtor nation's option to inflate away its external debt has not been paid much attention to in the academic literature, the general question of why countries do or do not service external payment obligations is well explored. Since creating surprise inflation is economically equivalent to partially defaulting on payment obligations, the literature on external debt

[2]A related and even more voluminous body of literature examines the optimal use of seigniorage as a way to tax holdings of money. Since this refers to the optimal degree of anticipated instead of unanticipated inflation, there is no direct connection to this chapter.

and repudiation, in fact, discusses questions similar to those in this chapter. According to Eaton and Gersovitz (1981) and many subsequent studies—e.g. Grossman and van Huyck (1988), Atkeson (1991), or Cole and Kehoe (1997)[3]—the reason why countries repay their external debt, and thus the reason why they can borrow in the first place, is that they fear to lose access to international capital markets following repudiation. Reputational considerations are also subject of the analysis in this chapter. In contrast to the models in the aforementioned literature, the model here does not try to explain the maximum amount of external borrowing that is sustainable under reputational considerations. Rather, the amount of external debt is treated as an exogenous variable influencing the inflation rate in a reputational equilibrium. Despite of these differences, both approaches lead to the same basic conclusion that (partial) defaults—both in the form of surprise inflation and outright defaults—are particularly likely in countries exhibiting a debt overhang.

Since there are few studies dealing with the potentially adverse consequences of nominal external debt, it is not surprising that one of the possible solutions to this problem, namely the creation of currency unions between mutually indebted countries, has, to the best of my knowledge, not been brought forward in the literature so far. Thus, the work in section 3.3.2 contributes to the deep literature on optimal currency areas, which is for instance surveyed by De Grauwe (2012) or Baldwin and Wyplosz (2009). More specifically, the argument explicated in section 3.3.2 is that the creation of currency unions can help to internalize the negative externalities of nominal foreign indebtedness, thereby alleviating the potential for unsound policies. Therefore, this case can be regarded as an exemplification of the more general point made in the existing literature that the benefits of creating a currency union increase with the degree of financial integration between the respective countries.

3.2 The Basic Model

The model presented in this chapter is a simple and stylized version of a non-cooperative game between a policy-maker and the public. It is based on the seminal contribution of Barro and Gordon (1983b) and a recently published composite version of the model found in Alesina and Stella (2011).

[3]A general review of the literature on the repayment of foreign debt can be found in Eaton and Fernandez (1995).

Before introducing nominal external debt, section 3.2.1 outlines the baseline model and the underlying assumptions. The baseline specification—the closed economy case—serves as a benchmark for the subsequent extension of the model introduced in section 3.2.2.

3.2.1 Closed Economy

The model features a policy-maker (or central banker), who chooses monetary policy optimally by trading off the benefits and costs of inflation given inflation expectations, and the public representing the entire rest of the economy. Both the former and the latter are modeled as one individual, respectively—which implies that the model prescinds from all forms of coordination problems within the central bank and between the numerous agents forming the public.

The policy-maker's trade-off emerges from four main assumptions. First, the policy-maker can—at least indirectly—control the realized inflation rate. Second, expectations about current-period inflation are formed prior to the policy-maker's decision, which can be justified by all sorts of nominal rigidities existing in the real world. Third, there are some benefits of unexpected inflation to the policy-maker. Among the classic examples of these benefits are an extension of real economic activity—or equivalently a reduction of the unemployment rate—deriving from the expectational Phillips Curve and the previously mentioned possibility for the government to collect revenue in a non-distortionary way.[4] Fourth, inflation entails costs for the policy-maker that increase in the absolute value of the inflation rate. These can either be direct costs for the economy through the agents' need to adapt to new price levels, such as shoe leather or menu costs, or indirect costs resulting from the perceived unfairness of the redistributional effects between agents within the economy. All of the above-mentioned features are incorporated in the basic form of the model.

Suppose that the central banker's objective can be expressed by a loss function of the form

$$L_t = b(u_n - a(\pi_t - \pi_t^e)) + \frac{1}{2}\pi_t^2. \tag{3.1}$$

For simplicity, only one of the aforementioned benefits of a surprise inflation in the closed economy, i.e. the reduction of the unemployment rate due

[4]The government directly benefits from increased seigniorage revenues and indirectly through a reduction of real debt.

to the expectational Phillips-Curve relationship, is specified in this version. For the same reason, the benefit is modeled as a linear function of surprise inflation with a being the reciprocal of the slope of the expectational Phillips Curve and b being the weight the policy-maker puts on the unemployment rate relative to the inflation rate.[5] Parameter u_n is the natural rate of unemployment or more precisely, the unemployment rate that materializes if expected inflation equals actual inflation in one period. Since the distortions entailed by inflation intensify at high rates, its costs are modeled to rise at an increasing rate with the realized inflation rate, i.e. there are increasing marginal costs of inflation. All of the exogenous parameters are assumed to be constant over time.

The public's only objective is to predict inflation rates as precisely as possible. Since an informational advantage would be beneficial to any individual closing nominal contracts, all individual agents have the incentive to predict inflation in the best possible way. On an aggregate level, this implies that the public tries to meet future realizations of inflation when forming its inflation expectations. Put differently, the public suffers costs whenever realized inflation, π_t, differs from expected inflation, π_t^e.[6] It is assumed that the public forms inflation expectations rationally and that there are no informational constraints between the policy-maker and the public. In particular, this means that the public knows and understands the policy-maker's objective.[7]

In every period t, inflation expectations are formed prior to the policy-maker's decision on monetary policy, enabling the latter to induce unexpected inflation when desired. He chooses the inflation rate π_t that minimizes the loss function displayed in equation (3.1). By assuming that the policy-maker can steer the inflation rate directly, the model abstracts from all kinds of exogenous shocks influencing the realizations of the inflation rate in reality. Allowing for these would complicate the analysis without significantly augmenting the informative value of the model.

[5] This formulation stems from an expectational Phillips Curve of the form $\pi_t - \pi_t^e = -\alpha(u_t - u_n)$. Solving for u_t, one arrives at $u_t = u_n - a(\pi_t - \pi_t^e)$ with a being the reciprocal of the slope of the expectational Phillips Curve.

[6] For instance, the public's objective could be described by a utility function of the form $U_t = -(\pi_t - \pi_t^e)^2$. As long as the public's utility decreases with the absolute difference between expected and realized inflation, its exact formulation does not matter.

[7] For an analysis of settings in which the public is incompletely informed about the policy-maker's objective function, refer to Barro (1986).

The One-Shot Game

If there are no repetitions, or as Barro and Gordon (1983b) put it, if future inflation expectations do not depend on today's inflation rate, this sequential game is easily solvable by backward induction. When the public forms its inflation expectations, it tries to anticipate the rate of inflation the policy-maker sets in the second step. The latter's preferred inflation rate is obtained by minimizing equation (3.1) with respect to π_t. Applying standard optimization procedure yields a preferred inflation rate of $\pi_t^* = ab$. Irrespective of the public's expectations, the policy-maker always sets the inflation rate equal to ab.[8] With rational expectations, the public understands the policy-maker's objective and correctly anticipates this inflation rate. Hence, the only Nash equilibrium of the one-shot game is $\pi_t = \pi^e = ab$. The equilibrium inflation rate increases with both the weight the policy-maker puts on the unemployment rate, b, and the marginal effect of one unit of surprise inflation on the unemployment rate, a. Multiplied with each other, the two parameters can be interpreted as the policy-maker's marginal utility of one unit of surprise inflation. The marginal costs of one unit of surprise inflation are equal to those of inflation. Here, these are equal to the inflation rate.

This equilibrium features an unemployment rate at its natural level but an inflation rate above the social optimum of zero. Thus, the result of the non-repeated game is socially not desirable, which led Kydland and Prescott (1977) and numerous subsequent scholars to the conclusion that monetary policy should rather follow a strict rule than be conducted under discretion. Although society and the policy-maker would be better off if actual and expected inflation were at a lower level—the optimal level of anticipated inflation is zero here— the policy-maker would never choose an inflation rate other than $\pi_t = ab$ once inflation expectations are formed. In other words, under discretion, the only time-consistent inflation rate in the one-shot game is $\pi_t = ab$. Thus, a binding rule depriving the policy-maker of his discretionary power can improve public welfare.

If binding rules are either not available or not desirable,[9] other ways to overcome or minimize this well-known time-consistency problem have to be

[8] Note that the linear specification of the benefits of surprise inflation results in a preferred inflation rate that is independent of inflation expectations. Letting the benefits of surprise inflation enter non-linearly into the policy-maker's loss function would lead to slightly more complicated cases in which preferred inflation rates depend on inflation expectations. Qualitatively, however, this would not alter the results of the model.

[9] Arguments in favor of discretionary decisions usually stem from the stabilization function of monetary policy, which is not modeled here.

considered. Among the various approaches that have been suggested in the academic literature, the two most prominent ones are picked up here. First, Rogoff (1985) famously proposes to delegate monetary policy to a conservative central banker, i.e. to an individual or institution that has a high aversion to inflation.[10] In the above-drafted model, this can be expressed by a low weight of the unemployment rate relative to the inflation rate. Suppose that the loss function displayed in equation (3.1) represents the preferences of society, i.e. b expresses the relative importance of unemployment *vis-à-vis* inflation in a social welfare function. Then, handing monetary policy over to an individual whose aversion against inflation is higher than society's—or whose aversion against unemployment is lower than society's—$\hat{b} < b$, improves public welfare. The less utility a policy-maker derives from additional output or employment, the less tempted is he to induce surprise inflation; hence, the lower is his preferred inflation rate, which is also the inflation rate in equilibrium. Thus, delegating monetary policy to a central banker that is more conservative than a benevolent social planner improves public welfare in this framework. In fact, such a delegation is simply a way to commit to low inflation policies for society and thus a direct substitute for a binding rule. Of course, this way of reducing the inflation bias of monetary policy necessitates that the policy-maker operates independently from public pressure.

Reputation in the Repeated Game

Explaining the second proposal to mitigate the time-consistency problem requires the introduction of a repetition of the game between the central bank and the public. A simple way of doing this is to add a second period representing all future periods to the model. With this, it is possible to model reputational forces that help to support more favorable equilibria. The proposal to reduce the inflation bias then consists in ensuring that the individuals in charge of monetary policy are actually constrained by these reputational forces.

Suppose that the policy-maker announces an inflation rule $\hat{\pi} < ab$ at the beginning of the first period. The rational public only believes that the policy-maker adheres to the rule if it is credible, i.e. if the policy-maker does not have an incentive to deviate from the rule given $\pi^e = \hat{\pi}$. Without

[10] In contrast to Rogoff (1985), output shocks are not modeled here. Thus, there are no benefits of a positive weight on output or employment in the loss function and the optimal degree of conservatism is infinite here.

punishment of some form in the second period, the policy-maker will never follow a rule other than the discretionary equilibrium $\pi_t = ab$. If, however, the public's inflation expectations in the second period depend on the realized inflation rate of the first period, an enforcement mechanism emerges. For instance, following Barro and Gordon (1983b) inflation expectations in the future period could take on the form

$$\pi^e_{t=2} = \begin{cases} ab, & \text{if} \quad \pi_{t=1} \neq \hat{\pi} \\ \hat{\pi}, & \text{if} \quad \pi_{t=1} = \hat{\pi} \end{cases}. \tag{3.2}$$

If the central banker has stuck to his preassigned rule in the first period, the public will also expect him to do so in the future period. If he has deviated from the rule in period one, the market will not expect him to follow the rule in the future and will anticipate a further deviation. The only punishment the public can credibly enforce is to play the discretionary equilibrium in the future period, which is the public's best answer to a further deviation from the rule. Thus, a trade-off between the benefits of surprise inflation in the first period and the associated loss of reputation in the future period emerges for the policy-maker. The former can be expressed by the difference between the loss in case of adherence to the rule and the loss in case of deviation from the rule,[11]

$$L_1(\pi_1 = \hat{\pi} = \pi^e_1) - L_1(\pi_1 \neq \hat{\pi} = \pi^e_1) = \frac{(ab - \hat{\pi})^2}{2}.^{12} \tag{3.3}$$

The present value of the policy-maker's additional loss due to deviation from the rule in the present period equals

$$\beta[L_2(\pi_2 = ab = \pi^e_2) - L_2(\pi_2 = \hat{\pi} = \pi^e_2)] = \frac{\beta}{2}[(ab)^2 - (\hat{\pi})^2].^{13} \tag{3.4}$$

Parameter β represents the policy-maker's discount rate. It is assumed to be smaller than unity indicating a preference for present benefits over future benefits or a preference for future losses over present losses, respectively. The best-enforceable rule, $\hat{\pi}^*$, is the one in which the policy-maker is exactly indifferent between following the rule and deviating from it. Equal-

[11] Of course, the discretionary inflation rate $\pi^*_t = ab$ is the only deviation making sense for the policy-maker given the loss function specified in equation (3.1).

[12] The derivation of this result is provided in the appendix on page 186.

[13] Again, the derivation of this result is provided in the appendix on page 186.

izing equations (3.3) and (3.4), one arrives at

$$\hat{\pi}^* = \frac{1-\beta}{1+\beta}\, ab.^{14} \tag{3.5}$$

The lower the policy-maker's time preference rate (the higher β), the closer is this second-best rule to the first-best rule of zero inflation. From $0 < \beta < 1$, it follows that $0 < \hat{\pi}^* < ab$, i.e. the best-enforceable rule lies between the socially optimal inflation rate and the equilibrium inflation rate of the one-shot game. This result is an abbreviated version of the theoretical case for a conservative central banker with a long-term planning horizon. In fact, the inflation bias induced by the time-consistency problem becomes negligible within this framework if the policy-maker has a high aversion against inflation (low b) and a low time preference rate (high β).

Knowing the characteristics of an ideal central banker, the crucial question is how it can be assured that monetary policy is actually conducted by persons matching this description. Which institutional arrangements minimize the time-consistency problem and favor far-sighted monetary policy?

A famous and well-approved approach is granting the monetary authority independence from the legislative and the rest of the executive and to endow policy-makers with long-term contracts. Certainly, these settings do not guarantee sound monetary policies. Yet, insulating monetary policy from political pressures has proven helpful to avoid myopic policies in reality.[15] Recalling that the ideal central banker is more inflation averse than a benevolent social planner—and more inflation averse than the majority of voters—the case for central bank independence is even more apparent. Since such a person often opts against the short-term interests of the electorate—for instance, by not inducing surprise inflation—he must be given a certain degree of operational independence to actually pursue his desired policies. Enabling politicians or the electorate to replace the policy-maker whenever his decisions are perceived inconvenient would create incentives for the central banker to avoid such decisions and, thus, completely undermine the benefits of delegating monetary policy to a non-elected government body. In fact, handing monetary policy over to more or less politically independent institutions with a distinct mandate to safeguard price stability has proven

[14] Again, the derivation of this result is provided in the appendix on page 187.

[15] Although causality remains a controversial issue, all in all, there is good empirical support for the assertion that central bank independence does indeed promote price stability. For an overview and discussion of the broad empirical literature examining the effects of central bank independence, refer to Cukierman (2008).

to be an appropriate solution to the time-consistency problem of monetary policy for many industrialized countries.

So far, the basic problem of time-consistent monetary policy was exposed and discussed for the standard case of a closed economy. In such a setting, it is easy to rationalize that redistributional effects of surprise inflation do not play a role in the objective of a policy-maker serving the national interest. After all, unexpected increases in the price level do not change the level of national wealth if all nominal contracts are between agents within the domestic economy. It leads to a mere redistribution of wealth within the economy, which is not necessarily of concern for policy-makers devoid of special interests.

Up until the early 1990s, the archetype of a closed economy had been a reasonable description of most countries in this regard. For the majority of countries, cross-border portfolio investment in nominal securities was small compared to their economic sizes. For those countries that did rely on external finance, borrowing seldomly occurred in domestic currency. Correspondingly, policy-makers in charge of monetary policy did not have opportunities to redistribute wealth from foreigners to the domestic economy back then. This, however, has changed significantly for some countries, as the calculations in section 2 demonstrate. Adapting the discussion of time-consistent monetary policy to this new situation is subject of the following section.

3.2.2 Open Economy

In today's situation of open economies—which, in this context, are characterized by large cross-border holdings of nominal securities—a complete neglect of the redistributional effects of surprise inflation in the policy-maker's loss function is no longer appropriate. Some forms of redistribution, namely those from foreign countries to the domestic economy and vice versa have to be included in a loss function representing national welfare or the preferences of policy-makers with a mandate to act in the national interest.

A simple, but general implementation of international holdings of nominal assets in the closed-economy framework of Barro and Gordon (1983b), for instance, is a loss function of the form

$$L_t = b(u_n - a(\pi_t - \pi_t^e)) + \frac{1}{2}\pi_t^2 + cR_t(\pi_t - \pi_t^e). \qquad (3.6)$$

R_t stands for the redistribution of wealth from the domestic economy to the rest of world that occurs if the realized inflation rate exceeds the expected inflation rate by one percentage point in period t; this means that $-R_t$ covers the redistribution of wealth from the ROW to the domestic economy. The sign of R depends on the net holdings of nominal assets in the domestic currency. If a country is net nominal creditor in its own currency, R takes on positive values. In this case, surprise inflation (i.e. $\pi > \pi^e$) induces a net transfer of real wealth from the domestic economy to the rest of the world, which increases the policy-maker's loss, or reduces his utility, respectively. Compared to the closed economy case, the marginal utility of surprise inflation decreases. On the contrary, if a country is a net nominal debtor in its own currency, R is negative. Here, surprise inflation leads to a transfer of real wealth from the ROW to the domestic economy, which reduces the policy-maker's loss, or increases his utility, respectively. In this case, the marginal utility of surprise inflation increases compared to the closed economy case, in which there are no cross-border holdings of nominal securities ($R = 0$).

The magnitude of R is also subject to the exact inflation scenario, for instance to how fast inflation expectations adjust to the new inflation rate etc., which is discussed in greater detail in section 2. In equation (3.6), the redistribution of wealth depends on the magnitude of surprise inflation instead of actual inflation since nominal payment streams in debt contracts account for the rate of inflation that is expected at the time of conclusion of the contract but are invariant to the ex-post realized inflation rate.[16] Here, the redistribution of wealth from the rest of the world to the domestic economy, $-R_t(\pi_t - \pi_t^e)$, is assumed to depend linearly on the scope of surprise inflation. Analogous to the discussion in section 2.3, this simplification does only make sense for small levels of surprise inflation.

Parameter c indicates the weight the policy-maker puts on the level of domestic wealth relative to the level of inflation. The higher c, the more important is the level of national wealth to the decision-maker and thus

[16] Note that creditors also suffer losses from future anticipated inflation that occurs within their bonds' remaining time to maturity. These losses don't have to be considered separately, however, if t in the latter summand of (3.6) is interpreted as the time span for which payments in debt contracts between domestic and foreign agents are fixed. In reality, this might not necessarily be the same time span for which payments are fixed concerning the nominal rigidities that facilitate the other aforementioned benefits of surprise inflation. Since an allowance for different time spans would not change the argument qualitatively, the above formulation abstracts from these potential differences and all summands of equation (3.6) refer to the same length of period t.

the higher is his temptation to create surprise inflation given a negative R_t. Although c could, in principle, take on positive and negative values, the following analysis is restricted to the more plausible case in which c is larger than zero. In this case, the level of national wealth enters positively in the policy-maker's utility function.

The One-Shot Game

Straightforward minimization of equation (3.6) yields an optimal inflation rate of $\pi_t = ab - cR_t$. Under rational expectations this is also the Nash equilibrium of the one-shot game between the central banker and the public. Note that if a country is net debtor in its own currency, $R_t < 0$, and the policy-maker puts some weight on the level of national wealth, $c > 0$, the equilibrium inflation rate is higher than in the standard case of a closed economy.[17] Since there is again no surprise inflation in equilibrium, the higher inflation rate corresponds to a higher value of the loss function or a lower level of welfare. The intuition behind this is obvious. Given fixed inflation expectations, a policy-maker in a net nominal debtor country now faces an additional incentive to create surprise inflation. Apart from an extension of real economic activity, surprise inflation now also entails a redistribution of real wealth from foreign creditors to the domestic economy. This additional benefit of surprise inflation increases the optimal amount of inflation from the policy-maker's perspective given fixed inflation expectations. Since the public is perfectly aware of these additional benefits, it correctly anticipates the policy-maker's preferred inflation rate and the economy is left with an equilibrium inflation rate that is higher than in the absence of cross-border debt contracts. Put differently, the inflation bias caused by the time-consistency problem of monetary policy exacerbates once a country is net debtor in its own currency.

If a country is net creditor in its own currency, the inflation bias could either be reduced or, if R_t is sufficiently large, it could turn into a deflation bias. Whenever the marginal utility of transferring real wealth from foreign debtors to domestic creditors through surprise deflation is larger than the marginal disutility of the induced reduction of real economic activity, $cR_t > ab$, the discretionary inflation rate is negative. In such a case, the time-consistency problem of monetary policy would lead to a deflation bias, which is equally undesirable as an inflation bias in this setting.

[17] On the other hand, there is an incentive to deflate if a country is net creditor in its own currency.

Another important property of the result is that some of the previously mentioned assumptions needed for a time-consistency problem to emerge, can be relaxed in the open economy case. Now, there neither needs to exist an actual (or believed) possibility to boost real economic activity through expansive monetary policy, $a > 0$, nor does the policy-maker have to have an interest in pushing the unemployment rate below its natural rate, $b > 0$, nor does he have to have an interest in using inflation as a source of revenue for the government. Given nominal foreign indebtedness ($R_t < 0$), a time-consistency problem in the one-shot game originates whenever the decision-maker values domestic wealth higher than foreign wealth, $c > 0$—an assumption that does not seem to be particularly strong for policy-makers with a mandate to act in the national interest.

Summing up, policy-makers in net nominal debtor countries face an additional incentive to create surprise inflation, which aggravates the inflation bias in the discretionary equilibrium. Compared to closed economies, the policy-maker's leeway in decision-making is—at least potentially—more harmful in indebted countries. Thus, the opportunity to transfer real wealth from foreigners to the domestic economy strengthens the case for rules rather than discretion. Correspondingly, the existence of nominal foreign indebtedness also increases the importance of substitutes for binding rules if these are not feasible.

The allowance for cross-country holdings of nominal securities also motivates a slight modification of the ideal central banker's characteristics. Apart from conservativeness in the conventional sense, i.e. a high aversion towards inflation relative to the aversion towards unemployment, a new aspect of this attribute has to be added. In order to minimize the temptation to create surprise inflation, the policy-maker should now attach little or no importance to the level of national wealth. In other words, an ideal central banker should value foreign real wealth just as highly as domestic real wealth, so that he does not derive any utility from gains of the domestic economy that are at the expense of the rest of the world, $c = 0$. To put it bluntly, in a world with substantial cross-holdings of nominal assets, it is in the national interest that monetary policy be conducted by true cosmopolitans.[18]

[18] Another rationale for this statement, that goes beyond the scope of this thesis, is the possible emergence of currency wars and other "beggar-thy-neighbor policies" as the creditor nations' response to a devaluation of their assets.

Reputation in the Repeated Game

Just as in the above-sketched closed economy case, the time-consistency problem in the open economy can be mitigated by a reputational mechanism. Starting from the extended version of the loss function in equation (3.6), the two-period game features the same course of action and the same strategies as in the closed economy case. Again, the best- (lowest-) enforceable inflation rate can be calculated by equalizing the policy-maker's gain of deviating from his previously announced rule in the present period and the present value of his loss of reputation in the future period. Both sides of the trade-off change due to the allowance for redistributional effects. On the one hand, *ceteris paribus*, the marginal utility of deviation from an announced rule in the first period increases if a country is net debtor in its own currency since surprise inflation leads to net windfall gains for the domestic economy. Formally, the gain from deviation in the first period in the open economy case is

$$L_1(\pi_1 = \hat{\pi}_1) - L_1(\pi_1 \neq \hat{\pi}_1) = \frac{1}{2}(ab - cR_1 - \hat{\pi}_1)^2.^{19} \tag{3.7}$$

On the other hand, *ceteris paribus*, the policy-maker's loss in the second period resulting from deviation in the first period also increases with the degree of foreign indebtedness in the country's own currency. The reason for this is that the discretionary inflation rate, with which the policy-maker is "punished" following deviation, rises with the country's nominal indebtedness (decreases with R). Including R, the present value of the second-period loss is

$$\beta[L_2(\pi_2 = ab - cR_2 = \pi_2^e) - L_2(\pi_2 = \hat{\pi}_2 = \pi_2^e)] = \frac{\beta}{2}[(ab - cR_2)^2 - \hat{\pi}_2^2].^{20} \tag{3.8}$$

Since both benefit and loss due to deviation decrease with R, the dependence of the redistributional potential and the best-enforceable inflation rate is a priori not clear. While a larger gain due to deviation, *ceteris paribus*, increases the best-enforceable inflation rate, a harsher punishment, *ceteris paribus*, reduces the second-best inflation rate. For the simple case in which the potential for redistribution is constant, $R_{t=1} = R_{t=2}$, however, it can easily be shown that the former effect always dominates the latter.

[19] The derivation of this equation can be found in the appendix on page 187.
[20] Again, a brief derivation of this result can be found in the appendix on page 187.

Equalizing equations (3.7) and (3.8), solving for $\hat{\pi}^*$ yields a best-enforceable inflation rate of

$$\hat{\pi}^* = \frac{1-\beta}{1+\beta}(ab - cR).^{21} \tag{3.9}$$

As expected, the second-best inflation rate is higher for a country that is net debtor than for a country whose nominal assets equal its nominal liabilities in its own currency. This means that, given the former best-enforceable rule, the additional gain of deviation from the rule in the present period is not completely compensated by the additional loss due to the worse discretionary equilibrium played in the future period. Hence, the announced rule has to be higher to equalize the gains and losses of deviation and thus be credible. Another interesting property of the result is the increased sensitivity of the second-best inflation rate towards the policy-maker's discount rate β. This stems from both the benefit of deviation in the present period and the loss of reputation in the second period being higher than in the closed economy case. Therefore, if the country is indebted in its own currency, it is of further importance that monetary policy be conducted by individuals that have a long planning horizon, i.e. a low time preference rate.

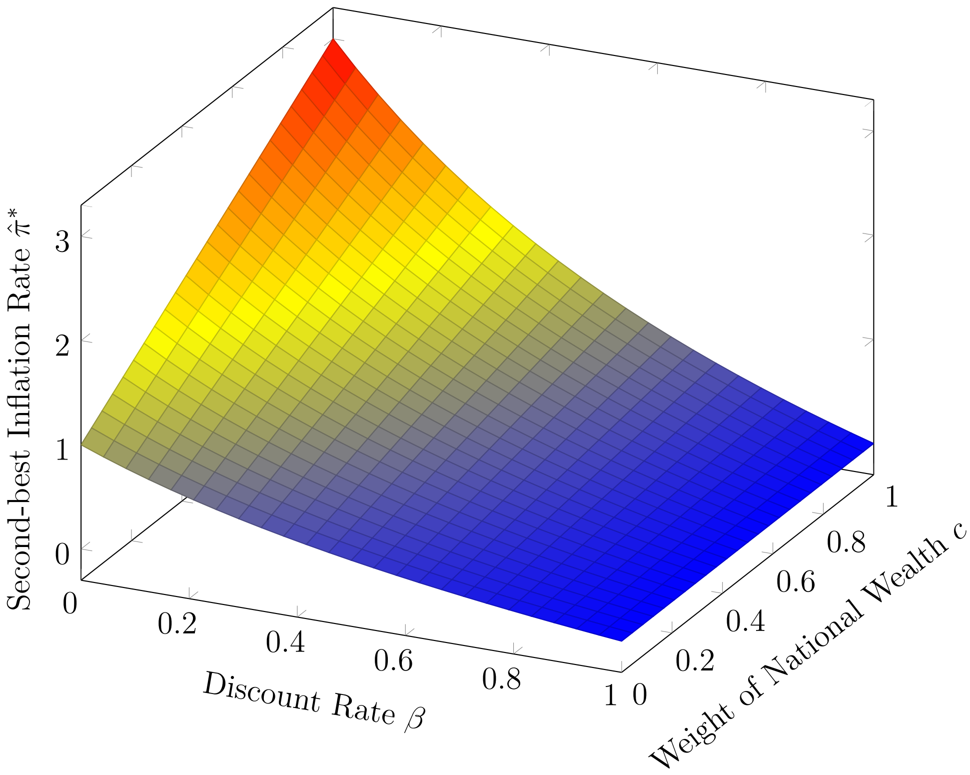
The importance of the policy-maker's planning horizon is also observable in a visualization of different reputational equilibria. Figure 3.1 illustrates the relationship between the policy-maker's two key characteristics and the best-enforceable inflation rate for a country that is net debtor in its own currency. Holding the other parameters of equation (3.9), i.e. a, b, and R, constant, the graph illustrates the influence of the policy-maker's discount rate (plotted on the x-axis) and the weight he puts on the level of national wealth (plotted on the y-axis) on the second-best inflation rate.

For the visualization, the parameters were chosen in a way that the two sources of inflation bias—the temporary increase of employment and the increase in national wealth—are roughly of equal quantitative importance.[22] More precisely, the two sources are of the same magnitude if the parameter c, ranging from zero to one, takes on the value of one-half. The coloring of the surface indicates the level of the second-best inflation rate and thus the

[21] Again, a brief derivation of this result can be found in the appendix on page 187.

[22] Parameters a and b are both set to one, implying that the best-enforceable inflation rate ranges from zero to one if the level of national wealth does not play a role in the policy-maker's objective ($c = 0$). The redistributional potential R takes on the value of -2. Thus, isolated from the inflation bias stemming from the traditional (closed economy) sources, the inflation bias stemming from the redistribution of wealth ranges from zero to two, depending on β and c.

Figure 3.1: Reputational Equilibria in a Net Nominal Debtor Country



severity of the time-consistency problem. The colors range from blue for the lowest level, to yellow for intermediate levels, and red for the highest level of the second-best rate.

The inclination of the surface shows that the second-best inflation rate increases with both the weight the policy-maker puts on national wealth and his time preference, i.e. it falls with his discount rate. Moreover, the inclination indicates that the influences of the two parameters are somewhat different from each other. In particular, the flat-running right edge indicates that c is irrelevant as long as the policy-maker's discount rate is close to unity. This implies that a policy-maker whose rate of time preference is very low (a β close to one) is effectively constrained from inducing surprise inflation by reputational forces, no matter how important the level of national wealth is to him. At the other extreme, c becomes very important when the policy-maker has a strong time preference, which can be seen by the very steep course of the left edge of the surface. Comparing the front to the rear edge of the surface, one can see that the importance of the discount rate increases with the potential to redistribute wealth to the domestic economy.

Although the redistributional potential R is fixed, the effect of quantitative variations of R can implicitly be read from the graph as variations of c have the same effect as variations of R in this context.[23] Since the front edge of the surface refers to constellations in which the policy-maker puts no weight on the level of national wealth at all, it represents the benchmark case of the closed economy. In this, there is a negative relationship between the discount rate and the best-enforceable inflation rate, indicated by the negative slope (from left to right) of the front edge of the surface. The closer a crossline is to the rear end of the surface, the steeper is its slope. Economically, this means that the sensitivity of the second-best inflation rate to the policy-maker's time preference rate rises with the importance of wealth redistribution. As explained before, this result stems from an increase of both gain from deviation in the present period and loss resulting from deviation in the future period.

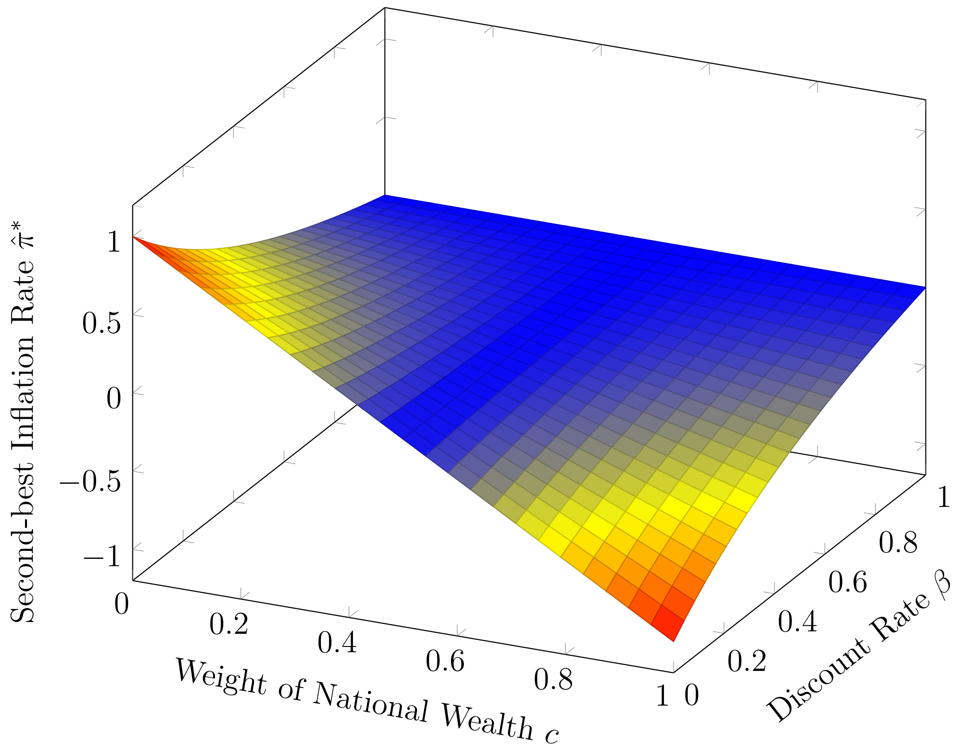
While a higher weight of national wealth is always detrimental to social welfare in nominal debtor countries—the vertical level of the surface in figure 3.1 increases with the y-axis at all points—the influence of c on social welfare is more complex in nominal creditor countries.[24] To shed light on the impact of c and β on the best-enforceable inflation rate in nominal creditor countries, figure 3.2 visualizes the interdependencies in a three-dimensional plot similar to that in figure 3.1. Regarding the parameter values, the only difference between the two cases is the redistributional potential R switching signs. This means that there now is a potential to redistribute wealth from the domestic economy to the ROW that is of equal magnitude, but opposite sign to that discussed above. Another slight difference between the two figures concerns the coloring of the surface. Just as in figure 3.1, blue indicates constellations in which the time-consistency problem of monetary policy is marginal and red indicates those in which it is severe. In the net creditor case of figure 3.2, however, coloring no longer refers to the normal value but to the absolute value of $\hat{\pi}^*$. Thus, the coloring indicates the absolute difference between the first-best inflation rate of zero and the second-best inflation rate given a parameter constellation. A third difference between the two figures concerns the allocation of parameters to the axis. Plotting c on the x-axis and β on the y-axis facilitates the visual traceability of the effects.

Qualitatively, the discount rate has the same effect on the second-best inflation rate as before. No matter whether a country is debtor or creditor

[23] Qualitative variations cannot be studied as the sign of R remains fixed.

[24] Of course, in the extreme case of $\beta = 1$, the effect of c is neutral.

Figure 3.2: Reputational Equilibria in a Net Nominal Creditor Country



in its own currency, a time-consistency problem only emerges if the policy-maker has a preference for present over future benefits. The larger the rate of time preference (the lower β), the larger is the potential for unsound policies. Even more interesting is the effect of parameter c on the second-best inflation rate in this setting. The best way to understand this effect is to consider the front edge of the surface representing the extreme case of zero weight on future levels of utility—which, by the way, depicts the equilibria of the one-shot game. Starting on the left corner point (i.e. zero weight on national wealth), an increase in c lowers the best-enforceable inflation rate and thus attenuates the time-consistency problem. For $c \geq 0.5$, however, this statement is no longer true. A further increase still lowers the best-enforceable inflation rate, however, since the inflation rate is already at its optimum of zero, a further decrease is no longer beneficial to public welfare. Remembering that policy-makers in net creditor countries have an incentive to induce surprise deflation instead of surprise inflation and that there are certain benefits of surprise inflation apart from wealth redistribution, the intuition behind these observations become clear. As opposed to the situation in debtor countries, the two sources of time-inconsistent policies—the opportunity to increase employment and to redistribute wealth between countries—counteract each other. If the importance of national wealth is low—or equivalently if the redistributional effects of surprise inflation are low—$c < 0.5$, the benefits of surprise inflation outweigh its costs and the policy-maker's preferred rate of surprise inflation is positive. Once the importance of national wealth—or equivalently, the redistributional potential—reaches a certain level ($c > 0.5$), the costs of surprise inflation outweigh its benefits and the policy-maker's preferred rate of surprise inflation is negative. Put differently, if a country's net creditor position in its own currency is sufficiently large, the policy-maker's incentive to induce wealth transfers from the ROW to the domestic economy by means of surprise deflation dominates his incentive to induce surprise inflation in order to increase real economic activity. For intermediate levels of c, it is possible that the policy-maker's two opposing incentives cancel each other out, which is indicated by the blue stripe in the middle of the surface. Thus, in net nominal creditor countries, there are constellations in which a time-consistency problem does not emerge, no matter how myopic the policy-maker is.

Lacking real world examples of countries that are net creditors in their own currency, the above-described case currently is purely theoretical. In contrast, with the U.S. as the prime example, the practical importance of the net nominal debtor case is obvious. Thus, in the following discussion of model variations, the focus is on situations in which the domestic economy is nominally indebted to foreigners.

3.3 Model Variations and Supplemental Interpretations

The following section provides two adjuncts to the basic model. First, in section 3.3.1, I analyze the effectiveness of the reputational mechanism when the level of foreign indebtedness changes over time. Second, after introducing additional countries to the model framework, I argue in section 3.3.2 that the formation of currency unions—at least theoretically—provides a solution to the problem of nominal foreign indebtedness.

3.3.1 Reputation and Debt Overhangs

So far, in the calculations of reputational equilibria, the potential to redistribute wealth from the ROW to the domestic economy or vice versa through unexpected inflation was assumed to be constant over time ($R_t = R, \ \forall \ t$). However, as was shown for the U.S. example in section 2, this assumption does not hold in reality. Indeed, in the mid and long run, variations in international cross-holdings of nominal securities can be substantial. Examining how such variations effect the best-enforceable inflation rate is thus an essential extension to the basic model introduced in 3.2. With the U.S. example in mind, situations in which a country is heavily indebted to the ROW now, but is expected to reduce its dependency on external funds in the future—situations which are often referred to as "debt overhangs"—are of particular interest.

Allowing the potential to redistribute wealth across countries to vary from period to period makes things more complicated. The problem is that now the second-best inflation rate also is not constant anymore. Constancy of R and $\hat{\pi}$, however, is necessary to obtain the simple analytical solution of the best-enforceable inflation rate stated in equation (3.9). Still, the condition to derive today's second-best inflation rate is that gains of deviation from an announced rule, specified in equation (3.7), equal the present value of implied future losses, specified in equation (3.8). Without a time-constant redistributional potential, however, one can only express today's best-enforceable rule as a function of tomorrow's best-enforceable rule. The latter, in turn, can only be expressed as a function of the best-enforceable rule of the next period and so on. Thus, today's best-enforceable rule becomes a function of all future best-enforceable inflation rules, or equivalently, of the entire path of future values of R_t. Of course, this implies that the policy-maker's incentives can no longer be analyzed using the simple two-period framework of the basic model. Instead, to avoid end-game effects, it is henceforth assumed that the game never ends, i.e. there always is a future period. For analytical convenience, however, it is assumed that the policy-maker is still only interested in his utility of the present and the following period. Although this might appear to be a strong assumption at first sight, it is not. In fact, neglecting the values of the loss function in the distant future when deciding on today's monetary policy simply implies that the impact of today's decision does not reach beyond the next period. Put differently, following deviation, the policy-maker is only punished for one period. Allowing for longer punishment periods would only have a scaling effect on the policy-maker's discount rate without qualitatively changing the model's message.

Thus, obtaining solutions for the second-best rule requires taking assumptions on the future path of R_t. In the following, the evolution of the best-enforceable inflation rate is analyzed for five different developments of R_t, which are referred to as scenarios one to five. In each of the scenarios, it is assumed that the policy-maker and the public are perfectly informed about the future path of R.[25]

Scenario One

The first scenario is the simplest and the only one in which the second-best inflation rate is calculated analytically. Its results form the basis for the numerical analysis of the more complicated scenarios following below.

In scenario one, the future redistributional potential is constant, $R_t = R,\ \forall\ t \in [2, \infty)$. The redistributional potential of the present period, however, differs from its future value, $R_1 \neq R$. Since R is constant over all future periods, tomorrow's best-enforceable rate equals that of the basic model, which, in turn, enables the calculation of today's best-enforceable rate as a function of R_1 and R. Remembering equations (3.7) and (3.8), the gain from deviation in the first period and the present value of the second-period loss due to deviation are $\frac{1}{2}(ab - cR_1 - \hat{\pi}_1)^2$ and $\frac{\beta}{2}[(ab - cR_2)^2 - \hat{\pi}_2^2]$, respectively. With $R_2 = R$ and $\hat{\pi}_2 = \frac{1-\beta}{1+\beta}(ab - cR)$, the present value of the second-period loss can be written as

$$\frac{\beta}{2}[(ab - cR)^2 - (\frac{1-\beta}{1+\beta}(ab - cR))^2] = \frac{\beta}{2}[(ab - cR)^2(1 - (\frac{1-\beta}{1+\beta})^2)]. \quad (3.10)$$

Thus, the condition for today's best-enforceable inflation rate is

$$\frac{1}{2}(ab - cR_1 - \hat{\pi}_1)^2 = \frac{\beta}{2}[(ab - cR)^2(1 - (\frac{1-\beta}{1+\beta})^2)]. \quad (3.11)$$

After some algebra, solving for $\hat{\pi}_1$ yields a second-best inflation rate of

$$\hat{\pi}_1^* = \frac{1-\beta}{1+\beta}ab - c(R_1 - \frac{2\beta}{1+\beta}R).^{26} \quad (3.12)$$

Today's best-enforceable rate decreases with the difference between R_1 and R. Conversely, this means that $\hat{\pi}_1^*$ increases with the difference between today's potential to redistribute wealth from the ROW to the domestic economy and tomorrow's. Put differently, the higher a country's current level of

[25] Alternatively, all future levels of R_t simply be interpreted as expected levels. Adding uncertainty to these expectations, e.g. by allowing R to fluctuate stochastically, would complicate the analysis without adding major new insights.

[26] The derivation of this result can be found in the appendix on page 188.

nominal foreign indebtedness relative to its future levels, the higher an inflation rule must be to be credible. Comparing the best-enforceable inflation rate under this scenario with that of the basic formulation of the model, in which R_t was assumed to be constant over all periods, yields further insights. With equations (3.9) and (3.12), the condition for the second-best inflation rate under this scenario exceeding that in case of a constant R is

$$\frac{1-\beta}{1+\beta}ab - c(R_1 - \frac{2\beta}{1+\beta}R) > \frac{1-\beta}{1+\beta}(ab - cR).^{27} \tag{3.13}$$

This condition is met if $R_1 < R$.[28] Whenever the current-period potential to redistribute wealth from the ROW to the domestic economy is higher than its long-term level, the current-period second-best inflation rate also exceeds its long-term level. This means that the reputational mechanism constraining the policy-maker to induce surprise inflation is less effective when the current level of nominal foreign indebtedness is unusually high. Put differently, there are inflation rules that are enforceable in normal times, i.e. when $R_1 = R$, but are not enforceable in periods featuring an especially low value of R. In these periods, the rewards of a deviation from a previously established policy rule are especially high—a deviation entails a particularly high transfer of nominal wealth from the ROW to the domestic economy—while the costs in terms of a higher expected inflation rate in the following period are only on its normal level. This result that a reputational equilibrium is less likely to hold in periods featuring especially high rewards of a deviation is straightforward and well-known from other fields of economic research.[29] On the contrary, the result also implies that the reputational mechanism is especially effective when today's level of nominal foreign indebtedness is unusually low ($R_1 > R$). In this case, the rewards of a deviation from an announced rule are comparatively small, making the announcement of lower than average inflation rates credible.

The intuition behind this result becomes even more apparent when a special case of this scenario, namely that of a temporarily indebted economy, is considered. In such a country, there is an opportunity to redistribute wealth from foreign creditors to domestic debtors today, but none tomorrow.

[27]Naturally, comparing the two rates in this form implies that R refers to the same level of the redistributional potential under both settings, i.e. R on the left-hand side equals R on the right-hand side of the inequation.

[28]The proof of this supposition can be found in the appendix on page 188.

[29]For instance, Rotemberg and Saloner (1986) find that oligopolists are more tempted to deviate from a collusive equilibrium in periods with high demand than in periods with little demand for their products.

Inserting $R_1 < 0$ and $R = 0$ in equation (3.12) yields a best-enforceable inflation rate of

$$\hat{\pi}_1^* = \frac{1-\beta}{1+\beta}ab - cR_1. \tag{3.14}$$

This inflation rate is not just higher than that in the closed economy case, but also higher than that in case of a constant negative R. In such a case, the economy's temporary debtor position—the debt overhang—makes surprise inflation especially appealing to the policy-maker. Thus, with rational investors, the announced rule must be particularly high in order to be credible. Put differently, the time-consistency problem of monetary policy is most severe when the domestic economy is only transiently a net debtor in its own currency.

To analyze more complex paths of R, it is useful to express the best-enforceable inflation rate in period t as a difference equation. Starting from the condition that today's gain from deviation equals the present value of tomorrow's losses due to deviation, solving for $\hat{\pi}_t^*$ yields

$$\hat{\pi}_t^* = ab - cR_t - \sqrt{\beta}\sqrt{(ab - cR_{t+1})^2 - \hat{\pi}_{t+1}^*}. \tag{3.15}$$ [30]

Today's best-enforceable inflation rate increases with today's level of nominal external debt and, *ceteris paribus*, decreases with next period's level of nominal external debt. Apart from the direct effects of R_t and R_{t+1}, $\hat{\pi}_t^*$ also depends on next period's best-enforceable rate, $\hat{\pi}_{t+1}^*$. Since the latter, in turn, is influenced by the redistributional potential in $t+2$, there also is an indirect effect of R_{t+2} on today's best-enforceable rate. Moreover, through the dependency of tomorrow's best-enforceable rate on the best-enforceable rate of the period following tomorrow, which, in turn, depends on R_{t+3}, $\hat{\pi}_t^*$ is also indirectly influenced by R_{t+3} and so on. Essentially, today's best-enforceable inflation rate depends on the entire future path of R. Quantitatively, however, the influence of future levels of R diminishes with the number of periods between today and the respective future period.

Knowing that the levels of R in the remote future only negligibly influence $\hat{\pi}_t^*$, the behavior of the best-enforceable inflation rates under different paths of R for the near future can be analyzed numerically using a simple trick: It is assumed that, beginning at an arbitrary point in the remote future, R stays constant. Thus, for this point in time, the best-enforceable rate can be calculated using equation (3.9). As long as the time interval between the

[30] The derivation of this equation can be found in the appendix on page 189.

periods under review and the period from which onwards R is constant is sufficiently large, the value at which R is assumed to be fixed is irrelevant. Knowing the best-enforceable rule at some point in the remote future then allows to calculate the entire path of best-enforceable rules given different paths of R and fixed values of the exogenous parameters a, b, c, and β.

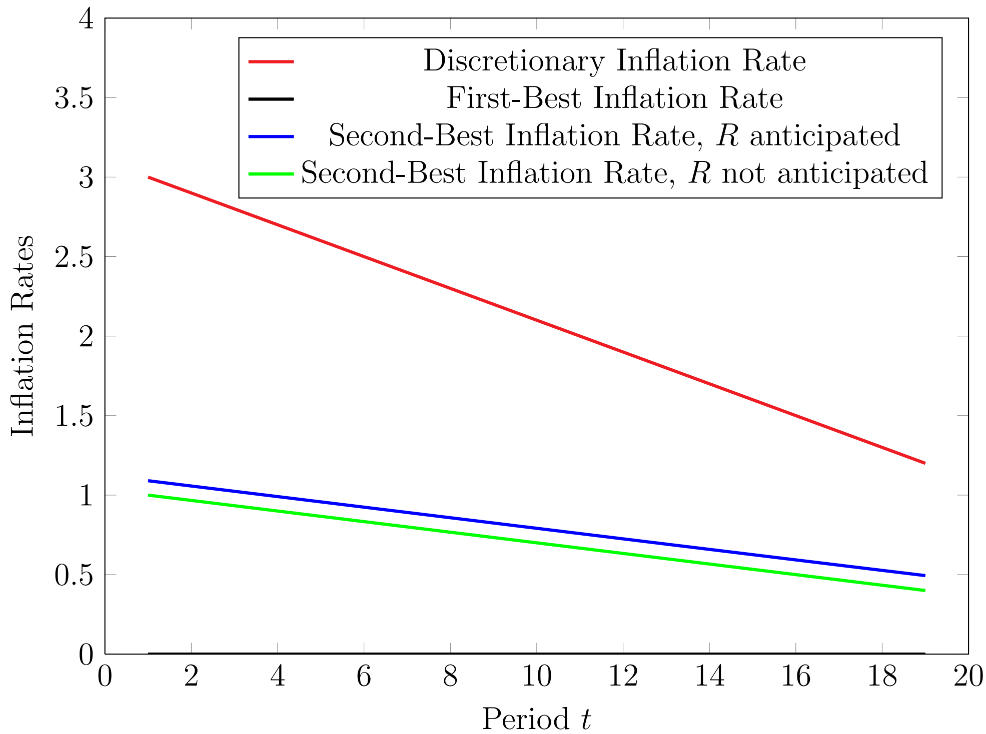
Scenario Two

Under this scenario the redistributional potential from the domestic economy to the rest of the world increases monotonously by the amount $Z > 0$ per period,

$$R_{t+1} = R_t + Z. \tag{3.16}$$

Starting from a situation in which the economy is a net nominal debtor in its own currency, $R_1 < 0$, the redistributional potential from the ROW to the domestic economy decreases linearly with time.[31] Thus, the scenario represents a situation in which a country is initially confronted by a debt overhang that is gradually reduced over the next periods.

Figure 3.3: The Evolution of Inflation Rates under Scenario Two



[31] I also repeated the exercise for an exponentially increasing R. Apart from the non-linearity in the path of the discretionary rate, there are no major differences to the linear case. Thus, an inclusion of this case would not provide much further insight.

Figure 3.3 depicts the evolution of the best-enforceable inflation rate for twenty periods and contrasts it with those of the first-best and the discretionary (i.e. the inflation rate of the one-shot game) inflation rate. Moreover, a fourth line shows another second-best inflation rate, namely that in case of a constant future redistributional potential. It can be interpreted as the best-enforceable inflation rate under the assumption that the policy-maker as well as the public expect the redistributional potential to remain at its current level. As in the previous visualizations of numerical examples, the exogenous parameters are set to values for which the two sources of time-inconsistency are roughly of equal magnitude. More precisely, a, b, and c are each set to one and β is set to one-half. From its initial level of $R_1 = -2$, R increases by the amount $Z = 0.1$ each period.[32] As a, b, and c are constants, starting from its initial level of $\pi_1 = 3$, the discretionary inflation rate decreases linearly with time. Since any anticipated inflation leads to costs without benefits, the first-best inflation rate is always zero in this model.[33] The second-best inflation rate also decreases with R, connoting that the first-period gain from deviation decreases more strongly in absolute terms than the present value of the second-period loss due to deviation. Thus, an increase in R generally leads to a more favorable situation, i.e. a lower enforceable inflation rule. Another striking result of the numerical analysis is that the distance between the second-best and the discretionary rate narrows over time. The reason for this is that the second-best inflation rate is an approximately constant fraction of the discretionary rate under this scenario. Hence, the absolute difference between the two rates falls with the absolute value of the discretionary rate, which itself falls linearly with R. A comparison between the two second-best inflation rates depicted in figure 3.3 is more revealing. Both curves run more or less parallel, with the second-best rate in case of an anticipated increase of R, the blue curve, lying above the second-best rate calculated under the assumption that R is expected to be constant, the green curve. Thus, in situations in which all agents expect the level of foreign indebtedness to be cut back in the future, the best-enforceable inflation rate is higher than in situations in which the

[32]From $t = 28$ onwards, R is assumed to be constant at an arbitrary level of $R = 0$. With eight periods between the fixation and the last period under review, variations of this value barely affect the best-enforceable rate of the twentieth period, let alone any of those in prior periods.

[33]Strictly speaking, a situation with an unemployment rate above zero (or the full employment rate) is not first-best. To arrive at the true first-best situation, one would need to efface the labor market distortions leading to a natural rate above zero. Evidently, monetary policy does not provide policy instruments to achieve that goal as rational agents are not willing to be deluded systematically in order to increase employment.

country's external debt is expected to remain at its current level. This stems from the decreasing rigor of punishment in the second period and thus affirms the conclusion of the previous paragraph that, at any point in time, the reputational mechanism is less effective if R is expected to rise in the future than if it is expected to remain constant.

Scenario Three

Scenario three is the exact opposite of scenario two. Now, R_t decreases monotonously by the amount $Z > 0$ per period. This implies that the potential to induce a transfer of wealth from the ROW to the domestic economy through an unexpected boost in inflation increases over time,

$$R_{t+1} = R_t - Z. \tag{3.17}$$

The scenario starts at the endpoint of the previous scenario, at which R is negative but very small. With respect to the values of all of the other parameters (i.e. a, b, c, β, and Z), scenario three does not differ from scenario two.

Figure 3.4: The Evolution of Inflation Rates under Scenario Three

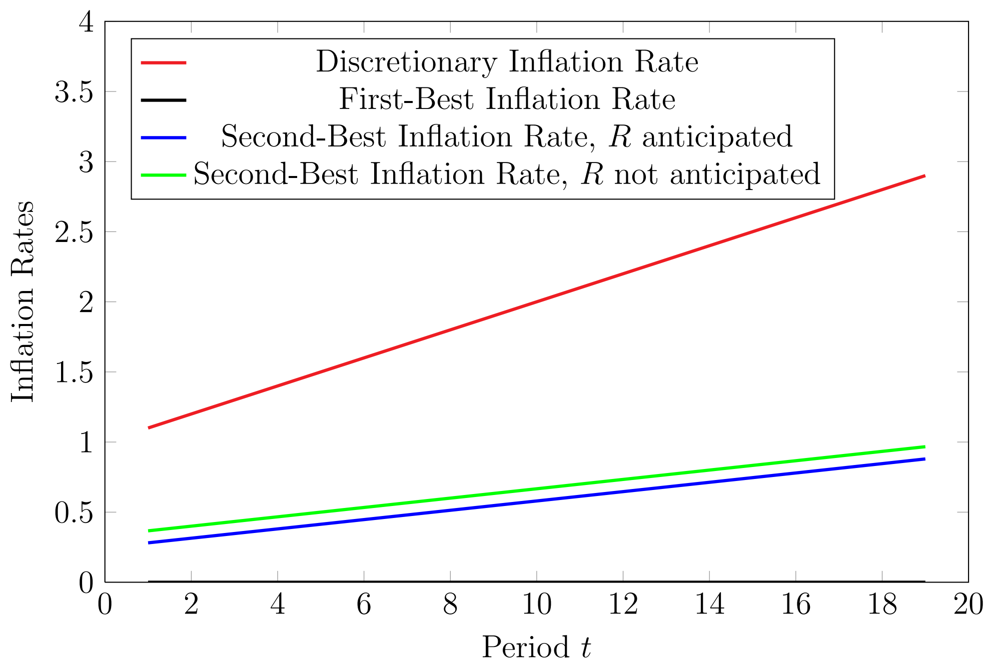


Figure 3.4 depicts the evolution of the first-best, the discretionary, and the two second-best inflation rates under scenario three. Expectedly, both

the discretionary and the best-enforceable inflation rate now increase from period to period. The graphs are almost mirror-inverted to those in scenario two. Here, the distance between the discretionary and the second-best rate widens from period to period. As explained above, this simply stems from the discretionary rate increasing over time. Comparing the two second-best inflation rates also yields the opposite result of scenario two. Here, the second-best inflation rate in case of an anticipated increase in the level of foreign indebtedness is always lower than the second-best inflation rate calculated under the assumption that the decrease in R is not anticipated. This implies that the reputational mechanism is particularly effective in times in which the domestic economy's net nominal position is steadily decreasing. Given the previous explanations, the intuition behind this result is straightforward. From the policy-maker's perspective, deviation, *ceteris paribus*, becomes less attractive as the prospect punishment in period two increases. The severity of punishment, in turn, increases as R decreases. Thus, policy-makers in economies that are currently building up external liabilities are little tempted to induce surprise inflation. Put differently, the reputational mechanism that restrains the policy-maker from creating surprise inflation is especially effective in phases in which the level of foreign indebtedness is on the rise.

Scenario two is a pointed, yet accurate, description of the situation the policy-makers at the Federal Reserve have found (and possibly still find) themselves in over the past 15 years. Starting from a small level in the late 1990s, U.S. nominal foreign indebtedness has increased sharply as a fraction of U.S. GDP. Although—as opposed to the situation in the model—neither the Fed nor the public can or could foresee the entire path of the future redistributional potential, it is plausible to assume that the approximate short- and medium-term trend in this number was common knowledge—at least until the financial turmoil of 2008. Eventually, the two broad macroeconomic factors driving the steadily increasing level of U.S. foreign indebtedness, large current account deficits and the process of financial globalization, were unlikely to simultaneously reverse from one period to the next. Thus, the results for this scenario deliver a potential explanation to why the Fed has seemingly not tried to induce surprise inflation so far, in spite of the opportunity to realize large wealth gains for the domestic economy.[34]

[34]There are, of course, many other possible and feasible explanations to why the Fed has not tried to induce a surprise inflation in the past decade. In the context of the model, possible explanations are, for example, a low weight on the level of national wealth, c, or a low level of time preference, a high β.

Scenario Four

Regardless of the appropriateness of the argument for the U.S. example, it is insightful to examine the policy-maker's incentives for a fourth path of R in the model context. The scenario is a combination of the two previous scenarios. Starting from a small negative value, R decreases linearly for 10 periods by the amount Z each period. After the trough in the 10th period, it increases by the same amount Z each period. At the end of the period under review it reaches its initial value. From the 22nd period onwards R remains constant.[35] Expressed formally, the path of R is

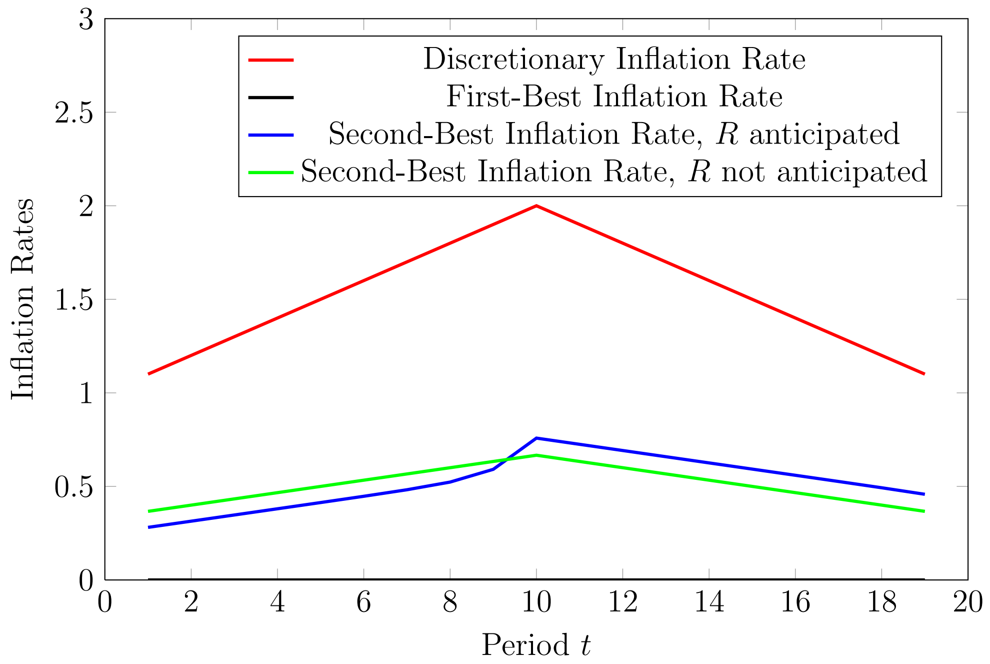
$$R_{t+1} = \begin{cases} R_t - Z & \forall \quad t \in [0\ ;\ 9] \\ R_t + Z & \forall \quad t \in [10\ ;\ 21] \\ R_t & \forall \quad t \in [22\ ;\ \infty) \end{cases} . \tag{3.18}$$

Just as in the previous two scenarios, the evolution of the first-best, the discretionary, and the two second-best inflation rates are visualized for a numerical example. The exogenous parameters are each set to the same values as in the previous two scenarios (i.e. $a = b = c = 1$, $\beta = 0.5$, $Z = 0.1$, and $R_1 = -0.1$). Thus, the graphs in figure 3.5 depict a situation in which the level of foreign indebtedness steadily increases over the first half and steadily decreases over the second half of the review period.

The discretionary rate runs proportionally to R and thus exhibits a symmetrical course. It rises linearly until its maximum in the 10th period before falling linearly back to its initial value in the 19th period. Similarly, the best-enforceable rule under the assumption that R is expected to remain constant also exhibits a symmetrical course. Just as under the previous scenarios, it is directly proportional to the discretionary inflation rate. More revealing is the course of the best-enforceable policy rule when R is correctly anticipated. It increases roughly linearly until the 7th period, then features a convex intercept until it reaches a peak in the 10th period and falls with a roughly constant slope over the remaining period under observation. Contrary to the discretionary rate, its course is neither symmetrical nor does it reach its initial value in the last period. Until the 9th period, while R is decreasing, the blue line runs below the green line. Subsequently, while R is increas-

[35] Again, the evolution of R after the 20th period is arbitrarily chosen and has no qualitative influence on the analysis. Alternative paths of R in the remote future only have slight effects on the second-best inflation rate for the last two periods of the examined interval.

Figure 3.5: The Evolution of Inflation Rates under Scenario Four

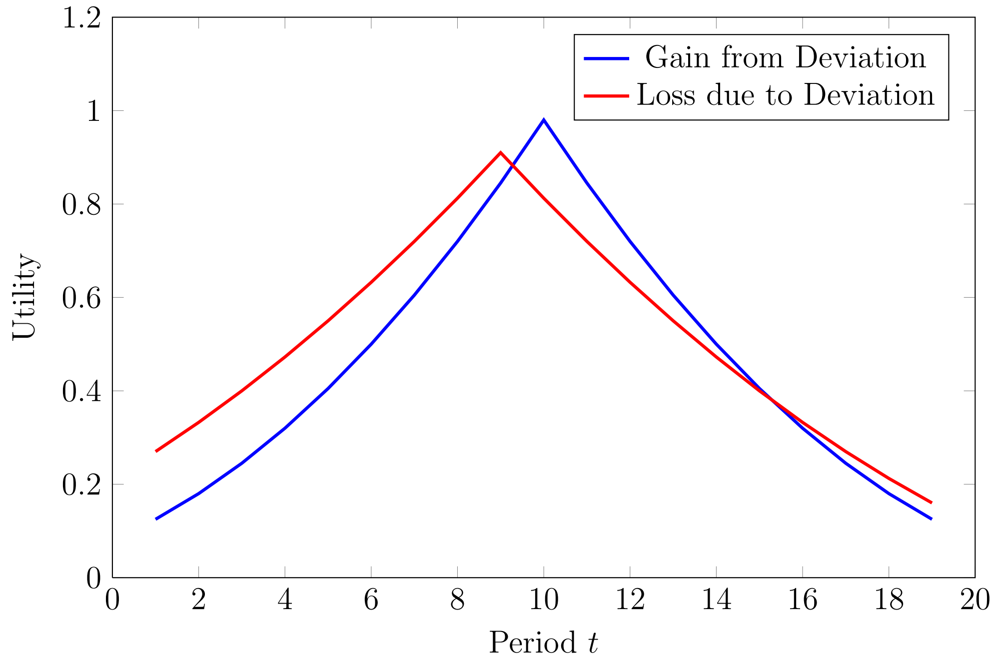


ing, it runs above the green line. This affirms the results of the previous scenarios that reputational forces are strong when the level of foreign debt is expected to increase and weak when the level of foreign debt is expected to decrease. As scenario three is a catenation of the first two scenarios, one might expect the blue curve to be a simple sequence of the second-best rules under the first two scenarios as well. While this applies to the second-best inflation rate if the path of R is not anticipated, it does not if the path of R is anticipated. Most notably, the sharp rise of the blue curve on the eve of its turning point in $t = 10$ is unique to the fourth scenario. It is caused by the anticipated trend reversal in the evolution of R. On the one hand, the gain from deviation falls with R_t. On the other hand, the present value of the punishment enforced in the next period increases with next period's discretionary rate and is thus negatively linked to next period's redistributional potential R_{t+1}. Hence, the appeal of deviation, *ceteris paribus*, increases with the difference of next period's and today's redistributional potential, $R_{t+1} - R_t$. As a result, today's best-enforceable rule, defined as the rule for which the benefits due to deviation equal the losses due to deviation, also increases with this difference. Moreover, today's best-enforceable rule positively depends on tomorrow's best-enforceable rule, which, in turn, is an upward sloping function of the difference between the redistributional potential in two periods and the redistributional potential in one period,

$R_{t+2} - R_{t+1}$. There is thus a second-order effect of this future difference on today's best-enforceable rule. By defining the difference between two future levels of R as $\Delta_x \equiv R_{t+x} - R_{t+x-1}$, the dependencies of $\hat{\pi}_t^*$ on the future path of R can be stated in more general terms. Δ_x has an effect of the order of x on the second-best rule in the current period. Given a loss function that is quadratic in the inflation rate, effects of a higher order than three influence $\hat{\pi}_t^*$ only marginally, which explains why the trend-reversal of R in the 10th period is barely detectable until the 8th period.

Another way to look at the model mechanics under scenario four is to examine the behavior of the gains from deviation and the present value of the implied losses given a constant and established rule. Established here means that the public expects the policy-maker to adhere to the rule.

Figure 3.6: Gains and Losses from a Given Inflation Rule under Scenario Four



For every period, the difference between the red and the blue line in figure 3.6 indicates how easily the rule is enforceable at that time.[36] In periods in which the red line lies above the blue line, the announced rule is not credible and hence not enforceable. In the beginning, the contemplated rule is very easily enforceable, signaling that there would be a lot of scope to lower the

[36] The rule used in the numerical analysis is $\hat{\pi} = 0.6$. Its exact value is chosen arbitrarily from a range of inflation rules that are initially enforceable but lose credibility during the transition period.

rule without losing credibility. Subsequently, the two curves converge very slowly until the 9th period, in which the red line peaks. Since the gains from deviation, depicted by the blue line, continue to rise for one more period until they peak, the two lines intersect between the 9th and the 10th period. From the 10th to the 13th period, gains exceed losses and the rule is not enforceable. The one period lag between the two curves' peaks results from the penalty for deviation predominantly depending on next period's redistributional potential, while the gains solely depend on today's. This time lag between gains and losses explains why the best-enforceable rule displayed in figure 3.5 jumps up in the 9th and 10th period.

Figures 3.5 and 3.6 directly correspond to each other. Essentially, they visualize the same numerical example in two different ways. While the inflation rule is the endogenous variable in figure 3.5, it is fixed in figure 3.6, which allows gains and losses to differ from each other. Both diagrams exemplify the main finding of this section that the reputational mechanism restraining the policy-maker from creating surprise inflation is, *ceteris paribus*, least effective in transition periods from a high to a low nominal foreign indebtedness. In other words, the creation of surprise inflation is most appealing to policy-makers when the domestic economy exhibits a large overhang of external debt and, at the same time, is no longer dependent on foreign funding in the future. The intuition behind this result is apparent. If the redistributional potential from the ROW to the domestic economy is expected to be at or near its peak, the incentives to create surprise inflation are most pronounced. The policy-maker gets maximum short-term gains while long-term losses are below their maximum level.

Scenario Five

The path of R in scenario four is explicitly chosen to reveal the problems in a transition period. In reality, one might object, there are no sudden and anticipated turns in the path of a country's nominal indebtedness. Indeed, slow and more or less smooth transition periods seem more realistic since sudden changes in the fundamental factors driving R are rather unlikely. Thus, the analysis is augmented with a fifth scenario featuring a smooth transition from a period of decreasing to a period of increasing R. The path of R equals that of the fourth scenario for the first 7 periods. From the 8th to the 10th period, the descend gradually slows down before R reaches its trough in the 10th period. After this, it begins to rise at an increasing rate until the 12th period. From the 13th period onwards, R increases by the same amount each period until its reaches its initial value in the 20st period. Formally, the path of R_t is

$$R_{t+1} = \begin{cases} R_t - Z & \text{if} \quad t \in [0 \; ; \; 7] \\ R_t - Z/2 & \text{if} \quad t = 8 \\ R_t - Z/4 & \text{if} \quad t = 9 \\ R_t + Z/4 & \text{if} \quad t = 10 \\ R_t + Z/2 & \text{if} \quad t = 11 \\ R_t + Z & \text{if} \quad t \in [12 \; ; \; 19] \\ R_t & \text{if} \quad t \in [20 \; ; \; \infty) \end{cases} . \tag{3.19}$$

Again, the evolution of the relevant inflation rates is visualized for a numerical example. All of the exogenous parameters are fixed at the same values as under scenario four (i.e. $a = b = c = 1$, $\beta = 0.5$, $Z = 0.1$, and $R_1 = -0.1$).

Figure 3.7: The Evolution of Inflation Rates under Scenario Five

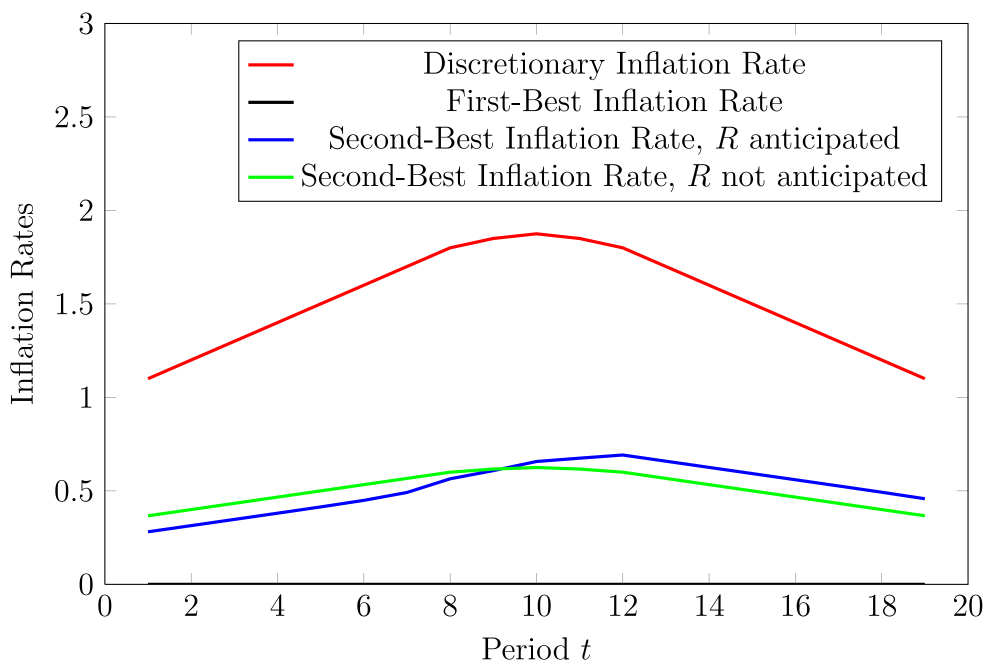


Figure 3.7 reveals the development of the second-best inflation rate along with those of the discretionary and the first-best rate. As always, the path of R_t is reversely reflected in the curve of the discretionary rate. With R changing more smoothly than under scenario four, it resembles a knoll rather

than a sharp peak. These slight differences can also be detected comparing the second-best inflation rates in case of incomplete information between the scenarios. The evolution of the best-enforceable rule under full information (the blue curve) also jumps up during the transition period albeit less pronounced than under the fourth scenario. It peaks in the 12th period when the difference between the squared current-period redistributional potential and the squared future-period redistributional potential, $R_t^2 - R_{t+1}^2$, is at its maximum. With the smooth path of R, this maximum is reached at a later stage than under scenario four. Apart from these minor disparities in the exact timing, the blue curve confirms the basic finding of the fourth scenario. When the potential to redistribute wealth from the ROW to the domestic economy today is large but is expected to be lower tomorrow, the policy-maker's temptation to deviate from an announced inflation rule is particularly high.

In the model, the aggravation of the time-consistency problem during a transition period stems from the costs of deviation depending on the future level of R. The costs accrue from the economy falling back into the less favorable discretionary equilibrium for at least one period. But is it plausible that the severity of punishment in reality depends on future levels of foreign indebtedness?

Sticking close to the theoretical model one might argue that, after a deviation, the public does not trust the policy-maker anymore and expects him to choose the rate that is optimal from his perspective in the short run. Since this optimal rate increases with the level of nominal foreign indebtedness, the public's expectations also positively depend on that number. Hence, the realized inflation rate in the future and thus the severity of punishment increase with the level of nominal foreign indebtedness. Separate from the argumentation in the model, other forms of punishment are plausible. For example, it is quite possible that international investors demand higher real returns from domestic debtors after a (perceived) deviation. Adverse funding conditions, *ceteris paribus*, lead to a reduction of national wealth. The magnitude of this effect on national wealth, in turn, is strongly related to the country's dependency on international capital flows in the contemplated period. Since a country's dependency on foreign capital is strongly related to its level of foreign indebtedness, this channel of punishment does qualitatively not differ from the one highlighted in the model. In both cases, the severity of punishment increases with the future level of foreign debt. Thus, the model's result that the creation of surprise inflation is most attractive in times in which a large debt overhang coincides with rather low (expected) refinancing requirements in the future, does not hinge on the specific modeling of how punishment is enforced.

3.3.2 A Case for Currency Unions

So far, the problem of foreign indebtedness was analyzed from the perspective of a single country. There was only one country, one currency, and one redistributional potential. Consequently, the model did not allow for possible interactions between different countries. In fact, for situations in which the debtor nation does not exhibit a significant exposure to foreign currencies, as is the case for the U.S. example, modeling other countries is not necessary. Analyzing symmetric situations—i.e. when countries are mutually indebted—however, requires augmenting the analysis by the introduction of other countries.

In general terms, every economy possesses an exposure to surprise inflation in every currency existing. Thus, if there are n currencies in the world, there are also n different redistributional potentials for each country. Since each country exhibits a vector of redistributional potentials, the total number of Rs for m countries is $m \times n$. For every period, all redistributional potentials can be displayed in a matrix of the form

$$\mathbf{R_t} = \begin{bmatrix} R_{1,1} & R_{1,2} & ... & R_{1,n} \\ R_{2,1} & R_{2,2} & ... & R_{2,n} \\ ... & ... & ... & ... \\ R_{m,1} & R_{m,2} & ... & R_{m,n} \end{bmatrix}. \tag{3.20}$$

This matrix comprises the entire cross-border exposures to surprise inflation in all currencies at one point in time. For instance, $R_{i,j}$ stands for the wealth gain of country i when the inflation rate in currency j exceeds the expected inflation rate in this currency by one unit. The other elements of row i stand for country i's exposure levels to other currencies. A column, on the other hand, depicts the net nominal holdings of all countries in one currency. For example, assessing the losses different countries would suffer in case of surprise inflation in the USD in section 2.4.2 can be seen as an attempt to quantify the USD column of matrix $\mathbf{R}$ for June, 2012. The sum of each column is always zero by construction. After all, no matter which currency is regarded, surprise inflation leads to a mere redistribution of wealth, implying that the sum of net gains must correspond to the sum of net losses.

With each of the n columns summing up to zero, the sum of all elements must also sum up to zero. The sum of a row, however, can take on any value. It is the net gain of country i if there is surprise inflation of one unit in all currencies, which may well be significantly below or above zero. An element of the matrix's main diagonal represents a country's exposure level to its own currency. Contraintuitively, these values must not add up to zero. Although it is impossible that all countries are net nominal debtors in total, i.e. over all currencies, it may well be that each country in the world is a net nominal debtor in its own currency. Thus, the sum of the main diagonal can quite significantly differ from zero.

Of course, in reality, most of the elements of **R** are very small, if not zero. In fact, the vast majority of cross-border holdings of nominal assets are denominated in one of the world's leading currencies. Thus, even in times of financial globalization, only few of the columns in **R** actually comprise large numbers. Nevertheless, the magnitude of the numbers in **R** have increased significantly over the last decades when cross-border capital streams have been soaring.

From a national perspective, only a country's own vector of R, describing the nation's exposure to different currencies, is of direct relevance.[37] Applied to the model, a policy-maker's loss function in country i now is

$$L_{i,t} = b(u_n - a(\pi_{i,t} - \pi_{i,t}^e)) + \frac{1}{2}\pi_{i,t}^2 + c_i \sum_{j=1}^{n} R_{j,t}(\pi_{j,t} - \pi_{j,t}^e). \tag{3.21}$$

This loss function is, in fact, simply a generalized version of that used in section 3.2.2. Still, the policy-maker's utility positively depends on the level of national wealth. Now, however, the latter is not only influenced by surprise inflation in the country's own currency but also by surprise inflation in other currencies. In this general form, the weight a policy-maker puts on the level of national wealth, c, differs from country to country. This does not just reflect differences in preferences but also differences in the size of countries. Since R_i refers to an absolute wealth gain of country i, c must, *ceteris paribus*, decrease with the size of an economy, as the importance

[37] Indirectly, a nation might also be interested in the column vector of its own currency, which indicates the exposure levels of different countries to the domestic currency. These values, however, are only relevant if other countries' future policies in some form depend on domestic monetary policy. For instance, the exposure of trading partners to the domestic currency becomes relevant if these are expected to punish the domestic economy in some form following surprise inflation.

of one unit of national wealth also decreases with the economic size of the respective country.

In the absence of strategic interactions between policy-makers of different countries, only the redistributional potential in the national currency is policy-relevant. This means that the domestic economy's exposure levels to inflation in foreign currencies do not influence the policy-maker's decisions on domestic monetary policy. Formally, the absence of strategic interaction implies that the level of surprise inflation in foreign currencies is independent of the domestic inflation rate, $\frac{\partial(\pi_{j,t}-\pi^e_{j,t})}{\partial\pi_{i,t}} = 0, \ \forall \ j \neq i$. Hence, the minimization of equation (3.21) results in a discretionary inflation rate of $\pi^*_{i,t} = ab - c_i R_{i,t}$, which is the same as that of section 3.2.2. From a national perspective, $\pi^*_{i,t}$ was considered undesirable as a rational public would anticipate it, only leading to higher expected inflation in equilibrium. Put differently, nominal foreign indebtedness was considered to be harmful as it provides incentives to create surprise inflation, which, however, does not take place in equilibrium. From an international perspective, the argument why foreign indebtedness might be harmful is much simpler. Even if surprise inflation actually takes place, i.e. even if the domestic economy realizes wealth gains due to surprise inflation, its effects are not desirable as the gains of some countries are the losses of others. For any negative redistributional potential in a column of $\mathbf{R}$, there must be a positive equivalent in the same column. Hence, the global amount of real wealth does not change as a result of surprise inflation, no matter which currency is considered. In fact, the existence of nominal foreign debt is a classic case of an externality. It provides an incentive to some agents, namely debtor nations, to engage in actions that benefit them at the expense of others, namely creditor nations.

A simple way to solve this externality problem has already been mentioned before. If monetary policy is delegated to a cosmopolitan central banker who is not interested in redistributing wealth between nations, no such problem evolves. Equivalently, the problem is solved when monetary policy is handed over to an international institution that pursues only common interests. Both of these solutions, however, are not very realistic. Somewhat closer to reality is a partial solution to the problem of nominal external debt, namely the creation of currency unions between mutually indebted countries.

Monetary Union as a Partial Solution to the Problem of Nominal Foreign Indebtedness

In the extreme case of a global institution governing monetary policy benevolently for all countries and currencies, the problem of nominal indebtedness between nations is solved completely. A much more plausible, partial solution to this externality problem is the foundation of currency unions between countries featuring close economic ties to each other. Precondition for such a partial solution, however, is that monetary policy in the common currency is not influenced by national interests. In other words, monetary policy must be delegated to a *true unionist*, i.e. a person or institution that puts equal weight on the levels of unemployment and wealth of all countries participating in the union. In this case, only the union's aggregate values matter and the policy-maker's loss function is

$$L = b(u_{n,u} - a(\pi_{u,t} - \pi^e_{u,t})) + \frac{1}{2}\pi^2_{u,t} + c_u R_u(\pi_t - \pi^e_t). \tag{3.22}$$

Apart from the subscript u indicating union aggregate values, the notation does not differ from previous versions of the loss function, i.e. $u_{u,t}$ stands for the union's unemployment rate, $\pi_{u,t}$ for the unions's inflation rate,[38] and $R_u(\pi_{u,t}+\pi^e_{u,t})$ for the change in the currency union's total wealth. The discretionary inflation rate then is $\pi^*_{u,t} = a_u b - c_u R_{u,t}$. To understand why common monetary policy is superior to individual policies in this framework, one has to compare the policy-makers' incentives prior to and after the formation of the union. First, consider the extreme case in which the member countries are solely indebted among themselves, i.e. when the currency union as a whole has a balanced nominal position ($R_u = 0$). In this, policy-makers in nominally indebted countries have an incentive to fleece their foreign creditors prior to the formation of the union, which might result in a permanent inflation bias. After the formation of the union, however, there is no bias due to nominal indebtedness despite of nominal imbalances *within* the currency area as a true unionist is only interested in the aggregate level of wealth in the union. At the other extreme, if there are no cross-border holdings of nominal securities between the participating countries, the union's inflation bias is simply the weighted average of the member countries' inflation biases prior to the formation of the union. As a rule, however, one can as-

[38] The model abstracts from the problem that the inflation rate is in reality not perfectly controllable by the central bank and assumes that the policy-maker can choose the inflation rate directly. Thus, there is no room for differing inflation rates among the members of the currency union.

sume that the importance of nominal wealth redistribution decreases with the size of the currency union. The larger the currency area, the lower is the share of foreign assets and liabilities in the union's total wealth and, thus, the smaller are the incentives to create surprise inflation. This is all the more true for currency unions formed by neighboring countries with highly integrated goods and capital markets. Formally, this can be expressed by

$$|c_u R_u| < |\sum_{i=1}^{k} \alpha_i c_i R_i|. \tag{3.23}$$

Coefficient α_i represents the economic weight of one of the k members forming the currency union. R_i here refers to the redistributional potential of surprise inflation in the domestic currency prior to the formation of the union. Thus, the right-hand side indicates the weighted sum of the individual inflation biases stemming from nominal external indebtedness prior to the formation of the union. The weighted sum of redistributional potentials after the formation of the union is, of course, always equivalent to the union's aggregate redistributional potential. Inequation (3.23) is true as long as there are *some* cross-border holdings of nominal assets between the k countries forming the union. Put differently, a country or currency union converges to the closed economy case ($cR = 0$) with increasing size. Thus, the scope of external effects and the potential for unsound policies stemming from these diminishes.

With respect to the matrix of redistributional potentials, the creation of a currency union reduces the number of columns. In the presence of a true unionist in charge of monetary policy, it also implicitly reduces the number of rows as only the union's aggregate exposure to the world's currencies matters. Moreover, the creation of a currency union might also reduce the magnitude of the redistributional potentials of the member states as the following example illustrates.

To enhance the clarity of the argument, consider a simple example of two countries. Both have a currency of their own and a balanced net foreign asset position. However, each country holds nominal assets denominated in the other country's currency. Although both countries' external assets equal their external liabilities, they are nominal debtors in their own currency. Their foreign liabilities are exclusively denominated in their own currency, while their foreign assets are denominated in foreign currency.

Table 3.1: An Example of Mutual Foreign Indebtedness

	Country 1	**Country 2**
Net Holdings of Foreign Assets	0	0
Net Holdings of Foreign Assets in Currency 1	-1	1
Net Holdings of Foreign Assets in Currency 2	1	-1

In the example of table 3.1, each country borrows the amount 1 in its domestic currency from its neighbor. Thus, both countries are nominal debtors in their own currency and nominal creditors in the foreign currency. Hence, both countries have the opportunity to increase their level of national wealth by creating surprise inflation in the currency they control. Describing this situation as a normal-form game, one sees that it is, in fact, a prisoner's dilemma. In order to use the normal form, the options for both countries are restricted to the choices inflating (I) and not inflating (NI). With the loss function used throughout this chapter, these two options refer to the discretionary rate, $\pi^* > 0$, and the first-best inflation rate of $\pi = 0$, respectively. Since the two countries are mutually indebted, their payouts depend on each other's monetary policy. X_i is defined as country i's gain due to the reduction of its foreign liabilities in case of inflation in the domestic currency. From the other country's perspective, inflation in the foreign currency implies a real reduction of its assets, leading to a loss that is equivalent to the other country's gain.[39] Inflation in a country's own currency also leads to costs, which are denoted as C_i.

Table 3.2: The Prisoner's Dilemma of Mutual Nominal Indebtedness

		Country 2 I	**Country 2** NI
Country 1	I	$X_1 - C_1 - X_2,\ X_2 - C_2 - X_1$	$X_1 - C_1,\ -X_1$
Country 1	NI	$-X_2,\ X_2 - C_2$	$0,\ 0$

[39] Although the loss in absolute terms must be equivalent to the other country's absolute gain, the changes in utility must not correspond to each other. For simplicity, however, both countries loss or utility functions are assumed to be identical here.

As long as a country's gain from inflation exceeds its costs ($X_i > C_i$), inflating its own currency is the dominant strategy. Since inflating here means to choose the discretionary inflation rate—which is defined as the inflation rate that minimizes the present-period loss given inflation expectations—this condition is always met. Thus, in the unrepeated game, both countries always choose to inflate their currency and the only Nash equilibrium (I, I) is Pareto-inferior to the cooperative solution (NI, NI). As always, there are different ways to overcome the prisoner's dilemma. For example, if the countries can credibly commit themselves to punish each other's inflationary policies, possible equilibria in the repeated game are much more favorable than that of the one-shot game.[40] A more elegant solution to this problem is to directly tackle the source of misguided incentives. One way to do this is to create a monetary union between the two countries. Introducing a common currency implies that all existing assets and liabilities denominated in the two national currencies are converted into the new currency. In the example above, such a conversion leads to balanced nominal holdings in the new currency for both countries. Consequently, the introduction of the common currency completely eliminates this form of inflation bias as none of the two countries would benefit from surprise inflation in the common currency. Note that, in this example, the creation of a currency union solves the problem of nominal indebtedness even if it cannot be assured that common monetary policy is conducted by a true unionist. Since the negative external effects of surprise inflation are internalized for both countries, no inflation bias stemming from this source arises, no matter whether policy-makers serve national or common interest.

Of course, the example above, in which the countries' external liabilities are entirely denominated in domestic currency while their external assets are entirely denominated in foreign currency, is set to the extreme. However, with respect to the present situation of most industrialized economies, it is not completely unfounded. Those countries' external liabilities predominantly consist of government debt that is almost exclusively denominated in the countries' own currencies. On the other hand, those countries' portfolios of foreign assets are usually much more diversified and include significant holdings of nominal assets in foreign currencies. Thus, there are many coun-

[40] In general, punishment through foreign monetary authorities is complementary to the one by the public that is extensively discussed throughout this section. Thus, reputational forces constraining policy-makers from creating surprise inflation are expected to be stronger in countries exhibiting nominal external assets in foreign countries—especially if these assets are denominated in currencies that are controlled by countries that would bear significant losses following surprise inflation in the domestic currency.

tries that are net nominal debtors in their own currency in spite of having a balanced or even positive external asset position in total. To diminish these countries' incentives to engage in beggar-thy-neighbor-policies, currency unions between them might indeed make sense.

The last paragraphs dealt with the possible reduction of misguided incentives through the creation of a monetary union between mutually indebted countries. While this case is explicit for countries exhibiting a symmetrical exposure to each other's currency, it is less so when creditor and debtor nations form a union. In this case, the creation of a common currency does not automatically eliminate misguided incentives for policy-makers acting in their national interests. In fact, as is extensively discussed for the specificities of the European Monetary Union in chapter 4, the creation of a currency union does not guarantee sound monetary policies when there is asymmetric foreign indebtedness between member countries.

3.4 Discussion

The theoretical treatise in this chapter expounds that the time-consistency problem of monetary policy amplifies with a country's level of nominal foreign indebtedness. Moreover, the model reveals that the incentives for policy-makers to succumb to surprise inflation are most prominent in transition periods from a high to a low level of foreign indebtedness. An obvious question to ask is whether these results and this whole approach of modeling monetary policy are of any relevance for the real world. In fact, some economists have challenged the usefulness of the Barro-Gordon model as a positive theory right from its initial publication.

3.4.1 The Model's Relevance as a Positive Theory

A first point of critique refers to the realism of some of the model's rather strong assumptions. For instance, one could ask whether central banks are in fact able to control the inflation rate. Can policy-makers actually create surprise inflation if they want to? Certainly, the model's assumption that the policy-maker can directly decide on the rate of inflation in every period is a broad simplification. In reality, there are, of course, various phenomena such as supply- or demand-side shocks that impede the inflation rate from being perfectly controllable in the short run. In the long run, however, it is fair to say that monetary policy does have a strong and direct influence on realized inflation rates—irrespective of the discussion what policy-instruments the central bank uses. Thus, the inflation rate in the model should rather be interpreted as the targeted inflation rate, not the one that actually materializes. Accordingly, surprise inflation in the sense of the model presents cases in which the targeted, not the realized inflation rate exceeds the previously anticipated one.

This interpretation also helps to justify another seemingly strong assumption of the model, namely that the public is fully rational and perfectly informed about the policy-maker's objective. Indeed, interpreted as surprising changes of the inflation target, surprise inflation is easily detectable by the public, enabling it to build inflation expectations contingent to the central bank's past behavior similar to those supposed in the reputational mechanism in the model. From a long-term view, the assumption of perfect rationality on the side of the public does also not appear to be that strong. This assumption simply implies that the public cannot be fooled systematically, i.e. surprise inflation cannot be sustained in a long-term equilibrium.

More challenging is the critique of economists neglecting that issues of time-consistency actually cause an inflation bias in developed economies. For instance, in an early response to Barro and Gordon (1983b), Taylor (1983) argues that the superiority of the first-best solution is so obvious that societies are easily able to overcome the time-consistency problem in reality. Blinder (1997) takes the same line, reporting that during his time at the Federal Reserve neither he nor his colleagues had ever been tempted to create surprise inflation in order to push unemployment below its natural rate. Statements like this are hard to refute. Generally, the empirical relevance of the inflation bias predicted by models of the type presented here is hard to test econometrically. Among the obstacles to econometric testing are the existence of all types of economic shocks, lacking knowledge on the lags between monetary policy decisions and inflation realizations, changing preferences or even changing doctrines at central banks, and the possibility that realizations of inflation rates and inflation expectations are not equilibrium outcomes. It is thus not surprising that the body of empirical literature on the inflation bias is much smaller than that of the theoretical literature.

Ireland (1999) conducts one of the few direct tests of the Barro-Gordon model. Using time-series methodology, he attributes a significant part of the long-term movements of the U.S. inflation rate to shifts in the natural rate of unemployment and interprets this result as support of the inflation bias predicted by the Barro-Gordon model.[41] This view, however, is not without challenge. For instance, Romer and Romer (2002) consider the positive correlation of the natural rate of unemployment and inflation to be coincidental rather than causal and offer an alternative explanation. They argue that policy-makers at the Federal Reserve falsely believed in a permanent trade-off between unemployment and inflation in the late 1960s and 1970s, a time when the U.S. economy was hit by supply-side shocks that shifted the natural rate of unemployment upwards. Thus, policy-makers reacted overly expansionary to supply-side shocks out of a misperception about the nature of the economy and not in an attempt to exploit the benefits of surprise inflation. Romer and Romer (2002) argue that the correlation between unemployment and inflation broke down after the natural-rate hypothesis had commonly been accepted in the early 1980s.

In principle, the results of the extended Barro-Gordon model presented in this section could be tested in a similar way to Ireland (1999). Interpreted as a positive theory, the model predicts a positive relationship between the magnitude of nominal indebtedness and inflation rates. At a first glance, a positive correlation between these two variables does not exist for the U.S. So far, the sharp increase in nominal foreign indebtedness over the previous two decades, documented in section 2.2, has not been accompanied by an upward trend in inflation rates. Thus, until now, policy-makers at the Federal Reserve have apparently found a way to commit to low inflation policies in spite of opportunities to increase national wealth through surprise inflation. Nevertheless, formal testing of the relationship between nominal indebtedness and (surprise) inflation for long time series of U.S. data would be a worthwhile research endeavor.

An alternative way of testing for the inflation bias was introduced in an influential paper by Romer (1993). He argues that the benefits of surprise inflation are lower in more open economies as larger parts of the increase in aggregate demand caused by an unanticipated monetary expansion go to foreign producers. Put differently, he expects the short-run Phillips-Curve to be steeper in more open economies. Thus, the incentives to create surprise inflation and, hence, the inflation bias should be lower in more open economies. He tests this hypothesis using cross-sectional data for the 1970s and 1980s and finds a significant negative effect of the degree of openness (measured as

[41] With a loss function that is quadratic in both the inflation and the unemployment rate, the marginal benefit of surprise inflation increases with the absolute level of the unemployment rate. Thus, in this specification, the model predicts the inflation bias to increase with the natural rate of unemployment.

the ratio of imports to GDP) on average inflation rates. Although Romer's explanation has been challenged by subsequent scholars, his basic finding of a negative relationship between openness and inflation persists and has been confirmed by various follow-up studies.[42] The theory presented in this chapter potentially provides an alternative explanation to this finding. Smaller and more open economies are less likely to be able to borrow from abroad in their own currency than large economies. Thus, since they resort to foreign currencies when borrowing from abroad, small countries are less likely to be nominal debtors in their own currency. Hence, these countries do not have an opportunity to realize gains at the expense of foreign creditors through surprise inflation. As a result, the inflation bias is expected to be lower in small and open economies whose domestic currency does not play a significant role in international finance. Of course, this hypothesis remains purely speculative without empirical testing. Such a test would involve regressing average inflation rates on countries' net nominal holdings in their own currency. Since this requires time series data on net nominal holdings for a broad range of countries, which is not readily available, it goes beyond the scope of this study. Collecting data or constructing proxies to conduct such a test is another promising field of future research.

An adjunct idea for empirical research is to examine whether the creation of the European Monetary Union did, in fact, reduce the incentives to induce surprise inflation for the participating nations, as suggested by the theory presented in section 3.3.2. To check this, one would need to compare the hypothetical redistributional effects of surprise inflation on the national wealth of all participating countries before and after the introduction of the euro. However, since official statistics on cross-border investments for European countries are far less detailed than those for the U.S. used in chapter 2, there are serious obstacles to answering this research question.

Even if one believes that the time-consistency problem does not play an important role in explaining real-world inflation rates, the results of this chapter are not irrelevant. For instance, the fact that there are no signs that policy-makers at the Federal Reserve have tried to create surprise inflation over the last years,[43] does not imply that these incentives do not exist. Rather, this implies that policy-makers at the Federal Reserve have found

[42]For instance, Gruben and McLeod (2004) confirm this basic finding in an updated version of Romer's data using panel data methodology.

[43]Critics of the Fed's aggressive reaction to the financial crisis may oppose this view and argue that the Fed's extraordinary measures, such as the use of "quantitative easing," is indeed an attempt to induce surprise inflation; only the inflationary effect is still to come. This view, however, does not comply with current inflation expectations. Believing that

ways to commit to non-inflationary policies until now. One reason for this result could simply be that, so far, the incentive to induce surprise inflation has not been strong enough to succumb to it. This would imply that U.S. policy-makers might seize the opportunity to increase national wealth through surprise inflation at a future time, for instance, when the U.S. has reduced its current account deficit and thereby its reluctance to funding from abroad.

Irrespective of the question of why U.S. policy-makers have apparently contained themselves over the last years, it is worth reviewing the practical relevance of the theoretical solutions to the time-consistency problem suggested here. Of particular concern is the question of how institutions should be designed to mitigate commitment problems of the form discussed in this chapter.

3.4.2 Implications for Institutional Design

The most elegant way of avoiding time-consistency problems in monetary policy is to directly eliminate the benefits of surprise inflation. With respect to the traditional closed-economy source of the inflation bias, this would necessitate a widespread adoption of inflation-indexed contracts in labor and product markets. Similarly, inflation-indexed debt contracts in cross-border lending would eliminate the adverse incentives for policy-makers in the open economy. For example, nations could arrange that sovereign borrowing in international capital markets is solely conducted in a currency that is outside of the control of any single nation, as, for instance, the International Monetary Fund's Special Drawing Rights.[44] Restrictions of this form, however, can only be rationalized by paternalistic arguments. In fact, one has a hard time arguing that investors and issuers should not be allowed to conclude nominal contracts. Since rational investors should be aware of the incentives for unsound monetary policies deployed by nominal contracts, they should, in theory, only lend to those nations in nominal terms that they trust not to succumb to surprise inflation. Of course, one cannot guarantee that risks are always efficiently priced in international lending markets—especially not ex post.[45] To conclude from this that one form of risk, namely the risk of surprise inflation, should not be priced on markets at all, goes too far. More-

the public is currently continuously being fooled by the Federal Reserve cannot be aligned with the assumption of rational expectations.

[44]In fact, the gold standard was an institutional framework of this kind.

[45]European sovereign debt markets are a recent example of ostensible mispricing of risk. Even without a proper methodology to assess "fair" prices for government bonds,

over, such a radical reform of international capital markets is simply not a realistic policy option from today's perspective.

Theory suggests other ways to mitigate the time-consistency problem entailed by nominal external debt. For instance, monetary policy could be delegated to cosmopolitan individuals who do not derive any utility from beggar-thy-neighbor policies. A radical way to implement this proposal would be to internationalize monetary policy decisions, i.e. to delegate monetary policy to an international institution. In fact, the adoption of the euro can be regarded as an attempt to overcome the time-consistency problems inherent to some of the national institutions preceding the European Central Bank.[46] For other regions in the world, such an internationalization of monetary policy is barely conceivable. A less radical approach to avoid an inflation bias from this source is to enhance cooperation between central banks. For example, regular meetings or a rotation of staff between central banks of debtor and creditor nations might help to build ceilings on beggar-thy-neighbor policies. Of course, just as in the case of Rogoff's proposal to put a conservative individual in charge of monetary policy, institutional settings cannot guarantee that the persons nominated match the desired characteristics. Nevertheless, theory and history make a strong case in favor of certain institutional features.

A very basic result of the theoretical studies dealing with the time-consistency problem is that policy-makers should have a low time preference. As shown above, this characteristic is of even further importance in the presence of nominal external debt. Only individuals who are sufficiently concerned about future policy outcomes will restrain from inducing surprise inflation. In practice, long-term orientation is ensured by endowing policy-makers at central banks with long-term contracts and insulating them from the turbulences of day-to-day politics. The characteristics of the ideal central banker—cosmopolitanism and a long-term planning horizon—are not to be expected from politically dependent decision-makers. Faced by adverse political incentives, such as frequent election dates and short terms of office, elected officials commonly lean towards myopic decisions.[47] Moreover, it also seems implausible that politicians are particularly reluctant towards

the rapid surge of interest rates from very low to very high levels experienced by Southern European countries can barely be explained by fundamentals.

[46] Alesina and Stella (2011) make this point. However, their case is not based on solving the externality problem of foreign debt, but on reducing political influence on monetary policy decisions.

[47] Numerous studies in the field of public finance support this assertion. For instance, Weizsäcker (2012) explains that public officials in democracies have a tendency to opt

policies favoring national debtors at the expense of foreigners, especially if large parts of domestic gains accrue to the government.

Certainly, delegating monetary policy to unelected officials alone is not sufficient to avoid political influence on these decisions. Policy-makers must also be largely independent from politics. For instance, granting the executive or the legislative the power to replace central bankers whenever desired would erode the benefits of delegating monetary policy in the first place. Thus, if one holds the opinion that politicians should not decide on issues of monetary policy, one must also endorse a largely independent central bank. In fact, the U.S. and many other countries around the world have fared well by granting their central bank a certain degree of independence.[48]

From this perspective, recent attempts to circumscribe the Federal Reserve's independence must be seen with skepticism.[49] Indeed, the very fact that the U.S. is currently able to borrow large sums in its own currency from abroad proves that investors trust U.S. monetary policy and more generally U.S. institutions. This reputation and the accompanying benefits are at stake when further steps towards a politicization are undertaken.

In conclusion, long-term orientation and, thus, independence from immediate political pressures are essential determinants of a central bank's ability to commit to a policy of low and stable inflation—especially in times when nominal foreign indebtedness abound incentives for inflationary policies.

By focusing on the problem of time-consistency, the connection between monetary policy and foreign indebtedness was analyzed from a general perspective in this chapter. In contrast, the following chapter goes into some more details, namely by investigating the specificities of external debt and monetary policy in the European Monetary Union.

for the least perceivable way to finance spending. In this regard, an implicit taxing of foreigners might be particularly attractive to politicians.

[48]Numerous empirical studies have confirmed that the inflation bias is less pronounced in countries with an independent central bank. For a classic contribution, see Alesina and Summers (1993), for a recent overview, see Klomp and De Haan (2010).

[49]For instance, U.S. Congress passed a bill called the *Federal Reserve Transparency Act of 2012* (H.R. 459) which increases the Government Accountability Office's powers of audit over the Federal Reserve. In principle, increased transparency and accountability of the Fed does not have to be at odds with the concept of central bank independence, but granting Congress the power to actuate investigations of specific decisions by the Federal Reserve carries with it the danger of expanded political influence on monetary policy.

Chapter 4

Inflation Targeting and External Debt in the Euro Zone

This chapter deals with the cohesion of foreign debt and monetary policy in the European Monetary Union. More precisely, I investigate how foreign indebtedness between member countries might influence collective decisions on common interest rate policy. In contrast to chapter 3, the focus is no longer on the problem of time-consistency (i.e. a long-term problem), but on the central bank's task to stabilize inflation around a target value in the short-term. I argue that a specific, novel form of external debt increases policy-relevant heterogeneity among the member states of the EMU and ascertain under which circumstances this results in malfunctioning common interest rate policies. Applying the theoretical insights of this chapter to the rules and regulations of the European Central Bank leads to clear proposals for reform.

The central question addressed in this chapter is whether the European Debt Crisis, and the novel forms of external debt that have come along with it, might compromise the soundness of monetary policy in the euro zone. Following a brief review of the two branches of the literature tangent to this study—the consequences of the European Debt Crisis and monetary policy in currency unions—I proceed in two main steps to answer the question. First, in section 4.2, I dissect the policy-relevant implications of the European Debt Crisis—business cycle heterogeneity and particular forms of nominal external debt. Second, in section 4.3, the findings of the previous section are implemented in a stylized theoretical model of inflation targeting in a monetary union. At last, a discussion of the main conclusions and policy recommendations ends the chapter.

4.1 Literature Review

Discussing the potential implications of the European Debt Crisis on monetary policy in the European Monetary Union, the boundary points to other academic works are plentiful. First, the chapter is closely related to the rapidly growing literature on the European Debt Crisis. Second, it borders the literature on optimal monetary policy in currency unions. More specifically, there are points of contacts to the two sub-branches of optimal currency areas and optimal central bank design. Since all of these literature strands comprehend numerous specific research topics, the following review narrows attention to seminal contributions, making no claim to completeness. For a discussion of more specific issues, literature surveys are provided.

Notwithstanding future developments, the European Debt Crisis will go down as the first caesura in the history of the European Monetary Union. Hardly surprising, the crisis has also boosted academic interest in the related fields of economics. So far, most of the academic work on the crisis centers on explaining how it could evolve and discussing how it could be solved. Since these debates only tangentially touch upon the work in this chapter, I restrain from entertaining the different narratives and arguments brought forward by proponents and opponents of interventionist policies. For unbiased preliminary summaries of this part of the literature refer to Lane (2012) or Shambaugh (2012). A collection of more detailed studies on the causes of the crisis including the first empirical tests of the different approaches to explain the crisis can be found in Aizenmann et al. (2013).

A related branch of the literature, which cannot always be clearly differentiated from the previously mentioned branch, deals with potential consequences of the policies enacted in the course of the crisis. Among these are the resolution to pool the supervision of financial institutions at the supranational level—the formation of a so-called *banking union*—which is extensively discussed in Beck (2012) and the resolution to implement ceilings on the levels of public debt in the national constitutions of EU member states—the formation of the so-called *fiscal compact*—which is discussed in Barnes et al. (2012), Manasse (2012), Bird and Madilaras (2012) or Fabbrini (2013). Another controversial political response to the crisis is the adoption of all kinds of austerity measures in the countries hit by the crisis which is comprehensively covered in Corsetti (2012). Potential consequences of the creation of the *European Rescue Fund*[1] are also widely discussed among aca-

[1] For an introduction of the newly formed institutions constituting the rescue fund refer to section 4.2.2.

demics. For instance, Sinn (2012) opposes the measures claiming that these undermine debtor nations' incentives for reforms and, thus, eventually lead to the creation of a "transfer union." In contrast, De Grauwe (2013) approves the creation of the rescue fund, arguing that the current volume must be extended even further to appropriately cope with the crisis. Gros and Mayer (2010) take the same line advocating that the rescue fund should be equipped with a banking license in order to leverage its funding means in a future crisis.

The various policies enacted by the European Central Bank (ECB) to cope with the crisis have also sparked a debate among economists. Particularly controversial are the ECB's interventions on sovereign bond markets.[2] Some authors, such as Belke (2010) or Baltensperger (2012), criticize the ECB's actions arguing that these undermine the separation of fiscal and monetary policies and, thus, endanger the ECB's independence. On the contrary, Darvas (2012) defends the ECB's policies on the grounds of breaking self-fulfilling pessimism on financial markets. Panico and Purificato (2013) go even further by arguing that the ECB should have intervened earlier and more resolutely to fulfill its function as a lender of last resort. They interpret the ECB's reluctance to intervene on sovereign bond markets as the result of increasing conflicts of interests within the ECB, which they deem to be detrimental to the efficiency of the ECB's policies. Similarly, Eijffinger and Hoogduin (2012) also identify escalating tensions within the ECB as one of the negative side-effects of the crisis. Applying a more formal approach, this chapter arrives at the same main conclusion.

Finally, there is a growing literature discussing the implications of a specific item in the balance sheets of the national central banks forming the Eurosystem, so-called *TARGET2 balances*. The main contentious issue is of whether these balances (which are introduced and discussed in 4.2.2) entail specific credit risks for creditor nations or not. On the one hand, Sinn and Wollmershäuser (2012) argue that TARGET claims are direct substitutes for other cross-border credit claims and, thus, involve an exposure to debtor nations' solvency risks. De Grauwe and Ji (2012), on the other hand, contest this view emphasizing that gains and losses only arise in the unlikely case of a break-up of the euro zone.

Surprisingly, another potential risk of these novel forms of external debt—inflation risk—has almost completely been neglected in the academic discus-

[2] There are two novel channels through which the ECB can intervene on bond markets, the *Securities Markets Programme* (SMP) and *Outright Monetary Transactions* (OMT).

sion so far. In fact, neither the literature on the European Rescue Fund nor that on TARGET balances comprises a discussion of inflation risks. The following study intends to fill this gap. In particular, this chapter examines whether the remuneration of these new forms of external debt depend on the ECB's interest rate policy. Inferred from this analysis, the question is raised of whether, and under which circumstances, these forms of intra-European debt might influence national preferences on monetary policy within the euro zone. Thus, this chapter not only complements to the existing literature on the European Debt Crisis but also connects it to studies dealing with the difficulties of common interest rate policy in currency unions.

This branch of the literature is much older than the European Monetary Union itself. Following the seminal paper of Mundell (1961), many scholars have studied the conditions of optimal currency areas both on theoretical and empirical grounds. Surveys of these studies can, for instance, be found in De Grauwe (2012) or Baldwin and Wyplosz (2009). Among the central results of this literature is that the efficiency of common monetary policy decreases with the asymmetry of economic shocks within the currency area. On these grounds, the large number of empirical studies examining the synchronicity of business cycles in the European Union is self-explaining. For a survey of the literature on the co-movements of cycles prior to the financial crisis refer to De Haan et al. (2008). Section 4.2.1 adds to this literature by comparing the synchronicity of business cycles in the euro zone prior to with that during the European Debt Crisis.

The subsequent theoretical model in section 4.3 replicates the above-mentioned key finding of the optimal currency area literature and augments the analysis by implementing a second source of diverging interests—country-specific debt levels. In particular, the model discusses how diverging interests might affect the efficiency of collective decisions on common monetary policy. Thus, this section is also related to a third branch of the literature which discusses collective decision-making and the optimal institutional design of central banks. Berger (2006) supplies a general review of these studies. A more detailed discussion of the assets and drawbacks of the one-country-one-vote regime in place at the ECB can be found in Berger and Müller (2007). They argue that the potential bias resulting from the overrepresentation of small EMU member states must be traded off against its benefits. These are a reduced impact of shocks in national preferences and a potentially more efficient processing of information in more heterogeneous groups (Cf. Gerlach-Kristen (2006) or Blinder and Morgan (2005)).

4.2 The European Debt Crisis

For almost five years, several European have persistently found themselves in a state of economic crisis. What began as a financial turmoil spilling over from the U.S. in late-2008, has long since morphed into Europe's own crisis. While the financial crisis of 2008 and the subsequent economic downturn affected all countries in the EMU, the second phase of the crisis hit European countries very differently. Whereas countries in the European *periphery*[3] are suffering from a deep recession, countries in the *core*[4] are barely struck by the crisis.

Rather than discussing the causes or remedies of these discrepancies, this section sheds light on a specific consequence of the crisis, namely an increase in the intricacies of conducting common monetary policy. A particular focus is on two potential sources of conflicting interests concerning the choice of a common interest rate brought about by the European Debt Crisis: the asymmetry of business cycles in section 4.2.1 and intra-European debt positions in section 4.2.2.

4.2.1 Business Cycle Heterogeneity

Like many other central banks around the globe, the ECB achieves its objective of price stability by targeting the euro zone's inflation rate. More precisely, it periodically varies the euro zone's main interest rate trying to offset exogenous fluctuations in aggregate demand for goods and services. With its interest rate policy, it aims at preventing cyclical fluctuations in exogenous inflationary pressures from translating into fluctuations of the realized inflation rate. Thus, even as a central bank with the sole objective of price stability, the ECB reacts to business cycle developments in its territory. Naturally, when business cycle shocks vary between countries, so do also preferred interest rates. Hence—as is analyzed in greater precision in section 4.3.1—the degree of business cycle heterogeneity affects national preferences for monetary policy and the efficiency of monetary policy in a currency union.

Over the first decade of the millennium, most observers held the opinion that business cycles in the euro zone were running more or less parallel. Of course, some countries, such as Germany and Italy, exhibited below average-

[3]These countries include Greece, Ireland, Italy, Portugal, and Spain.

[4]Particularly, these countries include Germany, the Netherlands, Finland, and Luxembourg.

growth rates, while other countries, such as Spain or Greece, continuously exhibited higher growth rates. These discrepancies, however, were rather attributed to different growth potentials than to different cyclical developments. Since there is widespread agreement that monetary policy is unable to influence the long-run trend in economic growth, policy-makers did not perceive these differences as major challenges to the conduct of a common monetary policy.

Even the outburst of the global financial crisis of 2008 had initially not been considered as a particular problem for the common interest rate policy in the euro zone. After all, the financial crisis hit all countries at the same time, albeit in somewhat different magnitudes. Thus, there was little opposition to the ECB's quick and distinct response to the financial crisis. In spite of its countercyclical measures, the ECB could not entirely avoid spillover effects to the euro zone's real economy and almost all member countries experienced a decline in economic activity in 2009. Beginning with the economic recovery after the preliminary trough the euro zone reached in mid 2009, the first signs of cyclical asymmetries unfolded. Although the recovery was shared by the majority of the euro zone's member countries, the speeds at which the economies rebounded showed significant variation. At least since the global financial crisis faded to the European Debt Crisis in 2011, economic activity in the euro zone has become increasingly disparate. While economic recovery in the European periphery came to a sudden end, economic activity continued to improve in the core. This development can be read from table 4.1, which exhibits recent growth rates in six exemplary euro-zone countries. The first three countries, Austria, Germany, and the Netherlands represent countries of the European core. The last three countries Greece, Italy, and Spain represent the European periphery.

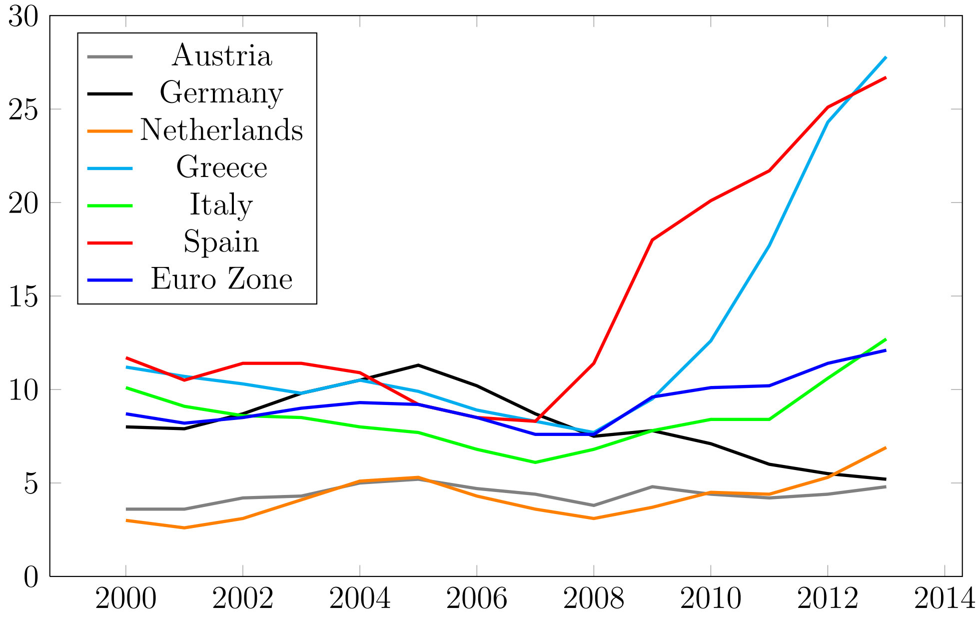
Comparing the recent development of unemployment rates between these countries reveals even more drastic disparities. As is illustrated in figure 4.1, unemployment rates in the European periphery have risen dramatically since 2009, whereas unemployment in the European core has not increased markedly. In Germany unemployment today is even lower than before the start of the financial crisis of 2008, which is in sharp contrast to the situation in Greece where unemployment rates skyrocketed as a result of its prevailing debt crisis.

Table 4.1: Real GDP Growth Rates of Selected Euro-Zone Countries in Percent

Country	2000-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013[b]
Austria	2.1	-3.8	1.8	2.8	0.9	0.4
Germany	1.4	-5.1	4.0	3.3	0.7	0.4
Netherlands	2.0	-3.7	1.5	0.9	-1.2	-1.0
Greece	3.6	-3.1	-4.9	-7.1	-6.4	4.0
Italy	1.0	-5.5	1.7	0.5	-2.5	-1.8
Spain	3.1	-3.8	-0.2	0.1	-1.6	-1.3
Euro Zone	1.7	-4.4	2.0	1.6	-0.7	-0.4

[a] Data on real GDP growth rates are derived from Eurostat (2014b).
[b] Numbers for 2013 are forecasts.

Figure 4.1: Unemployment Rates in Selected Euro-Zone Countries in Percent



Data on unemployment rates are from Eurostat (2014a).

Raw data on unemployment rates and economic growth gives a first indication on the current divergence of business cycles in the EMU. However, shifts in economic growth or unemployment rates do not necessarily have to be relevant for monetary policy. As mentioned above, there is widespread agreement that monetary policy should only react to transitory shocks and not to permanent shifts in real economic activity. Distinguishing cyclical from structural movements, however, is far from trivial. The most frequently used concept to measure business cycles is that of the output gap, which is the deviation of actual (and observable) output from the unobservable level of potential output. How the latter should be estimated is a controversial issue among macroeconomists.[5]

There is no information on which of the various methods to calculate the output gap officials at the ECB rely on when deciding on monetary policy. However, the European Commission publishes its own measure of output gaps for all members of the European Union. This measure is highly policy-relevant, as it is used, for instance, as a corner point in the fiscal surveillance of EU member countries related to the Stability and Growth Pact. Unlike other frequently used measures of the output gap, such as the Hodrick-Prescott Filter, the European Commission's estimate of the output gap is not calculated by purely statistical methods, but based on economic grounds. It follows the so-called production function approach, i.e. potential output is calculated using econometric estimates of a country's aggregate production function.[6] Table 4.2 provides an overview on the evolution of output gap estimates for the six exemplary countries since the beginning of the financial crisis in 2008.[7]

Data in table 4.2 reveals that the recent divergence in growth rates across euro-zone member countries can to large parts be attributed to different cyclical developments. While the trend in output gaps in the Netherlands and Italy bear strong resemblance to that of the aggregate euro zone, the trends in the other four countries do not. On the one hand, Austria and Germany have significantly outperformed euro-zone averages since 2010. On the other hand, the crisis-strapped economies of Greece and Spain have continuously underperformed euro-zone averages. In contrast to the euro-zone average, their output gaps have not narrowed since 2009. In the extreme case of Greece, economic activity even deteriorated further to its current level of well below 90% of potential output.

[5] Döpke and Chagny (2001) provide an overview of the different methods to calculate the outgap including a discussion of their respective assets and drawbacks.

[6] A detailed explanation and discussion of the methodology can be found in D'Auria et al. (2010).

[7] Annual values are calculated as simple averages of quarterly data.

Table 4.2: Output Gaps of Selected Euro-Zone Countries as Percentages of Potential Outputs

Country	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**[a]
Austria	1.9	-2.9	-1.7	0	-0.3	-1.0
Germany	1.9	-4.0	-1.0	0.7	0	-1.0
Netherlands	2.1	-2.7	-1.7	-1.4	-2.5	-3.4
Greece	1.5	-1.3	-4.9	-9.4	-12.2	-12.8
Italy	1.7	-3.6	-1.8	-1.6	-3.1	-4.5
Spain	0.5	-4.2	-4.7	-4.1	-4.6	-5.2
Euro Zone	1.5	-3.6	-2.4	-1.7	-2.6	-3.0
Median Country[b]	1.9	-3.0	-1.7	-1.2	-2.0	-2.9

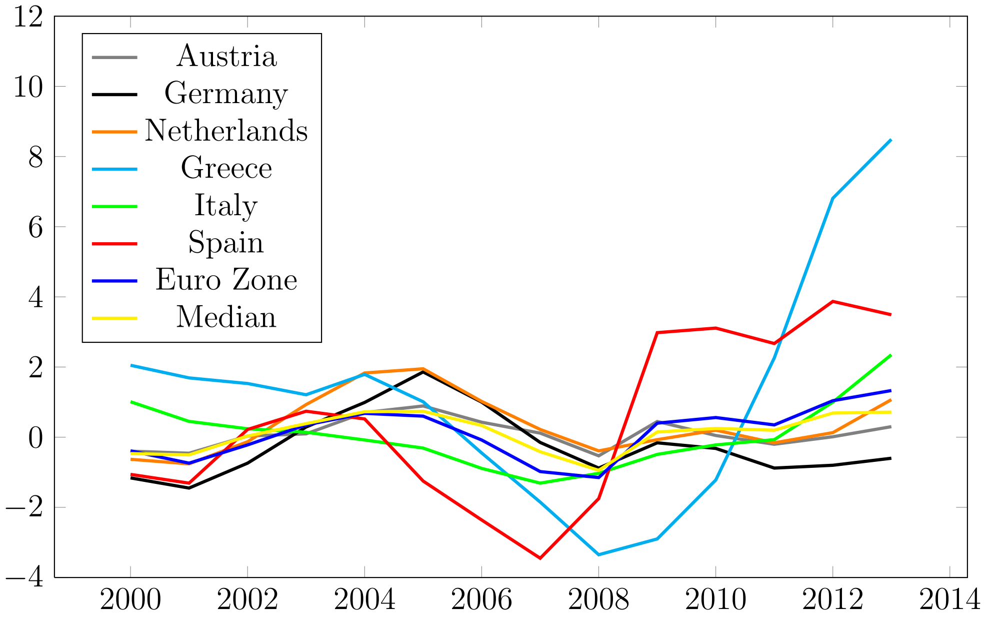
[a] All values are from Commission (2013). Those for 2013 are forecasts from autumn 2013, which are the latest available data at the point of writing.

[b] The median country is defined as the country exhibiting the median output gap, i.e. the outgap which divides the seventeen euro-zone member states into two groups of equal size; eight countries possess a higher and eight countries possess a lower output gap. For all points in time, the median is calculated on the basis of the euro zone's current composition to avoid biases resulting from changes in the euro zone's size.

A related concept to potential output is that of a non-accelerating inflation rate of unemployment ($NAIRU$)[8]. It defines the unemployment rate, at which there is neither an upward nor a downward pressure on the inflation rate from the labor market. Put differently, NAIRU is the unemployment rate that is compatible with a stable rate of inflation. In analogy to the output gap, one can define an *unemployment gap* measuring the difference between a country's actual unemployment rate and its NAIRU at a point in time. Since the ECB's sole objective is to assure price stability (i.e. to guarantee a low and stable rate of inflation), this measure is a superior to the raw data on unemployment depicted in 4.1.

[8]The term NAIRU was originally phrased by Tobin (1980). However, the very similar concept of a noninflationary rate of unemployment (NIRU) harks back to the earlier study of Modigliani and Papademos (1975).

Figure 4.2: Unemployment Gaps in Selected Euro-Zone Countries in Percentage Points



Data on unemployment rates are found in Eurostat (2014a), data on NAIRU in European Commission (2013). For details on the methodology to estimate NAIRU values refer to McMorrow and Röger (2000).

Figure 4.2 depicts the recent development of cyclical unemployment in six exemplary euro-zone countries as well as the euro-zone average and the median euro-zone country. Cyclical unemployment or the unemployment gap is calculated on the basis of actual unemployment rates and the European Commission's estimates of country-specific NAIRUs. Compared to the raw data on unemployment illustrated in figure 4.1, the evolution of unemployment gaps is less severe. This means that a part of the recent surge in unemployment rates in the European periphery is not expected to increase deflationary pressures in these countries. Nevertheless, unemployment gaps in Spain and particularly Greece have risen sharply since 2010. On the other end of the spectrum, Germany's unemployment gap currently is negative, i.e. its actual unemployment rate is below its NAIRU. That is to say that any further decline in German unemployment is expected to increase the German inflation rate. On this account, the difficulties of choosing a common monetary policy meeting the needs of all euro-zone members require no further explanation.[9]

[9]Those regarding the divergence of price levels prior to the financial crisis as the root cause of the current debt crisis assess the likely future divergence of inflation rates (which

On the one hand, a monetary policy tailored to the needs of countries in the core (with Germany in particular) would be significantly tighter than that geared to euro-zone averages. On the other hand, countries in the periphery would prefer an even easier monetary policy to avoid deflation. Thus, the current situation of an asymmetrical crisis almost inevitably leads to conflicts of interests between EMU member countries. Unless the countries' representatives in the ECB's Governing Council are completely uninfluenced by their respective national interests, this situation also results in tensions within the central decision-making body of the ECB.

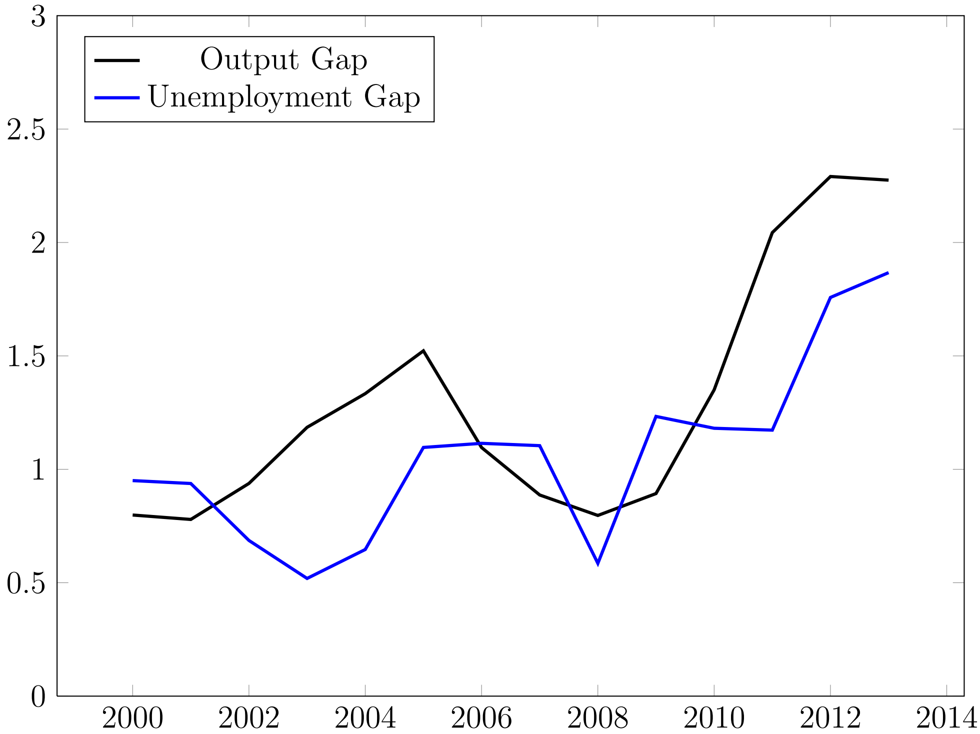
Another way to evaluate the concurrence of business cycles in the EMU is to compare the standard deviations of output and unemployment gaps over time. The standard deviation is measured as the square root of the weighted sum of squared deviations of output or unemployment gaps from the respective euro-zone averages,

$$\sigma_{\theta_t} = \sqrt{\sum_{j}^{n} \alpha_j (\theta_{j,t} - \bar{\theta}_t)^2} \quad \text{or} \quad \sigma_{\eta_t} = \sqrt{\sum_{j}^{n} \alpha_j (\eta_{j,t} - \bar{\eta}_t)^2}. \tag{4.1}$$

Both the standard deviation of output gaps, σ_θ, and the standard deviation of the unemployment gaps, σ_η, are calculated as weighted averages of country-specific deviations from euro-zone averages, $\bar{\theta}$ and $\bar{\eta}$, respectively. A country's weight α_j refers to its share in the ECB's capital, which represents its economic weight in the EMU. Since EMU averages are calculated as weighted averages of country-specific values, it is straightforward to calculate the standard deviation of output gaps also as weighted average deviations from EMU averages. With this definition, σ_θ can be interpreted as the expected value of the absolute difference between a random region's output gap and the euro zone's output gap at one point in time. It is thus a direct measure of the concurrence of business cycles in the EMU. Figure 4.3 illustrates the evolutions of the standard deviations of output and unemployment gaps for the euro zone since 2000.

is of opposite sign to those in advance of the crisis) as a necessary correction of price and wage levels to restore a balance of competitiveness within the euro zone.

Figure 4.3: Standard Deviations of Output and Unemployment Gaps in the Euro Zone in Percentage Points



All values are calculated on the basis of the output gaps of the seventeen current euro-zone members.

Since both numbers are measures of business cycle heterogeneity in the EMU, it is hardly surprising that they are roughly following similar trends. Particularly, both numbers account for a distinct increase of business cycle heterogeneity since 2011. For instance, in the fourth quarter of 2013, the output gap in a random region was expected to differ from the euro zone's aggregate output gap by about 2.3 percentage points, while the average deviation between 2000 and 2010 was only about one percentage point. Similarly, the unemployment gap in a random region was expected to differ from the euro zone's unemployment gap by about 1.9 percentage points, while the average deviation over the first decade of the millennium was less than 0.9 percentage points.

The apparent increase in business cycle heterogeneity certainly is a side-effect of the European Debt Crisis and the policies enacted to combat it. Business Cycles—at least the part of cycles that are relevant for monetary policy decisions—mostly reflect fluctuations in aggregate demand for goods and services. Naturally, the latter is temporarily weak in countries whose public and private sectors try to dispose of large debt overhangs. Consequently, inflationary pressures in the periphery are expected to be significantly lower than in the core, where neither the public nor the private sector is forced to increase savings. Until the peripheral countries have resolved their debt problems, the ECB thus faces a trade-off between containing inflation in the European core and avoiding deflation in the European periphery. In other words, the efficiency of common monetary policy decreases in periods of asymmetric demand shocks. A temporary increase in the variation of inflation rates is thus likely to be among the aftereffects of the European Debt Crisis yet to come.

In fact, the divergence of business cycles is not the only consequence of the European Debt Crisis that might lead to conflicting interest concerning common interest rate policy. As is explained in the following section, one of the new forms of external debt that have originated in the course of the crisis might also influence national preferences of monetary policy.

4.2.2 Novel Forms of External Debt

Foreign Debt within the euro zone is by no means a new phenomenon. As a result of sustained current account deficits against Northern European countries, some countries in the European periphery have run up substantial amounts of foreign debt over the last decade. Until the beginning of Europe's Debt Crisis in late 2009, however, these imbalances went largely unnoticed by the public. The main reason for this is that the periphery's current account deficits were predominantly financed by private capital flows from Northern Europe prior to the outbreak of the crisis. In other words, Northern European countries were willing to acquire securities of various forms in return for their net exports of goods and services to the periphery. Beginning in 2010, however, this willingness faded; suddenly, perceived credit risk soared and debtors in the European periphery, first and foremost Southern European governments, faced rapidly deteriorating financing conditions on private capital markets. Since then, European politicians have taken various actions to relieve the peripheral countries' tightening financing constraints.

In the course of the vigorous debates accompanying these decisions, foreign indebtedness between the members' of the EMU came to the fore. As was mentioned above, imbalanced net foreign asset positions within Europe are not a result of the European Debt Crisis itself. Much rather, they are the product of continuous current account imbalances between parts of Southern Europe and parts of Northern Europe. The crisis only lead to shifts in the composition of intra-European borrowing. Most notably, the crisis brought about two new forms of foreign debt, loans granted by the newly founded institutions *European Financial Stability Facility* (EFSF)[10] and *European Stability Mechanism* (ESM)[11] and liabilities or claims within the European system of central banks.

These shifts, in particular the transfer of some of the credit risk from private investors to the euro zone's governments, partially explains the surge in the public's attention to this topic. So far, the public and academic debates centered on the expedience of international fiscal assistance and the credit risks creditor nations take by issuing guarantees to investors lending to the crisis countries. In contrast, the focus here is not on credit but on inflation and interest rate risks involved with these new forms of external assets. In particular, the question is raised of whether the real value of these assets depends on the ECB's interest rate decisions. To answer this question, the two aforementioned forms of foreign debt are introduced and analyzed in the remainder of this section.

Official Rescue Packages

The creation of the two institutions EFSF and ESM, which together form the so-called European rescue fund, is certainly among the most controversial measures enacted by European officials to combat the crisis. In principle, the two institutions are nothing other than a European version of the International Monetary Fund (IMF). Similarly to the IMF, they provide liquidity support to troubled sovereigns subject to certain conditions. In contrast to the IMF, however, the circle of eligible countries is restricted to the members of the euro zone. All of these are mandatory shareholders of the ESM and EFSF. Their shares in the paid-in and callable capital are computed according to the ECB's capital key.

By the time of writing, the two facilities had a combined maximum lending capacity of 700 billion Euros[12] of which around 340 billion euros have

[10]EFSF is designed as a temporary institution and stopped to engage in new lending activities in July, 2013. After all outstanding contracts expire, it ceases operation.

[11]A precursor institution to the ESM, called *European Financial Stabilisation Mechanism* (EFSM) has been merged into to the former. In contrast to EFSF, ESM is designed to be a permanent facility.

[12]This sum is composed of the roughly 200 billion euros committed to EFSF programmes and the ESM's maximum lending capacity of 500 billion euros.

already been committed to assistance programmes and around 230 billion euros have actually been paid out. Table 4.4 displays the composition of these sums.

Table 4.3: Volume of EFSF/ESM Lending in May, 2013

Receiving Country	Paid-out Sums in bn. Euros	Agreed Sums in bn. Euros	Agreed Sums in % of Total Gov. Debt[a]
Ireland	33.7	40.2	21
Greece	113	144.6	48
Portugal	41.1	52	25
Spain[b]	41.4	100	11
Total	229.1	336.8	–
In % of Max. Lending Volume	33	48	–

[a] The values of outstanding government debt are those of end-2012 according to Eurostat (2013b).
[b] The funds granted to Spain are strictly earmarked for the recapitalization of its banking system.

So far, four countries have been granted assistance by the European rescue funds. Although the involved sums are dwarfed by the total amount of government debt outstanding in the respective countries, these numbers justify an investigation of interest and inflation risks coming along with these contracts. Of particular interest for this study is the question of whether the real interest rate payments by the countries drawing on the rescue fund's assistance depend on monetary policy decisions. For this purpose, it is useful to take a look on the operating mode of these facilities.

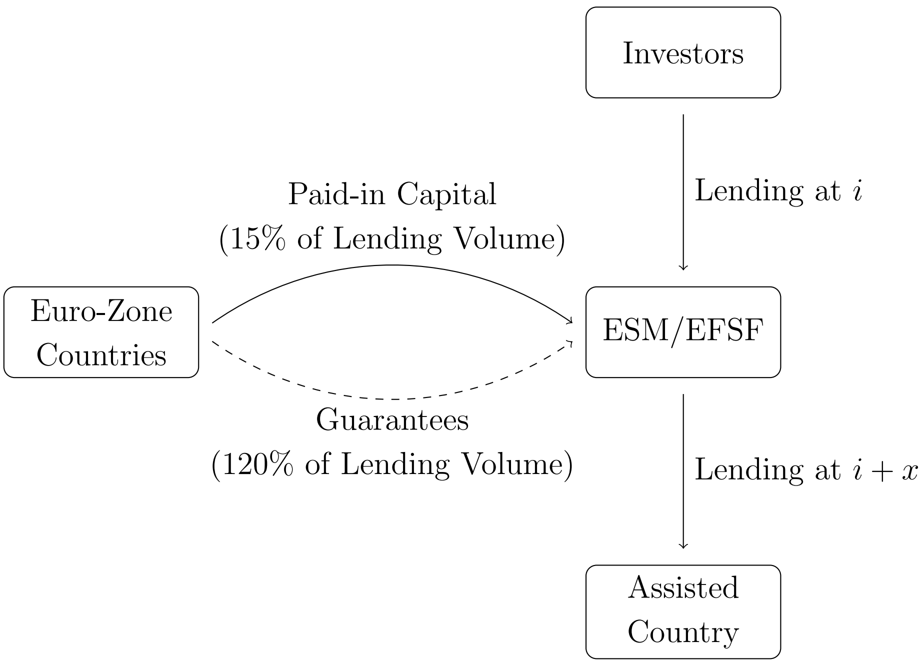
Despite their complicated names, the operating modes of the two Luxembourg-based facilities are fairly simple. First, a struggling member country of the euro zone and the Board of Governors of the ESM have to agree on a memorandum of understanding specifying the conditions under which liquidity support is granted.[13] Afterwards, the EFSM or ESM borrow funds

[13] The Board of Governors consists of the finance ministers of euro-zone countries. The voting share of a finance minister reflects the share of his country in the institution's capital. The decision of whether a country is assisted with ESM funds or not requires unanimity. In cases of urgency, 85% of the votes suffice to start an assistance programme. For the details of the statutes of ESM, refer to European Union (2013).

at private capital markets and use these funds to provide liquidity support to the country in question. The provision of liquidity is predominantly carried out through granting loans to the struggling country.[14] The interest accruing on these loans cover the institutions' "funding costs and operating costs," which are calculated on a daily basis.[15]

Figure 4.4 schematically illustrates the functioning of EFSF and ESM operations. Both EFSF and ESM are simply intermediary institutions between private investors and struggling countries. Since the institutions pass their financing costs (i) through to the countries under a support programme (adding a fixed component x covering operating costs), their lending operations do not entail interest or inflation risk for their owners, the euro-area countries. Regarding the owners' exposure to the debtor countries' credit risk, this assertion, of course, does not apply. Euro-zone member countries have installed the funds with an equity capital equivalent to 15% of the lending volume and guarantee for all of its liabilities. In order to maintain the facilities' top rating and the accompanying favorable borrowing conditions, each euro-zone member country guarantees for 120% of its share in the total lending of these institutions.

Figure 4.4: Structure and Functioning of the European Rescue Fund



[14]The ESM and EFSF can also acquire government bonds on primary and secondary markets to complement the liquidity support provided through the granting of loans.

[15]Cf. European Union (2013), Article 20.

Inflation and interest rate risks are borne by the ultimate borrower, the assisted country, or the ultimate lender, private investors, respectively. Hence, with respect to these forms of risks, indirect borrowing through the European rescue funds does not differ from direct borrowing on private capital markets. Apart from the premium covering the fund's operating costs, the interest rates on EFSF or ESM loans are determined on private capital markets and are thus not directly influenced by the ECB's interest rate decisions. Certainly, in practice, monetary policy also has some influence on the short-term real interest rates in private capital markets and hence also on those paid by EFSF and ESM. From a theoretical perspective, however, there is no distinct causal relationship between the expected real yield contracting parties agree on in private capital markets and the nominal interest rate set by the central bank.[16] Moreover, even if one assumes that interest rate policies influence real interest rate payments and thus the budget constraints of concerned governments, it is not clear whether these payments also affect national budget constraints. The answer to this question depends on the degree to which ESM or EFSF loans are actually part of a country's external debt which in turn depends on the final investors' residence or nationality. If, for example, a Portuguese citizen buys a bond issued by the ESM and these funds are subsequently passed on to the Portuguese government, the situation is equivalent to the Portuguese citizen lending directly to the Portuguese government. In such a case, any changes in the real interest rates of ESM loans only lead to redistributions within the Portuguese economy.

Summing up, with respect to interest rate and inflation risk, loans granted by the European rescue fund do not differ from conventional government financing. While the institutions mutualize credit risks, inflation and interest rate risks remain with the final investors or the receiving countries, respectively. Just as in the case of conventional government financing, the expected real interest rate the assisted countries have to pay is determined by demand and supply on capital markets and is thus not directly influenced by the monetary authority. Of course, as was extensively discussed in chapter 2, unexpected monetary policy measures might drive a wedge between expected and realized real returns. As expounded in chapter 3, the opportunity to influence realized returns on existing debt contracts might, under certain circumstances, constitute an incentive to engage in unsound monetary policies. These incentives, however, are not altered by the creation of the European rescue fund. Anyway, there is no reason for policy-makers

[16]From this point of view, the implied negative real interest rates of recently issued government medium- and long-term bonds are all the more puzzling.

acting in the long-term interests of their countries to change monetary policy preferences as a result of the creation of the European rescue fund. Whether this assertion also holds with respect to the other novel form of external debt, intra-Eurosystem balances, is subject of the following paragraphs.

Intra-Eurosystem Balances

In the Maastricht Treaty of 1992, eleven members of the European Union decided to form a monetary union and to introduce a common currency.[17] Among the many practical details that had to be settled was the question of how the newly formed monetary authority should be organized. Instead of merging all national central banks into a single institution, the contracting parties opted for the creation of a decentralized system consisting of the central banks of euro-zone member countries and the European Central Bank (ECB), henceforth the *Eurosystem*. Although decisions on monetary policy are taken centrally by the ECB's Governing Council, its implementation is mostly carried out by the national central banks (NCBs). Particularly, the creation of money—physically as well as electronically—is conducted by the NCBs. Executing monetary policy decentrally necessitates a system of clearing accounts between the individual institutions of the Eurosystem—so-called *intra-Eurosystem balances* (IEB).[18]

Central Banks create money by putting physical (i.e. notes or coins) or bank money into circulation. They can do so by either acquiring securities from the rest of the economy and paying with newly created money or by lending to private financial institutions. In both cases, the central bank's balance sheet extends. The acquired assets, whether securities or loans, show up on the left side of the central bank's balance sheet while the money in circulation represents a liability to the central bank and thus shows up on the right side of its balance sheet. In case of a single institution conducting monetary policy, the assets acquired in the process of money creation always correspond to the monetary base (i.e. the sum of the total amount of currency in circulation and the deposits of credit institutions at the central bank). Regarding the Eurosystem as a whole, this identity, of course, also applies. For an individual institution within the Eurosystem, however, acquired assets and its share of the monetary base may not match. The

[17] The treaty was signed in February 1992 and entered into force in November 1993. The euro zone's initial member countries are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain.

[18] This term and parts of the following explanations are borrowed from Jobst et al. (2012).

reason for this lies in the accounting conventions of the Eurosystem. When a NCB creates money, the acquired asset directly turns up on its balance sheet; it is considered an asset of this NCB. The created money, however, is not considered a liability of the NCB that put it in circulation. Instead, base money is considered a joint liability, i.e. a liability of the whole Eurosystem. The amount of the total base money outstanding attributed to an individual NCB depends on its share in the paid-up capital of the ECB.[19] The difference between the base money allocated to a NCB and the base money it has actually put in circulation (which is equivalent to the value of assets it has received in return) is covered in the NCB's intra-Eurosystem balances. NCBs that have put more money into circulation than is allocated to them exhibit net liabilities against the Eurosystem. NCBs that have created less base money than is allocated to them exhibit net claims against the Eurosystem. Apart from the balance sheets of the NCBs, intra-Eurosystem balances also appear in euro-zone member countries' balance of payments statistics. Net claims are part of a country's gross foreign assets, whereas net liabilities are part of a country's gross liabilities to foreigners. Although the ECB serves as a clearing house for intra-Eurosystem balances, i.e. there are no bilateral balances between the individual institutions of the Eurosystem, it also exhibits its own IEB. By definition, the sum of net claims within the Eurosystem must always equal the sum of net liabilities. Thus, the total amount of these balances is always zero and the balances neither turn up on the Eurosystem's consolidated financial statement nor on the euro zone's consolidated balance of payments.

The two most important[20] forms of intra-Eurosystem balances are the *balances from the adjustment of banknotes in circulation* and the *TARGET2 balances*.[21] The former displays the difference between a NCB's allocated and issued coins and notes. The latter displays the difference between a NCB's allocated and issued deposit money. Since there is no reasonable economic

[19]More precisely, it depends on the *banknote allocation key*, which slightly differs from the *subscribed capital key* since a small fraction of base money in circulation is allocated directly to the ECB. Exact provisions of its calculation and current values can be found in European Union (2011a).

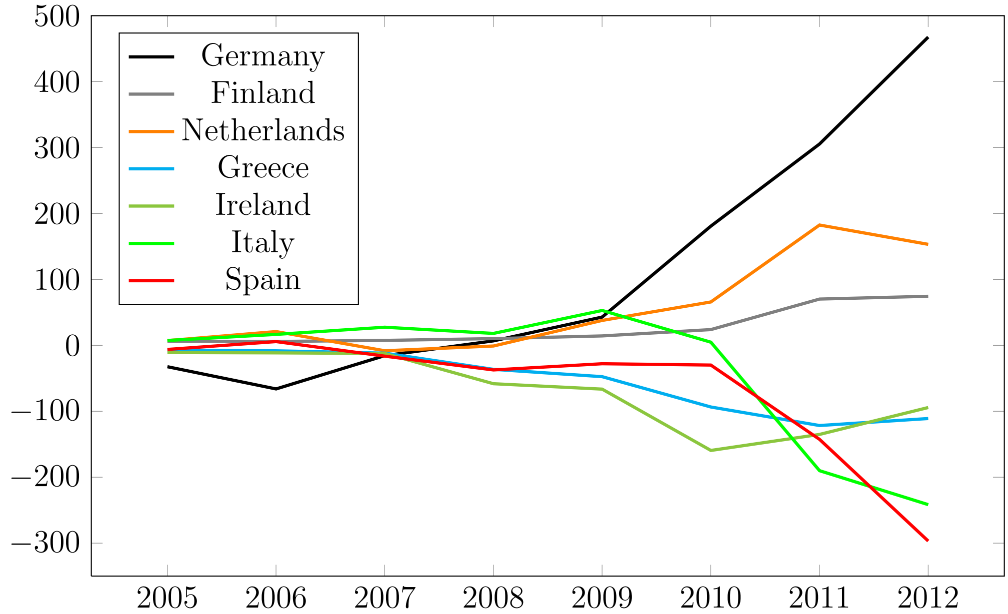
[20]Apart from the two quoted balances, IEBs comprise the items *participating interest in ECB* and *claims equivalent to the transfer of foreign reserves*. The magnitudes of these two items, however, are much smaller and have not shown remarkable variation over the past years. A more detailed explanation of the Eurosystem's accounting framework can be found in European Central Bank (2012).

[21]Again, this terminology is borrowed from Jobst et al. (2012). TARGET is an abbreviation for Trans-European Automated Real-time Gross Settlement Express Transfer System. TARGET2 is the Eurosystem's currently operating interbank payment system.

distinction between these two balance sheet values, they are henceforth analyzed together. Surprisingly, public and academic debates on these issues almost entirely focus on TARGET balances, whereas the balances relating to the distribution of euro banknotes and coins are mostly neglected.

For the first ten years of the Eurosystem's existence, intra-eurosystem balances went largely unnoticed by the general public as well as most economists working in academia. Those economists who were aware of their existence regarded the balances as mere accounting items without economic importance. This changed, however, following several publications by German economist Hans-Werner Sinn.[22] Since then, a vigorous and controversial debate on these issues has emerged.[23] To understand the sudden ascent of scholarly attention to this topic, one has to take a look at the evolution intra-Eurosystem balances over the past years, depicted in figure 4.5.

Figure 4.5: Net Intra-Eurosystem Balances of Selected Euro-Zone Countries in Billion Euros



Values are compiled from the NCB's annual reports, Deutsche Bundesbank (2013), Banco de España (2013), Banca d'Italia (2013), Central Bank of Ireland (2013), Bank of Greece (2013), De Nederlandsche Bank (2013), and Suomen Pankki (2013).

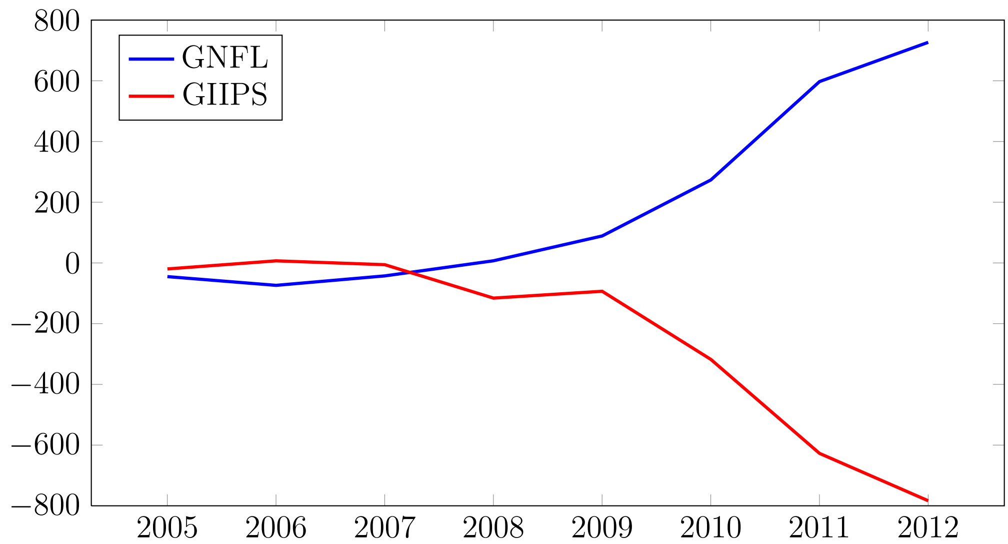
The graph shows the development of selected countries' intra-Eurosystem balances over the last seven years. Prior to the financial crisis of 2008, there

[22] Cf. Sinn (2011b), Sinn (2011a) or Sinn and Wollmershäuser (2012).

[23] For contributions opposing Sinn's views, refer to Bindseil and König (2011), Burgold and Voll (2012), or Cour-Thimann (2013).

is no clear trend in the data; intra-Eurosystem balances for most NCBs fluctuated around a mean of zero without reaching significant values in relation to the sizes of the respective economies. This implies that until 2008, the regional distribution of base money creation more or less conformed to the allocation of base money to the NCBs. Beginning in late 2008, the concurrence of base money creation and allocation faded for some countries in the euro zone. On the one hand, one group of countries commonly referred to the acronym *GIIPS*[24] (Greece, Ireland, Italy, Portugal, Spain) built up sizable net liabilities against the Eurosystem. On the other hand, a second group of countries consisting of Germany, the Netherlands, Finland, and Luxembourg, henceforth *GNFL*, built up significant claims against the Eurosystem. As figure 4.6 shows, the evolution of GNFL countries' aggregated balances is almost a mirror image of the evolution of GIIPS countries' aggregated balances. Thus, the residual euro-zone member countries' aggregated net balance must have been close to zero throughout the contemplated period. As table 4.4 shows, the individual balances of most of these countries were also essentially balanced at the time of writing.

Figure 4.6: Evolution of Intra-Eurosystem Balances in GNFL and GIIPS Countries in Billion Euros



Imbalances between the NCBs of GIIPS and GNFL countries increased steadily from end-2008 to mid-2012. In the summer of 2010, the speed of divergence accelerated and the imbalances increased sharply until they reached

[24]Cyprus should actually be added to this group. Due to its very small economy and the respective small absolute amounts of intra-Eurosystem liabilities, it is left out.

a peak in the middle of 2012. Essentially, figures 4.5 and 4.6 only prove that base money creation in the euro zone has been carried out disproportionately since 2008. While base money creation exceeded base money allocation in GIIPS countries, it fell short of base money allocation in GNFL countries. The ECB does not explicitly manage the regional distribution of base money creation. Rather, it determines the conditions under which financial institutions can lend from their NCBs, which are equal for all euro-zone member countries. This is exactly what constitutes a common monetary policy. Thus, the regional distribution of base money creation and accordingly the IEB levels simply reflect the regional distribution of demand for central bank liquidity within the EMU.

Two different and allegedly opposing explanations for the asymmetry of central bank liquidity demand in the EMU have been proposed in the academic literature on this topic. The first view, for instance held by Sinn and Wollmershäuser (2012), sees the GIIPS countries' need to finance their current account deficits as the primary source of their increased demand for central bank liquidity. The second view, which can, for instance, be found in De Grauwe and Ji (2012), identifies capital flight from GIIPS countries to GNFL countries as the source of ballooning intra-Eurosystem balances. Finding out what the causes of surging IEBs are, is not subject of this analysis. However, illustrating these two potential sources of imbalanced liquidity demand is also helpful to answer further questions. Particularly, it allows to analyze the remuneration of these claims from an economic perspective. This, in turn, is relevant to answering the question of whether the outstanding amounts in these claims or liabilities might influence national preferences on monetary policy.

To clarify the mechanics and the economics of IEB, it is useful to illustrate their emergence in a simple and stylized model of a monetary union. The model union consists of two nations or regions, A and B. Both nations are composed of a central bank, NCB_A or NCB_B, and one residual sector covering the entire rest of the economy, E_A or E_B. Moreover, there is a central agency serving as a clearing house for claims between the two NCBs. The two nations have agreed to share all income arising from monetary policy operations according to a fixed distribution key representing the economic sizes of A and B. For simplicity, the two countries are assumed to be of equal size, which means that both NCBs are entitled to receive half of total monetary income. Put differently, the total amount of base money (BM) is evenly allocated to the two NCBs. Apart from base money, there are two more classes of assets, real assets (*RA*) and debt certificates (*DC*). In contrast to base money (which are in fact debt certificates issued by the monetary authority), *DC* yield interest. The subscript of *DC* denotes the issuer of a debt certificate, i.e. DC_A is debt of sector A and DC_B is debt of sector B. The total amount of equity in the union is, of course, equivalent to the total amount of real assets.

Figure 4.7: Balance Sheets in the Initial Situation

$\mathbf{NCB_A}$

Assets	Liabilities
DC_A 100	BM 100
100	100

$\mathbf{NCB_B}$

Assets	Liabilities
DC_B 100	BM 100
100	100

$\mathbf{E_A}$

Assets	Liabilities
RA 100	Equity 100
BM 100	DC_A 100
200	200

$\mathbf{E_B}$

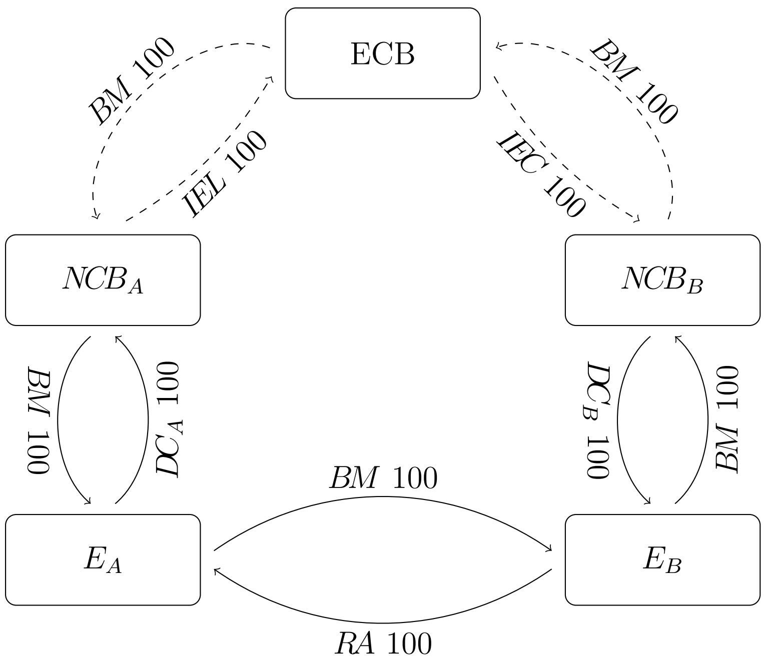
Assets	Liabilities
RA 100	Equity 100
BM 100	DC_B 100
200	200

Figure 4.7 illustrates the model union in an initial situation, in which there are no claims between the NCBs. The situation is perfectly symmetrical. Of the 200 units of base money in the union, one-half is allocated to NCB_A and the other half is allocated to NCB_B. For both NCBs, the sum of base money allocated to it coincides with the issued amount of base money. In return for the created units of base money, each NCB has acquired debt certificates issued by its domestic economy. These *DCs*—which can either be marketable securities such as government bonds or non-marketable securities such as loans to the domestic financial sector—are the only assets on the NCBs' balance sheets. Thus, the NCBs have an equity of zero in this framework. Nevertheless, each NCB earns an income of $100 \cdot i$ per period, which is equal to the interest payments an NCB receives from its domestic economy. As long as the interest rates on debt certificates issued by country A and B equal each other ($i_A = i_B$), no settlement of seigniorage revenues between the NCBs is necessary. The balance sheets of the rest of the economies are also on par with each other. In addition to the 100 units of base money, each economy holds real assets worth 100 units of currency, which is equal to each economy's equity or net worth. There are neither cross-border asset hold-

ings, nor cross-border interest payments. The only income flows between the four sectors depicted in figure 4.7 are vertical, i.e. between the two sectors of one country.

Starting from the situation in figure 4.7, claims between the two central banks can arise whenever there are transactions between E_A and E_B involving base money. As a first case, consider that agents in economy A buy real assets from economy B by paying with base money. Agents in B in turn use this additional amount of base money to pay back their liabilities to NCB_B. This reduces the amount of net lending carried out by NCB_B and, at first, also reduces the total amount of base money circulating in the union. However, agents in economy A demand additional base money from their central bank in order to compensate for the outflow of liquidity from economy A to economy B. Consequently, the amount of base money used by E_B to pay pack its liabilities to NCB_B is not sterilized but reissued in economy A, leaving the total amount of base money in circulation unchanged.

Figure 4.8: Case One: Acquisition of Real Assets



As a result of the transactions illustrated in figure 4.8, NCB_A increased its net lending beyond the amount of base money allocated to it, while NCB_B decreased its net lending below the amount of base money allocated to it. The discrepancy between these two numbers is captured by net claims between the two NCBs or between the NCBs and the ECB, respectively. In the example of figure 4.8, the flow of base money from E_A to E_B is so high that E_B reduces its net borrowing from NCB_B to zero. Put differently, the net inflow of base money from economy A is large enough to cover the entire demand of liquidity of economy B. Economy A on the other hand must borrow twice as much from its central bank to meet its liquidity demand. Since NCB_A lends 100 units of currency more than is allocated to it, it offers a liability to the ECB (*IEL*) worth 100. This is de facto equivalent to borrowing 100 units of base money from the ECB, which is indicated by the dotted arrows between the ECB and NCB_A in figure 4.8. In contrast, NCB_B offers a claim of 100 units of base money against the ECB (*IEC*), since its net lending of base money to the economy falls short of the amount of base money allocated to it. This is de facto equivalent to lending the ECB 100 units of base money. Again this is illustrated by the dotted arrows between the ECB and NCB_B.

Figure 4.9: Case One: Balance Sheets after the Acquisition of Real Assets

ECB

Assets	Liabilities
IEC 100	*IEL* 100
100	100

NCB_A

Assets	Liabilities
DC_A 200	*BM* 100
	IEL 100
200	200

NCB_B

Assets	Liabilities
IEC 100	*BM* 100
100	100

E_A

Assets	Liabilities
RA 200	Equity 100
BM 100	DC_A 200
300	300

E_B

Assets	Liabilities
BM 100	Equity 100
100	100

How these transactions manifest themselves in the sectoral balance sheets is illustrated in figure 4.9. For economy A, the transactions result in a balance sheet extension. Agents bought additional real assets and financed these acquisitions by borrowing additional amounts from NCB_A. The latter's balance sheet also extends. NCB_A lends an additional amount to E_A and finances the additional lending by borrowing from the ECB. On the contrary, the balance sheet of economy B contracts. E_B sold its real assets to E_A and used the incoming funds to pay back its debt at NCB_B. For NCB_B, the transactions only entail a change of debtors from the domestic economy to the ECB.

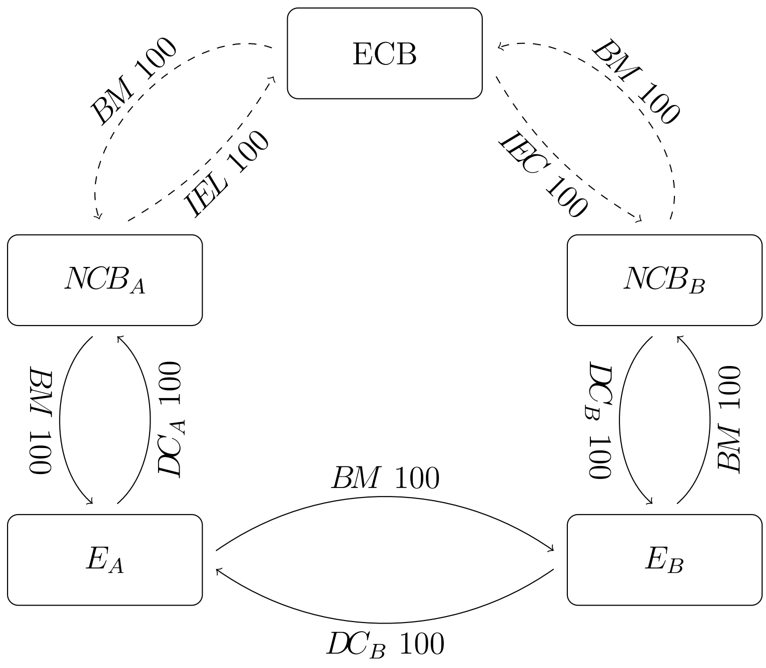
Regarding national aggregates, country A purchases real assets from country B on credit in this example. The borrowing involved, however, is not carried out directly through the issuance of debt certificates to economy B, but indirectly through the system of central banks. Summing up, from the perspective of country B, holdings of real assets were exchanged for a claim against the ECB. Country A, on the contrary, received real assets from abroad in return for a liability against the ECB. Examples like these are given by critics of the Eurosystem's accounting system to argue that the current institutional framework enables GIIPS countries to finance purchases of real assets—such as goods, services, or real estate—from GNFL countries with the "printing press."[25]

Case two involves different (albeit, for the most part, similar) transactions leading to intra-Eurosystem balances. Starting from the initial situation depicted in figure 4.7, agents in economy A transfer funds to economy B, for instance, by moving credit from accounts in the domestic banking system to accounts in the banking system of economy B. In the framework of the model union, this is equivalent to buying debt certificates of country B by a transfer of base money. From an economic perspective such a flight of capital from A to B is equivalent to E_B borrowing from E_A, which might seem counterintuitively at first. In the balance of payments, however, any inflow of capital from abroad, necessarily turns up on the liability side of the receiving country, irrespective of which party initiated the transaction. All subsequent transactions are identical to those described in the first case. E_B uses the additional base money to pay back its liabilities to its national central bank. The amount of base money returned to the system of central banks by E_B is reissued by NCB_A to meet economy A's liquidity demand.

Figure 4.10 illustrates all transactions entailed in the example described above. Case one and case two only differ from each other with respect to the initial transaction. While agents in economy A use base money to purchase real assets from agents in economy B in the first case, they use it to buy debt certificates from economy B in the second case. Unsurprisingly, the

[25] Cf. Sinn and Wollmershäuser (2012), page 489.

Figure 4.10: Case Two: Capital Flight



transactions depicted in figure 4.10 affect sectoral balance sheets similarly to those of case one.

Ultimately, the capital flight scenario also leads to an extension of the balance sheet of economy B. Economically, E_A borrows an additional amount from NCB_A and lends this amount to economy B, thereby increasing its balance sheet total. In contrast to case one, the transactions of case two do not lead to a balance sheet contraction for E_B. Its balance sheet looks identical to that in the intital situation. For E_B, the only difference between the situation before and after the transactions is the change of its creditors, which is not reflected in its balance sheet. Instead of borrowing from its national central bank, it now borrows from economy A. With respect to the system of central banks, the situations after case one and after case two are identical.

Regarding national aggregates, however, case two indeed differs from case one in a significant way. Contrary to case one, country A does not borrow from country B in case two. Rather, country A borrows from the ECB and lends these funds to country B. While E_A became a net foreign creditor as a result of the transactions, NCB_A became a net foreign debtor. Together, the two sectors have a balanced position. Naturally, this also applies for country B. The net debtor position of its economy exactly offsets the net creditor position of its central bank.

Figure 4.11: Case Two: Balance Sheets after a Capital Flight

ECB

Assets	Liabilities
IEC 100	*IEL* 100
100	100

NCB_A

Assets	Liabilities
DC_A 200	*BM* 100
	IEL 100
200	200

NCB_B

Assets	Liabilities
IEC 100	*BM* 100
100	100

E_A

Assets	Liabilities
RA 100	Equity 100
BM 100	DC_A 200
DC_B 100	
300	300

E_B

Assets	Liabilities
RA 100	Equity 100
BM 100	DC_B 100
200	200

Regardless of the question of how intra-Eurosystem claims or liabilities emerged, the schematic representations make clear that IEB are part of a country's foreign assets or liabilities, respectively. From this insight, the question arises of whether these claims are remunerated, i.e. whether there are income revenues for a nation exhibiting claims against the Eurosystem from this position. The stylized account of the sectoral balance sheets above helps to answer this question.

As mentioned before, all incomes from monetary policy operations are shared according to the ECB's capital key.[26] Conveyed to the model union, this means that both NCBs always receive half of total seigniroage revenues, no matter which NCB realizes the earnings at first place. As long as lending conditions between the NCBs and their economies are equal across the union, the geographic distribution of base money creation does not influence the total amount of monetary income in the union. Thus, a NCB's profit is independent of its intra-Euroystem balance. It only depends on the

[26]Some lending operations by NCBs, such as providing *Emergency Liquidity Assistance* (ELA) are not considered to be part of monetary policy operations. Thus, revenues or losses from these operations are not shared but are effected on the respective NCB's own account. For detailed information on the distribution of monetary income within the Eurosystem, refer to Article 32 in European Union (2010) and European Union (2011b).

Eurosystem's aggregate monetary income, which is a function of the total amount of assets the NCBs acquired in the process of money creation and the remuneration of these assets. In the examples above, monetary income of both NCB_A and NCB_B is equal to $i \cdot 100$ in all three situations.

According to European Union (2011b), intra-Eurosystem balances are remunerated at the ECB's main refinancing rate, which has led to some confusion in the public debates on this issue. This remuneration does not imply that a higher interest rate increases the monetary income of creditor countries. In fact, these payments themselves are considered to be part of NCBs' monetary incomes, which are jointly settled at the end of each year. Since the sum of IEB is zero by construction, all interest rate payments on these balances necessarily cancel each other out; the debtors' payments are always equal to the creditors' earnings. Hence, the remuneration of intra-Eurosystem balances does not have an effect on a NCB's monetary income. Much rather, the interest rate payments on IEB are only a form of advanced adjustment payments reducing the payments between NCBs at the end of the accounting period.

One might conclude from this that intra-Eurosystem claims de facto bear no interest for a country. This, however, is not true from an economic perspective. Taking a look back on the model union, the actual remuneration of IEB becomes clear. After the transactions of case one, NCB_B offers a claim against the Eurosystem but does not receive an interest rate payment on this claim. The residual sector of country B also does not receive any payments from other sectors. Compared to the initial situation, however, E_B decreased its interest rate payments to NCB_B since it no longer needs to borrow any funds from the monetary authority. Thus, economically, economy B earns an income by not having to pay interest to the Eurosystem to meet its liquidity demand. The missing interest rate payment is equivalent to the interest rate economy B would have had to pay on its debt certificates times the outstanding intra-Eurosystem claim ($i \cdot IEC$). Therefore, from an economic perspective, IEB are remunerated at the interest rate to which the Eurosystem lends to the rest of the economy.

Comparing the regional distribution of seigniorage payments before and after the emergence of IEB adds further clarity to this issue. In the initial situation, illustrated in figure 4.7, one-half of total seigniorage income orginiates in economy A and the other half in economy B. In the situations of figures 4.9 and 4.11, on the contrary, the entire interest rate payments to the system of central banks accrue from E_A. Thus, the monetary authories' seigniorage income entirely arises at the expense of country A. Since all seigniorage income is shared among NCBs, a shift in the counterparties of base money creation, has an effect on the national incomes of the concerned countries. It can lead to a redistribution of wealth between the participating countries.

As case two makes clear, the remuneration of IEB is, in fact, an economic imperative. In the situation of figure 4.11, economy A holds debt certificates of economy B and thus receives interest rate payments from economy B. If the offsetting item in the balance of country B, the claims against the Eurosystem, did not yield any interest, the transactions depicted in figure 4.10 would create a "free lunch" for country A at the expense of country B. In the current accounting framework, however, the interest rate payments to E_A are compensated by the reduced interest rate payments to the system of central banks from the perspective of E_B.

In spite of their economic justification, these implied interest rate payments harbor a potential for conflicting interests concerning monetary policy. As is discussed above, countries exhibiting net liabilities against the Eurosystem pay an interest on the liabilities equivalent to the rate at which the Eurosystem lends to the economy. More precisely, it depends on the yield of the assets the Eurosystem acquired in the process of money creation. If these assets take on the form of loans to the financial sector, this yield is equivalent to the Eurosystem's main refinancing rate. If the lending is executed through direct purchases of debt securities (for instance, through the ECB's *Securities Market Programme*), the interest rate is equivalent to the yield of the acquired securities. On all accounts, the ECB's monetary policy decisions have a strong indirect if not direct influence on the implicit interest rate payments on IEB. Thus, the ECB's interest rate policy currently entails effects on the distribution of wealth within the union. The higher the real interest rate at which the Eurosystem lends to the economies, the higher are the implicit real returns that creditor countries receive on their claims against the Eurosystem. Correspondingly, debtor countries benefit from low real interest rates since this limits the implicit payments on their liabilities to the Eurosystem.

Of course, in the presence of nominal debt contracts, monetary policy always has some distributional effects. As was extensively discussed in chapter 2, monetary policy decisions might also lead to a redistribution of wealth between nations, if there are cross-border holdings of nominal debt contracts. With respect to marketable debt securities or more generally with respect to private debt contracts, however, the central bank can only indirectly induce wealth transfers by generating unanticipated inflation. Its direct influence on the real returns of these securities is limited. Regarding intra-Eurosystem balances, however, this is different as their remuneration is directly affected by the ECB's interest rate policy.

Whether this side-effect of monetary policy in the EMU actually substantiates regional differences in monetary policy preferences is an unsettled question. Apart from the objectives of the decision-makers in the ECB's Governing Council, the answer to this question depends on the magnitudes of outstanding intra-Eurosystem balances. For this purpose, table 4.4 presents recent values of outstanding IEB in absolute, per capita and per unit of GDP terms for each country that has adopted the euro. The table reveals that IEB have reached sizable levels for some euro-zone countries. At the lower extreme, each Irish inhabitant indirectly owed the Eurosystem more than 20,000 euros through the Central Bank of Ireland at the end of 2012. Every Luxembourgian, at the other extreme, had a claim against the Eurosystem of almost 60,000 euros at the same time. Of course, the magnitudes for these two countries—whose banking sectors are oversized compared to the rest of their economies—are not representative for the rest of the euro zone. However, even for some of the large member countries, balances per capita or unit of GDP are substantial. For instance, the Bundesbank exhibits a net claim against the Eurosystem that amounts to about 18% of German annual economic output. Spain, which is the largest debtor country in absolute terms, offers a liability against the Eurosystem equivalent to about 28% of its annual income. In light of the large outstanding volumes, the implicit interest payments on these claims are indeed a matter of public interest. Summing up, the economic remuneration of the balances has a non-neglible effect on the levels of national wealth for some of the euro zone's member countries and this remuneration depends on the ECB's interest rate policies. Thus, it cannot be ruled out that a country's intra-Eurosystem balance, in fact, alters national preferences on monetary policy.

Table 4.4: Outstanding Intra-Eurosystem Balances on December 31, 2012

Country	In Billion Euros[a]	In Euros Per Capita[b]	As a Percentage of GDP
Austria	3,387	399	1.1
Belgium	-22,715	-2,031	-6.0
Cyprus	-6,497	-7,537	-36.3
Estonia	3,398	2,641	20.0
Finland	74,382	13,707	38.2
France	75,028	1,143	3.7
Germany	468,587	5,701	17.7
Greece	-111,001	-9,832	-57.3
Ireland	-94,314	-20,512	-57.7
Italy	-241,634	-4,068	-15.4
Luxembourg	31,626	58,890	71.2
Malta	-240	-574	-3.5
Netherlands	153,195	9,130	25.5
Portugal	-39,679	-3,764	-24.0
Slovenia	-1,570	-763	-4.4
Slovakia	1,762	326	2.5
Spain	-296,753	-6,450	-28.3

[a] Data Sources for IEB at the end of 2012 are Österreichische Nationalbank (2013), National Bank of Belgium (2013), Central Bank of Cyprus (2013), Eesti Pank (2013), Suomen Pankki (2013), Banque de France (2013), Deutsche Bundesbank (2013), Bank of Greece (2013), Central Bank of Ireland (2013), Banca d'Italia (2013), Banque Central du Luxembourg (2013), Central Bank of Malta (2013), De Nederlandsche Bank (2013), Banco de Portugal (2013), Banka Slovenije (2013), Národná Banka Slovenska (2013) and Banco de España (2013). Although the total amount of IEB is always zero, the numbers quoted here do not exactly add up to zero. The reason for this is that the ECB itself also possesses a balance against the Eurosystem which might be different from zero.

[b] Data on population and GDP levels are from Eurostat (2013a) and Eurostat (2013c).

This section revolved around two specific symptoms of the European Debt Crisis, the asynchronicity of business cycles and nominal intra-European debt positions. Countries finding themselves at very different stages of the business cycle necessarily also have very different needs for monetary stimulus. If, on top of that, monetary policy decisions also entail redistributional effects benefiting economically tarnished regions at the expense of their better-performing neighbors, national interests among the EMU's member countries diverge even further. Whether and under which circumstances these discrepancies in national interests affect the efficiency of conducting common monetary policy is subject of the following section. To shed light on these issues, the two symptoms discussed above are implemented in a simple model of inflation targeting in currency unions. Identifying and discussing the conditions under which these symptoms might impede sound monetary policies in the EMU is at the center of attention.

4.3 The Political Economy of Euro-Zone Inflation

In this section, I present a simple and stylized model of inflation targeting in a monetary union. The model neither intends to provide the reader a profound account of business cycle dynamics nor on the transmission mechanism of monetary policies. In fact, it cannot add any new insights to the academic debates on these issues. Abstracting from the dynamics of policy and shock transmission does not intend to trivialize these problems, but to focus on the problem of conflicting interests within a monetary union and the resulting frictions. Rather than dealing with the classical questions of monetary economics, it starts at a later stage of the discussion. Assuming that the central bank is able to improve public welfare by buffering exogenous shocks hitting the economy, this section pursues the question of under which circumstances this ability is seriously constrained when policy decisions affect heterogeneous countries. A particular focus lies on situations when national and common interests conflict.

The following section introduces the theoretical framework and discusses the basic problems of choosing a common interest rate for a group of countries with individual business cycle shocks and collective decision-making in a committee. Section 4.3.2 then highlights how the presence of cross-border debt positions whose values depend on monetary policy decisions—such as intra-Eurosystem balances—enhances the polarization among member states, reinforcing the problems of collective choice.

4.3.1 Inflation Targeting in a Monetary Union

Consider a group of n countries forming a monetary union. Member countries have different sizes embodied by the coefficient α_j, which indicates the output of country j as a share of the union's total output. Each member country's economy can be described by two reduced-form equations. The first represents a short-run aggregate-supply relationship linking output and inflation:

$$\pi_{j,t} = \pi^e_{j,t} + l_j(y_{j,t} - y^p_{j,t}). \tag{4.2}$$

Equation (4.2) is a standard version of the so-called New Classical Phillips Curve. Current period inflation π_t equals current-period expected inflation π^e_t if current-period real per capita output y_t equals current-period real per capita potential output y^p_t. If the output gap $(y_t - y^p_t)$ is positive, inflation exceeds expected inflation. The coefficient l captures how strongly the inflation rate reacts to deviations of actual from potential output. For simplicity, it is assumed to be equal for all countries, i.e. $l_j = l_k = l$.

The original derivation of a structural equation of this form based on the assumption that firms temporarily mistake movements in the aggregate price level for movements in their product's relative price, leading them to extend production following observed increases in prices.[27] As contemporary New Keynesian dynamic stochastic general equilibrium models (NKDSGE) show, this assumption is not necessary to derive aggregate-supply relationships of such a form from optimizing models.[28]

The second reduced-form equation represents an aggregate-demand relationship linking output to the expected real interest rate $(i_t - \pi^e_t)$:

$$y_{j,t} = y^p_{j,t} - v_j(i_t - \pi^e_{j,t} - r^*_j) + \mu_{j,t}. \tag{4.3}$$

Equation (4.3) is an expectations-augmented Investment-Savings (IS) curve. In the absence of an exogenous aggregate-demand shock μ_t, aggregate demand equals potential output if the expected real interest rate equals the equilibrium real interest rate r^*. Put differently, excess demand $(y_t - y^p_t)$ decreases with the difference between expected and equilibrium real interest

[27] Lucas (1973) was the first to introduce an aggregate-supply relation of this form.

[28] For an introduction and illuminative overview of the New Keynesian model framework including the derivation of the New Keynesian Phillips Curve refer to Gali (2008). The most striking difference between the output inflation relationship in equation (4.2) and those in NKDSGE models is the use of expected future instead of expected current inflation. For the sake of explaining the difficulties of inflation targeting in monetary unions, this disparity is of minor importance.

rate. The demand shocks $\mu_{j,t}$ are assumed to be serially uncorrelated with a mean of zero and a constant and finite variance.

In traditional macroeconomic models, the negative relationship between demand and the real interest rate based upon the assumption that firms increase investment once credit becomes cheaper. On the contrary, modern NKDSGE models trace the connection between these two variables back to intertemporal substitution effects in the consumption of households.[29] Whether the effects of the expected real interest rate on aggregate demand operate through investment or consumption is of minor importance for the following lines of arguments.

For simplicity, both the equilibrium real rates and the slopes of the IS-curves are assumed to be constant over time and equal for all member countries, i.e. $r_j^* = r_k^* = r^*$ and $v_j = v_k = v$. On the one hand, confining country heterogeneity to different output shocks clearly comes at the expense of the model's realism. On the other hand, keeping the model's baseline specification as simple as possible bears the advantage of clarity and helps to illustrate the model's main arguments.

There is only one central bank in the union whose decisions on monetary policy affect all member countries. In every period t, the monetary authority chooses a nominal interest rate i_t. Since expectations are formed prior to the central bank's interest rate decision, the central bank can de facto decide on short-run real interest rates in the member countries, which influence output and inflation levels. The temporary fixation of inflation expectations can be rationalized by all sorts of nominal rigidities existing in the economy, such as staggered price and wage settings. Inserting equation (4.3) in equation (4.2) eliminates per capita output and yields the relationship between inflation, inflation expectations, the nominal interest rate, and the demand shock in the short-run equilibrium:

$$\pi_{j,t} = \pi_{j,t}^e(1 + lv) - lv(i_t - r^*) + l\mu_{j,t}. \tag{4.4}$$

Equation (4.4) exhibits the central bank's ability to influence the member countries' inflation rates through its choice of the common interest rate. In particular, it can offset the impacts of exogenous demand shocks (so-called demand-pull shocks) on the economies. The ability to stabilize inflation rests upon several assumptions. First, shocks must occur after the formation of inflation expectations but prior to the central bank's decision on the nominal

[29] In this case, the letters I and S should be interpreted as *Income* and *Spending* instead of *Investment* and *Savings*.

interest rate. Second, the central bank must be able to observe the shocks timely. Third, its interest rate policies must have an immediate effect on the economies; it must affect the economies in the same period the shocks appear. Neither of these assumptions is accepted without opposition in the academic debate on monetary policy. Actually, these very assumptions have played a central role in the general debate between economists favoring an activist approach of monetary politics and those opposing it. Without going into the details of these controversies among academic economists, I follow the conclusion of the vast majority of practitioners working at central banks around the globe by assuming that monetary authorities are—at least to some degree—able to buffer exogenous shocks to aggregate demand in the short run.

The policy-dependent part of the member countries' welfares can be grasped by a very simple loss function of the form

$$L_{j,t} = \frac{1}{2}(\pi_{j,t} - \pi^*_{j,t})^2. \tag{4.5}$$

Equation (4.5) implies that monetary policy's only function in this model is to stabilize the inflation rate around a target value of π^*, which corresponds to the ECB's sole objective of price stability. However, it is important to note that in this framework, adding a second objective—such as stabilizing employment or output—would not lead to any changes in the analysis. Since the model narrows the attention to demand shocks, which influence inflation only indirectly through their impact on the output gap, stabilizing inflation here is equivalent to stabilizing output. Hence, the model refers to situations in which there is no trade-off between these two goals, which Blanchard and Gali (2007) famously termed "divine coincidence."

By assuming that central bankers derive no utility from any beneficial effects of surprise inflation, for example from a temporary extension of output beyond potential output, I abstract from time-consistency problems of the kind discussed in chapter 3. Thus, decision-makers do not suffer from myopia in the model and are not tempted to fool the public by breaking previously announced policy rules.

It is useful to start the discussion of optimal monetary policy in the model by deriving the country-specific optimal interest rates i^*_j. The first step to find these is to insert equation (4.4) in the loss function given in equation

(4.5). The formal problem can now be stated by

$$\min_{i_t} L_{j,t} = \frac{1}{2}[\pi^e_{j,t}(1 + lv) - lv(i_t - r^*) + l\mu_{j,t} - \pi^*_{j,t}]^2. \qquad (4.6)$$

After minor rearrangements, the first-order minimum condition yields the nominal interest rate minimizing the value of the loss function of country j in period t:

$$i^*_{j,t} = r^* + \frac{1}{lv}(\pi^e_{j,t} - \pi^*_{j,t}) + \pi^e_{j,t} + \frac{1}{v}\mu_{j,t}. \qquad (4.7)$$

The optimal interest rate derived from the two reduced-form equations and the quadratic loss function strongly resembles the well-known Taylor rule.[30] The interest rate should be raised in case of an expansionary output shock ($\mu_t > 0$) and lowered in case of a contractionary output shock ($\mu_t < 0$). The larger the interest rate sensitivity of aggregate demand, v, the smaller is the interest rate adjustment necessary to countervail a demand shock. Moreover, the optimal interest rate increases with the difference between the expected and the target inflation rate. Note that the interest rate should be raised by more than one-for-one following an increase in expected inflation to keep actual inflation stable. This is a slightly modified version of the so-called "Taylor principle," stating that inflation can only by contained if the central bank raises the real interest rate when inflation is on the rise.

After reinserting the optimal interest rate expressed in equation (4.7)) in the equilibrium inflation rate stated in (4.4), it immediately follows that the inflation rate almost always equals the target inflation rate, if each country conducts its own monetary policy. The only situations when interest rate policy does not suffice to keep inflation stable are those of extremely large, negative demand shocks. This is due to the zero lower bound of nominal interest rates existing in reality.[31] For the following analysis, I abstract from a binding zero lower limit of the interest rate by assuming that the target inflation rate is set at levels that rule out the possibility of negative optimal interest rates. Hence, each country's loss function always takes a value of zero if monetary policy is conducted by national authorities. This result serves as a benchmark for the more complicated analysis of interest rate policy in a monetary union.

[30] In Taylor (1993), the original formulation of the rule in is $i = 2 + \pi_{t-1} + 0.5(\pi_{t-1} - 2) + 0.5(y - y^p)$. If one sets the equilibrium real rate r^* and the target inflation π^* rate equal to two percent and replaces expected inflation by past actual inflation, equation (4.7) perfectly complies with the orginial version of the Taylor rule.

[31] Technically, the best implementable policy rate should be stated as $i^{**} = \max\{i^*, 0\}$.

Optimal Common Policy

Stabilization policy becomes more difficult when interest rate decisions affect more than one country. Whenever member countries differ in respect to inflation expectations, target inflation rates, or demand shocks, optimal interest rates of union members also differ from each other. Hence, a policymaker faces trade-offs between minimizing the individual member countries' loss functions when deciding on the common interest rate.

For this paragraph, it is assumed that all member countries have agreed on a common inflation target ($\pi_j^* = \pi_k^* = \pi^*$). In fact, in the absence of inflation-dependent external debt, there are few reasons why target inflation rates within a monetary union should differ from each other.[32] The assumption limits the countries' heterogeneity and thereby the policy trade-off to different demand shocks or reactions to those, respectively.

A straightforward approach to finding a joint interest rate for the union is to hand over monetary policy decisions to a true unionist—a person who is only interested in the union's aggregate welfare. Such a decision-maker minimizes a weighted average of the individual countries' loss functions,

$$\min_{i_t} L_{u,t} = \frac{1}{2} \sum_{j=1}^{n} \alpha_j [\pi_{j,t}^e (1 + lv) - lv(i_t - r^*) + l\mu_{j,t} - \pi_t^*]^2. \tag{4.8}$$

After differentiating with respect to the nominal interest rate, one arrives at a first-order minimum condition of

$$lv(i_t - r^*) = (1 + lv) \sum_{j=1}^{n} \alpha_j \pi_{j,t}^e - \pi_t^* + l \sum_{j=1}^{n} \alpha_j \mu_{j,t}. \tag{4.9}$$

Since the country weights α_j sum up to unity, the sum operator drops out for all terms not differing across countries. After defining $\sum \alpha_j \mu_{j,t} \equiv \bar{\mu}_t$ and $\sum \alpha_j \pi_{j,t}^e \equiv \pi_{u,t}^e$, the union's optimal interest rate i_u^* can be expressed as

$$i_{u,t}^* = r^* + \frac{1}{lv}(\pi_{u,t}^e - \pi^*) + \pi_{u,t}^e + \frac{1}{v}\bar{\mu}_t. \tag{4.10}$$

The union's optimal interest rate exhibits the same properties as the country-specific optimal interest rates specified in equation (4.7). Since the

[32] A possible rationale would be heterogeneity in the volatility of aggregate demand. Countries exhibiting a high variation in demand shocks might need a higher equilibrium inflation rate to avoid a binding of the zero lower bound on the nominal interest rate than countries exhibiting a more stable aggregate demand.

country weights refer to the share of individual countries in the union's total output, the weighted-average output shock $\bar{\mu}_t$ is equivalent to the output shock one would observe treating the union as a whole. Unsurprisingly, the union's aggregate inflation rate—which is nothing different than the weighted sum of its members' inflation rates[33]—always equals the target inflation rate. An individual member country's inflation rate, however, is not necessarily equal to the target inflation rate anymore. Inserting i_u^* in the condition for the equilibrium inflation rate, stated in equation (4.4), leads to country-specific inflation rates of

$$\pi_{j,t} = (1 + lv)(\pi_{j,t}^e - \pi_{u,t}^e) + \pi^* + l(\mu_{j,t} - \bar{\mu}_t). \tag{4.11}$$

A member country's inflation rate differs from the target inflation rate whenever it features inflation expectations or a demand shock diverging from the respective union averages. Under rational expectations, however, heterogeneous inflation expectations are not plausible in this framework. This becomes apparent when the optimal inflation rate of equation (4.10) is interpreted as a publicly announced rule. Since there are no credibility problems in this model, the public believes the policy-maker to follow his rule and expects the union's inflation rate to be at its target value. Since the expected value of all individual demand shocks is zero, the expected value of the difference between an individual demand shock and the union's demand shock $(\mu_{j,t} - \overline{\mu_t})$ is also zero. Therefore, the expected value of the inflation rate equals the target inflation rate for all countries and equation (4.11) simplifies to

$$\pi_{j,t} = \pi^* + l(\mu_{j,t} - \bar{\mu}_t). \tag{4.12}$$

Consequently, a country's loss function in period t equals

$$L_{j,t} = \frac{1}{2}[l(\mu_{j,t} - \bar{\mu}_t)]^2. \tag{4.13}$$

The result is very intuitive. The larger the difference between a country's output shock and the union's average shock, the larger is the difference between the country's and the target inflation rate. Put differently, in periods in which a country's demand shock diverges strongly from the union's average shock, the common interest rate policy is particularly inappropriate for the country. Remembering that all loss functions take on the value of zero

[33] This identity is only true if inflation is calculated on the basis of output since the country weights also measure the economic size of a country by its share in total output.

in case of individual stabilization policies eases the display of the union's inefficiencies. For example, one attains a straightforward measure for the total inefficiency of the common interest policy in a period by reinserting the individual values of the loss function in the unionist's loss function displayed in equation (4.8),

$$L_{u,t} = \frac{1}{2}\sum_{j=1}^{n} \alpha_j (l(\mu_{j,t} - \bar{\mu_t}))^2 = \frac{1}{2}\, l^2 \operatorname{Var}(\mu_{j,t}). \tag{4.14}$$

The weighted average of the members' losses arising from joint monetary policy is l^2 times the weighted average of the squared deviations of the indivual output shocks from the union's output shock. This, in turn, can be written as l^2 times the weighted variance of output shocks in period t, $\operatorname{Var}(\mu_{j,t})$. Bearing in mind that l captures the output sensitivity of inflation and the losses are measured by the differences between actual inflation rates and the target inflation rate, it is obvious that inefficiencies increase with l. Given a fixed value of l, a larger cross-sectional variance of output shocks translates into a less efficient interest rate management by the central bank. Hence, in times when the divergence of demand shocks is particularly large across the union, the acceptance of a common interest rate policy is likely to crumble. Among others, this the reason why the debate on the pertinency of the EMU has flared up in the course of the European Debt Crisis, in which the EMU's members have experienced very different demand shocks.

For a more general assessment of the inefficiency created by common interest rate policy, one has to refer to the expected value of $L_{u,t}$. The latter is simply the weighted covariance of the demand shock vectors μ_j multiplied by l^2, $E[Lu_t] = l^2 \operatorname{Cov}(u_j)$. This result is a formalized version of a well-known argument that had originally been brought forward by Mundell (1961), a long time before Europe decided to form a monetary union. The higher the correlation between the members' output shocks—the more synchronic the countries' business cycles—the more expedient is the formation of a common currency area. Of course, potential benefits of a monetary union—such as economies of scope in administration or a reduction of transaction costs—are not modeled here, which is why Mundell's envisaged trade-off between the assets and drawbacks of a monetary union does not emerge.

The recent increase in business cycle heterogeneity documented in 4.2.1 poses a major challenge for the ECB's common interest rate policy. Its ability to smooth inflation rates across the union by buffering demand shocks directly depends on the synchronicity of the shocks. In times when these differ strongly across union members—which currently applies to the euro zone—the common interest rate policy is particularly inefficient. There simply is no single interest rate accommodating to the needs of depressed and booming economies at the same time. In terms of the model, this increase in inefficiency can be grasped by comparing the value of the union's loss function displayed in equation (4.14) between periods with low and high cross-sectional variations of demand shocks. Provided that the current institutional framework cannot be changed, the inefficiency caused by demand-shock heterogeneity is unavoidable. It occurs even if a benevolent social planner—a true unionist—is in charge of common monetary policy. As is shown in the following paragraphs, abandoning the assumption of a benevolent social planner opens the door for further inefficiencies. In contrast to those described above, however, these additional inefficiencies are, in principle, avoidable.

Collective Decisions and Common Policy

Now, the hypothesis that a single, benevolent policy-maker decides on monetary policy issues is dropped. Instead, it is assumed that interest rate decisions are reached by a committee consisting of representatives of the union's member countries. As long as the committee solely consists of true unionists—as, for example, is intended by the statutes of the ECB—the committee, of course, comes to the same decisions as the single policy-maker in the previous paragraph. To what extent national envoys, such as the directors of the national central banks in the ECB's Governing Council, actually act in their national instead of the common interest is an unsettled question.[34] A complete lack of national influences on decisions by committee members, however, is surely a quixotic assumption. Thus, augmenting the previous analysis by an investigation of the opposite extreme, namely that all members solely act in their national interests, is a worthwhile endeavor.

How the committee decides depends on the composition of its members and the voting protocol. For simplicity, the decision-making body is assumed to consist of n members, at which each member represents one country. This is in conflict with the ECB's Governing Council, which consists of the seventeen directors of the national central banks and the five members of the ECB's Executive Board. Whether the members of the Executive Board act on behalf of common interests or not is also debatable. If they do, the

[34] Unfortunately, the confidentiality of the Governing Council's proceedings hampers an empirical investigation of this issue.

decisions reached by committee are more likely to match those of a true unionist. If they do not, it is unclear whether these additional members will shift the committee's decisions closer or further away from the unionist's choice.

Before introducing the formal voting procedure, it is useful to aline the n committee members by their preferred interest rate. As previously explained, rational expectations in combination with serially uncorrelated demand shocks and a common inflation target rate imply that inflation expectations do not differ across countries. Thus, the country-specific optimal interest rates stated in equation (4.7) simplify to $i^*_{j,t} = r^* + \pi^*_t + v^{-1}\mu_{j,t}$. Hence, the distribution of $i^*_{j,t}$ only depends on the distribution of demand shocks in period t and the interest rate sensitivity of aggregate demand v. The larger v, the smaller are the interest rate shifts necessary to stabilize demand and thus, the smaller is the variation of optimal interest rates given a distribution of demand shocks.

Figure 4.12: Country-Specific Optimal Interest Rates

The length of the horizontal line in graph 4.12 represents the difference between the minimum and the maximum value of the optimal interest rate, which correspond to the country with the lowest or highest demand shock, respectively. The union's optimal interest rate $i^*_{u,t}$ lies somewhere in between the two extreme values. Its exact position depends on the distribution of $\mu_{j,t}$ and the country weights α_j. It does not have to be at or near the mean of i^*_{min} and i^*_{max}.

The decision-making of n committee members is now examined for a simple, but perspicuous voting procedure, whose description takes its cue from Riboni and Ruge-Murcia (2010). Starting from a status quo interest rate $i_{q,t}$, for instance, last period's interest rate, the committee decides by simple majority (i.e. a proposal must get $\frac{n+1}{2}$ votes to pass) whether the rate should be increased or decreased with respect to the status quo. Afterwards, the committee selects possible interest rates through a binary agenda. For instance, if there has been a majority for an interest rate increase in the first step, the committee holds a vote of $i_{q,t} + \lambda$ against $i_{q,t} + 2\lambda$, at which λ represents the smallest possible interest rate step. If $i_{q,t} + 2\lambda$ was preferred over $i_{q,t} + \lambda$ by a simple majority, the committee holds a vote of $i_{q,t} + 2\lambda$ against $i_{q,t} + 3\lambda$ and so on. The procedure stops when there is no majority for a further increase. The prevailing interest rate is the only one that gets a majority in a pairwise vote against any other possible interest rate. The voting protocol thus leads to a unique result that is independent of the initial interest rate.

The above-sketched voting procedure entails the well-known result that the median voter's preferences get implanted.[35] If each committee member has one vote regardless of the size of its home country—as applies for the ECB's Governing Council—the median voter's preferred interest rate is equivalent to the median country's optimal interest rate $i^*_{M,t}$. Regarding the final decision, the situation is thus equivalent to one in which a single policy-maker that is exclusively interested in minimizing the median member country's loss function chooses the common interest rate.

Inserting the median country's optimal interest rate $i^*_{M,t} = r^* + \pi^*_t + v^{-1}\mu_{M,t}$ in the member countries' loss functions yields $L_{j,t} = \frac{1}{2}[l(\mu_{j,t} - \mu_{M,t})]^2$. Thus, the weighted sum of the individual loss functions in period t is

$$L^M_{u,t} = \frac{1}{2} l^2 \sum_{j=1}^{n} \alpha_j (\mu_{j,t} - \mu_{M,t})^2. \tag{4.15}$$

The inefficiency of common interest rate policy can be indicated as l^2 times the weighted average of the squared deviations of the individual demand shocks from the median demand shock. Comparing the union's loss of equation (4.15) to that of equation (4.14), one finds that the inefficiencies in case of the above-described decision by committee exceed those in case of a unionist in charge, whenever the median country's demand shock differs from the union average shock,

$$\frac{1}{2} l^2 \sum_{j=1}^{n} \alpha_j (\mu_{j,t} - \mu_{M,t})^2 > \frac{1}{2} l^2 \sum_{j=1}^{n} \alpha_j (\mu_{j,t} - \bar{\mu}_t)^2 \ \forall \ \mu_{M,t} \neq \bar{\mu}_t. \quad ^{36} \tag{4.16}$$

The median country's shock only coincides with the union's average shock in the theoretical case when all countries are of uniform economic size and the demand shocks are perfectly symmetrically distributed. Hence, as a rule, the collective decision by a committee is inferior to that of a benevolent unionist. Indeed, this result is obvious as the unionist chooses his preferred interest rate $i^*_{u,t}$ by explicitly minimizing $L_{u,t}$.

[35] A purely technical prerequisite for this assertion is that all optimal interest rates can be expressed as a multiple integer of λ.

[36] The derivation of this result can be found in the appendix.

Regarding the union as a single country brings about an even simpler way to express the additional inefficiency caused by collective decision-making. By defining $\widetilde{L_u}$ as the union's loss exclusive of internal imparities, the additional loss due to choosing $i^*_{M,t}$ instead of $i^*_{u,t}$ is $(\widetilde{L^M_{u,t}} - \widetilde{L^*_{u,t}})$. Recalling that a country suffers no losses if it can set its own interest rate in this model, the union's loss in case of a unionist in charge, $\widetilde{L^*_{u,t}}$, is zero and the loss due to the implementation of the median country's preferences is

$$\widetilde{L^M_{u,t}} = \frac{1}{2} l^2 (\bar{\mu}_t - \mu_{M,t})^2. \tag{4.17}$$

Intuitively, the inefficiency increases in the absolute difference of the median country's and the union's demand shock. Note that the two measures $\widetilde{L_u}$ and L_u cannot be directly compared to each other as the latter comprises regional disparities, which are explicitly left out in the former.[37]

In light of these results, the question of how these inefficiencies can be avoided suggests itself. How should interest rate decisions be organized if it is impossible to hand these over to persons devoid of national interests? An apparent proposal to overcome these problems is to endow committee members with different voting powers reflecting the economic size of their home countries (i.e. the representative of country j has α_j votes).[38] Applying the above-described logic of collective choice to this situation leads to the result that the *weighted* median country's preferences get implemented. The weighted median country is the country w whose preferred interest rate i^*_w gets more than 50% of the votes against any other proposed interest rate. Since less than or equal to 50% of the votes prefer a lower interest rate than i^*_w *and* less than or equal to 50% of the votes prefer a higher interest rate, country w always excercises the pivotal vote. Whether this breakdown of the votes is actually superior to the one-country-one-vote regime discussed above is unclear. It is superior if the absolute difference between the weighted median and the union's optimal interest rate (which is the weighted average interest rate) is smaller than the absolute difference between the simple median and the union's optimal interest rate. In the appendix (Cf. page 190), two simple numerical examples illustrate that the weighted median coun-

[37] In principle, one could extend the analysis of regional diversity and the accompanying inefficiencies of a common monetary policy *ad infinitum* as every country consists of heterogeneous regions that consist of heterogeneous subregions and so on.

[38] An alternative would be to let the member countries send multiple representatives reflecting their economic weights to the committee. However, the vast extension of the committee required to reach a reasonably accurate representation of the union is not desirable.

try's preferred interest rate can be either closer or further apart from the weighted average rate than those of the median country. Thus, endowing committee members with different voting powers does neither guarantee to eliminate nor even to reduce the bias of collective decision-making within this framework.[39]

4.3.2 Inflation Targeting and Intra-European Debt

So far, the heterogeneity between member countries was restricted to different aggregate-demand shocks. In particular, it was assumed that all member countries aim for the same inflation rate. While this assumption might be realistic in normal times, it is less so in times when nominal imbalances within the union are large. Countries exhibiting significant nominal claims against other union members are likely to prefer lower rates of inflation than countries exhibiting significant nominal liabilities against other union members. While the creditor nations have an interest in preservering the purchasing power of their external savings, the debtor countries have an interest in reducing the real burden of their external liabilities.

Under normal circumstances, external wealth is predominantly held in the form of marketable securities, such as government bonds, corporate bonds, or equities. As was discussed in greater detail in chapter 2, real income from some of these marketable securities depend on the level of surprise inflation and thus on monetary policy decisions. The value of non-marketable securities such as intra-Eurosystem balances is even more reliant on monetary policy. As asserted in section 4.2, the real remuneration of IEB depends on the difference between the ECB's main refinancing rate and the inflation rate. This number—the short-term real interest rate—is controlled by the monetary authority.

The existence of large intra-Eurosystem and other nominal balances thus motivates the introduction of a further element of heterogeneity in national preferences on monetary policy. The easiest way to implement this situation in the model is to augment the policy-maker's loss function by an element reflecting a country's net real income from abroad. This real income is the product of a country's net financial exposure to monetary-policy decisions, $T_{j,t}$, and the short-term real interest rate $(i_t - \pi_{j,t})$.

[39] Of course, this does not rule out that settings in which there is no mismatch between the relative economic size of the union member countries and their voting rights yield superior policy decisions on average. For a more detailled discussion of this issue, refer to Berger and Müller (2007) and the references cited therein.

For the sake of concision and clarity, it makes sense to break down the policy-maker's minimization problem into two steps. In the first step, the policy-maker minimizes $\widehat{L}$ with respect to the nominal interest rate. The resulting first-order minimum condition yields a country's target inflation rate $\pi^*_{j,t}$. The preferred inflation rate is then plugged into the loss function specified in equation (4.5), which is used to derive the interest rate equalizing actual and target inflation rates in the second step. While there is no mathematical reason to solve the policy-maker's minimization problem in two steps, this procedure highlights the linkage to the previous analysis.[40] By deriving $\pi^*_{j,t}$ in the first step, it becomes clear that the existence of nominal external debt is just one potential source of different inflation targets across union members. Thus, the following analysis is simply an extension to that of section 4.3.1, namely by endogenizing country-specific preferred inflation rates.

The policy-makers minimize the loss function

$$\widehat{L_{j,t}} = \frac{1}{2}\pi^2_{j,t} - cT_{j,t}(i_t - \pi_{j,t}). \tag{4.18}$$

$\widehat{L}$ can be interpreted as the policy-maker's actual objective. The first element entails the standard assumption that welfare decreases quadratically with the realized inflation rate. The second component incorporates the real income that country j earns from its nominal external assets. $T_{j,t}$ thereby stands for the nominal balance of country j against the rest of the union in period t relative to its national income. For instance, $T_{j,t}$ can be interpreted as a country's intra-Eurosystem balance divided by its GDP at one point in time. This interpretation of $T_{j,t}$ is used throughout the remainder of this section. If $T_{j,t}$ is positive, national income increases with the short-term real interest rate. If the balance is below zero, national income decreases with the real interest rate. Just as in chapter 3, parameter c measures the relative weight of the level of national wealth vis-à-vis the inflation rate. In contrast to chapter 3, however, gains or losses occur whenever the real interest rate differs from zero and not just when actual inflation differs from expected inflation.

It is assumed that all member countries and representatives value changes of the level of national wealth relative to national income equally, i.e. $c_j = c_k = c$. In particular, c is treated as an exogenous preference parameter,

[40] Of course, one arrives at the same country-specific optimal interest rate if one isolates the nominal interest rate directly from the first-order minimum condition specified in 4.19.

which excludes the possibility of governments choosing their envoys strategically. Since the emergence of IEB could have hardly been foreseen at the time when most of the members of the ECB's Governing Council were selected, this assumption is not far-fetched. Allowing for heterogeneity in (exogenous) preferences expressed in c would only add a new parameter influencing the dispersion of inflation targets without significantly enhancing the informative value of the model.

Minimizing $\widehat{L_{j,t}}$ with respect to the nominal interest rate yields a first oder minimum condition of

$$\pi_{j,t}\frac{\partial \pi_{j,t}}{\partial i_t} - cT_{j,t}(1 - \frac{\partial \pi_{j,t}}{\partial i_t}) \stackrel{!}{=} 0. \tag{4.19}$$

With $\frac{\partial \pi_{j,t}}{\partial i_t} = -lv$ the country-specific target inflation rate can be stated as

$$\pi^*_{j,t} = -cT_{j,t}\frac{1+lv}{lv}. \tag{4.20}$$

For simplicity, the optimal inflation rate of countries exhibiting a balanced nominal position against the rest of the union ($T_{j,t} = 0$) is normalized to zero. Thus, IEB are the only reason for inflation targets differing from zero that are modeled here. A country's preferred inflation rate decreases linearly with T. The larger a country's liabilities against the rest of the union, the higher is its preferred inflation rate. On the contrary, the higher a country's intra-Eurosystem claims, the lower is its preferred rate of inflation or the higher is its preferred rate of deflation. The difference between preferred inflation rates increases with the weight of national wealth in the policy-makers' loss functions. Since the only changes of national wealth modeled here are those due to a redistribution of wealth within the union—the total amount of wealth in the union is independent of monetary policy—c can be interpreted as the policy-makers' degree of nationalism.

Inserting $\pi^*_{j,t}$ into the country-specific optimal interest rate stated in equation (4.7) leads to

$$i^*_{j,t} = r^* + \frac{1+lv}{lv}\pi^e_{j,t} + cT_{j,t}\frac{1+lv}{(lv)^2} + \frac{1}{v}\mu_{j,t}. \tag{4.21}$$

As expected, a country's preferred interest rate increases with its intra-Eurosystem claims. In other words, *ceteris paribus*, nominal creditor countries advocate a tighter monetary policy than nominal debtor countries. From the perspective of a nominal creditor country, an increase in the nominal interest rate has two effects. On the one hand, it leads to a reduction of aggregate demand and therefore indirectly lowers the inflation rate. On the other hand, a surge in the nominal interest rate directly leads to an increase in nominal income from IEB. This second effect augments the marginal benefits of an increase in interest rates relative to the situation devoid of nominal external wealth. Hence, the interest rate at which the marginal utility (originating from rising real income from intra-Eurosystem claims) equals the marginal costs of a further increase (originating from a larger deviation of the inflation rate from zero) increases with a country's IEB. The larger a country's intra-Euroystem claims relative to its national income, the larger is its marginal benefit of an increase in the interest rate and, hence, the higher is its preferred interest rate given a demand shock.

In spite of heterogeneous inflation targets, there is no reason for inflation expectations to differ from another in this framework. As long as the decision process and the countries' IEB are common-knowledge, the expected value of the inflation rate is equivalent across countries. Thus, the dispersion of optimal interest rates only depends on the dispersions of T_j and μ_j and their covariance. With $\pi^e_{j,t} = \pi^e_{k,t} = \pi^e_t$, the variance of i^*_j in period t can be conveyed as

$$\mathrm{Var}(i^*_j) = \frac{c^2(1+lv)^2}{(lv)^4}\mathrm{Var}(T_j) + \frac{1}{v^2}\mathrm{Var}(\mu_j) + 2\frac{c(1+lv)}{l^2v^3}\mathrm{Cov}(T_j, \mu_j). \quad (4.22)$$

The variation of optimal interest rates increases with the cross-sectional variance of demand shocks and the cross-sectional variance of intra-Eurosystem balances. In other words, the polarization among member countries accelerates with the absolute size of nominal imbalances within the union. Moreover, it increases with the covariance of demand shocks and intra-Eurosystem balances. If countries hit by a particularly adverse demand shock exhibit intra-Eurosystem liabilities and those countries hit by a particularly favorable demand shock exhibit intra-Eurosystem claims, the polarization among union members increases even further. Note, however, that the expected value of the covariance between T_j and μ_j is zero in this model as the demand shocks are modeled as random variables which are independently distributed over time. Thus, there cannot be a systematic correlation between μ_j and T_j.[41]

[41] Otherwise, T_j could be used by the public to forecast the demand shock, which would alter inflation expectations. This, in turn, would impair the central bank's ability to stabilize the inflation rate.

Summing up, nominal imbalances within the union in general, and intra-Eurosystem balances in particular, have the potential to magnify internal discrepancies concerning common interest rate decisions in the EMU. Examining under which circumstances these additional frictions translate into inferior policy decisions is subject of the following paragraphs.

Optimal Common Policy

There are two equivalent approaches to derive the union's optimal interest rate in this setting. The first is to treat the union as one country and to find the ideal interest rate in complete neglect of regional disparities. The second is to minimize the weighted sum of the member countries' loss functions by choosing i. Of course, both approaches lead to the same result. In line with the derivation of the country-specific optimal interest rate, it is useful to deliberate on the optimal inflation rate first. One arrives at an answer by minimizing the loss function

$$\widehat{L_{u,t}} = \frac{1}{2}\pi_{u,t}^2 - cT_{u,t}(i - \pi_{u,t}) \tag{4.23}$$

with respect to the interest rate. Just like those of its member countries, the union's target inflation rate, $\pi_{u_t}^* = -cT_{u,t}(1 + lv)(lv)^{-1}$, depends on the union's IEB. Yet, this is always zero. Since the balances only reflect imbalances within the union, they always sum up to zero in absolute terms. Of course, this also implies that the income-weighted sum of intra-Eurosystem balances per national income is also always zero ($\sum \alpha_j T_j = 0$). Thus, for any policy-maker who values a euro in country j equally to one euro in country k—which is the definition of a true unionist—intra-Eurosystem balances do not matter.[42] In this setting, this implies an optimal inflation rate of zero for the union.

With $\pi_u^* = 0$, the union's optimal interest rate, stated in equation (4.10), becomes

$$i_{u,t}^* = r^* + \frac{1 + lv}{lv}\pi_t^e + \frac{1}{v}\bar{\mu}_t. \tag{4.24}$$

Inserting $i_{u,t}^*$ into equation (4.12) yields an inflation rate in country j of $\pi_{j,t} = l(\mu_{j,t} - \bar{\mu}_t)$.

[42] Equivalently, a true unionist could also be defined as a person that puts no weight on the levels of national wealth, $c = 0$.

Bearing in mind that the target inflation rate of country j is $\pi^*_{j,t} = -cT_{j,t}(1+lv)(lv)^{-1}$, the loss function of country j can be expressed as

$$L_{j,t} = \frac{1}{2}[l(\mu_{j,t} - \bar{\mu}_t) + cT_{j,t}\frac{1+lv}{lv}]^2. \quad (4.25)$$

As in the case of homogeneous inflation targets, the union's loss can be specified either as the weighted sum of its member countries' losses or as the loss devoid of regional discrepancies. While the latter is zero, the former can be expressed as

$$L_{u,t} = \frac{1}{2}[l^2 \operatorname{Var}(\mu_{j,t}) + c^2\frac{(1+lv)^2}{(lv)^2} \operatorname{Var}(T_{j,t}) + 2c\frac{1+lv}{v} \operatorname{Cov}(\mu_{j,t}, T_{j,t})]. \quad (4.26)$$

The union's loss increases with the weighted cross-sectional variance of demand shocks and the weighted cross-sectional variance of intra-Eurosystem balances. The larger the absolute values of $T_{j,t}$, the further apart are the countries' preferred inflation rates. In turn, the larger the dispersion of inflation targets, the less appropriate is a common monetary policy from an individual country's view. It is important to point out, however, that losses stemming from nominal imbalances between the countries only emerge from the perspective of nationalistic policy-makers and can thus not be interpreted as inefficiencies caused by the creation of the monetary union per se.

Moreover, the union's loss increases with the weighted cross-sectional covariance between demand shocks and IEB. If intra-Eurosystem claims coincide with above-average demand shocks, the unionist's choice of a common monetary policy is particularly far from national preferences. However, as previously mentioned, there cannot be a systematic statistical relationship between these two variables in this setting and the expected value of the covariance is zero.

Irrespective of diverging objectives among member countries, a true unionist opts for the interest rate minimizing the weighted average demand shock hitting the union. Hence, the existence of nominal imbalances between member countries does not necessarily lead to less favorable policy outcomes from a collective perspective.

Collective Decisions and Common Policy

When a committee composed of national envoys decides on issues of monetary policy, nominal imbalances within the union might indeed matter. If all countries have one vote in the council regardless of their economic size, the committee member representing the median country has the pivotal vote and can de facto dictate the interest rate. Again, the median country is the country whose optimal interest rate divides the union into two groups of equal size, one assembling countries preferring a higher and one assembling countries preferring a lower interest rate. In contrast to the situation in section 4.3, the median country's interest rate is no longer simply determined by the median demand shock, but by the combination of the median country's demand shock and its intra-Eurosystem balance. Letting the index $\tilde{M}$ stand for the median country, the collectively chosen interest rate in this setting is

$$i_{\tilde{M},t} = r^* + \pi_t^e \frac{1+lv}{lv} + \frac{1+lv}{(lv)^2} cT_{\tilde{M},t} + \frac{1}{v}\mu_{\tilde{M},t}. \tag{4.27}$$

Assuming that all country's nominal positions are readily disclosed to the public and that composition and voting procedure of the decision-making body are common knowledge, a rational public expects that the preferences of the country exhibiting the median IEB get implemented. However, the median country *after* the occurrence of the demand shock does not have to be identical to the expected median country, which is why expected inflation may differ from the median country's target inflation rate in this setting. Since the policy-maker neutralizes inflation expectations by adopting the interest rate accordingly, this has no further consequences on actual inflation rates in the union.

Inserting the collectively chosen interest rate into equation (4.4) yields a country-specific inflation rate of

$$\pi_{j,t} = -\frac{1+v}{lv} cT_{\tilde{M},t} + l(\mu_{j,t} - \mu_{\tilde{M},t}). \tag{4.28}$$

With this equation, the union's loss expressed as the weighted average of its members' losses is

$$L_{u,t} = \frac{1}{2}\sum_{j=1}^{n} \alpha_j [l(\mu_{j,t} - \mu_{\tilde{M},t}) + \frac{1+lv}{lv} c(T_{j,t} - T_{\tilde{M},t})]^2. \tag{4.29}$$

The union's loss displayed in the equation above shares the same characteristics as that in equation (4.26). Again, the larger the cross-sectional variation of nominal imbalances and the larger the cross-sectional variation of demand shocks, the less efficient is a common monetary policy. To compare the union's loss under collective choice with that under a benevolent decision-maker, it is suitable to resort to the second expression of the common loss, $\widetilde{L_u}$, which can be expressed as

$$\widetilde{L_{u,t}} = \frac{1}{2}[l^2(\mu_{\tilde{M},t} - \bar{\mu_t})^2 + \frac{(1+lv)^2}{(lv)^2}c^2T^2_{\tilde{M},t} + 2\frac{1+lv}{v}c(\mu_{\tilde{M},t} - \bar{\mu_t})T_{\tilde{M},t}].^{43} \quad (4.30)$$

The inefficiency of the collectively chosen interest rate increases with the absolute difference between the shock hitting the median country and the union's average shock. Furthermore, the losses increase with the absolute value of the median country's IEB. The intuition behind this result is apparent. If the median country exhibits sizable intra-Eurosystem claims, it is interested in realizing a high return on these claims. Translated into inflation-rate preferences, such a country aims at extending the purchasing power of its claims through deflation. Conversely, if the median country exhibits sizable intra-Eurosystem liabilities, it is interested in pushing the real yield on these liabilities below zero. In other words, such a country aims at diluting the real value of its liabilities through inflation. In both cases, its preferred inflation rate departs from the socially optimal inflation rate of zero. This bias is mitigated if the product of the median country's nominal balance and the difference between its own and the union's average demand shock is negative. For instance, if the median country is a net debtor and experiences an above-average demand shock, the negative consequences of having the median committee member instead of a true unionist to decide are less severe. On the contrary, if the median member country is a net debtor and is hit by a worse-than-average demand shock, its preferred interest rate is further apart from the union's optimal interest rate and the bias of collective decision-making escalates.[44] Evidently, the same logic also applies to a net creditor country having the pivotal vote.

[43] Remembering that the union's optimal inflation rate is zero, the union's loss is $\widetilde{L_{u,t}} = \frac{1}{2}[\pi^*_{\tilde{M},t} + l(\bar{\mu_t} - \mu_{\tilde{M},t})]^2 = \frac{1}{2}[l^2(\mu_{\tilde{M},t} - \bar{\mu_t})^2 + \frac{(1+lv)^2}{(lv)^2}c^2T^2_{\tilde{M},t} + 2\frac{1+lv}{v}c(\mu_{\tilde{M},t} - \bar{\mu_t})T_{\tilde{M},t}]$

[44] Couterintuitively, the expected value of the last summand in equation (4.30) is not necessarily zero. Numerical simulations of median interest rates in the appendix on page 191 and the following show that, in some constellations, the expected value of $(\mu_{\tilde{M},t} - \bar{\mu_t})T_{\tilde{M},t}$ is of opposite sign to the median country's IEB, when country-specific demand shocks are normally distributed around zero. The reason for this result is that the probability that the median IEB country is also the median interest rate country decreases if its demand shock pushes its preferred interest rate further away from the union average. Thus, the expected absolute value of the union's inflation rate lies somewhat below the absolute value of the median IEB country's preferred inflation rate. However, the simulations also demonstrate that this secondary effect is only of minor importance when the member countries' preferred inflation rates vary significantly from each other.

Summing up, while the existence of nominal imbalances within the union is not detrimental to the union's welfare when a true unionist decides on monetary policy, it might well be when decisions are made by a committee of national representatives. When the member countries' nominal balances are large enough to motivate sizable differences in preferred inflation rates, the scope for biases in monetary policy is augmented. From a collective perspective, the efficiency of common monetary policy depends on the difference between the objectives of the pivotal country under a voting system and those of the union as a whole. Particularly, the union's welfare decreases with the absolute value of the median country's nominal balance vis-à-vis the rest of the union. For instance, if many small net debtor countries are opposed by few large net creditor countries, collective decisions are likely to be biased towards overly inflationary policies. If, on the other hand, few large net debtor countries face a large number of small net creditor countries in the committee, common monetary policy is likely to be biased towards deflation. Regardless of the danger of systematic biases in monetary policy, large nominal imbalances lead to a polarization of national interests in the union, which might well result in a derogatory effect on the cohesion of the union. Thus, it is of utmost importance to constrain the member countries' incentives to engage in deleterious distributional conflicts of this kind.

4.4 Conclusions and Policy Proposals

As was shown in section 4.2, two sources of conflicting interests within the EMU—business cycle asynchronicity and cross-country nominal debt positions—have abounded in the course of the European Debt Crisis. The subsequent model, expounded in section 4.3, illustrates how the combination of conflicting interests and collective decision-making compromises the efficiency of common monetary policy within a currency union. Finally, this section discusses the relevance of the above-sketched problems and comes up with simple ways to overcome the issues.

The easiest way to vanquish these problems would be to assign monetary policy to a true unionist—a person devoid of national interests. In fact, this is exactly how the ECB is supposed to work. Officially, decisions on monetary policy are exclusively based on aggregate data and the members of the Governing Council shall not act as national representatives but "jointly contribute to attaining our common goals."[45] Whether and to what extent

[45] Cf. European Central Bank (2013).

the members of the Governing Council represent their respective national instead of common interests is an empirical question. As the voting of individual members is confidential, finding an answer to this question entails multiple caveats and goes beyond the scope of this thesis. In fact, there are contradicting findings and no consensus on this issue has emerged so far in the empirical literature.[46] In any case, the existence of national biases cannot be ruled out completely. As long as the European Union is perceived as a confederation of independent nations instead of one single country by most of its citizens, finding true unionists to decide on common policies is not a matter of course. Surely, the EU might evolve into a federation with a strong national identity in the future.[47] Until then, however, the EU should design its institutions in a way that conflicting national interests do not impede the efficiency of collective policies.

One apparent proposal for reform is to centralize decision-making at the ECB, i.e. to remove the presidents of the national central banks from the Governing Council or at least restrict their voting power within the committee.[48] The idea behind this proposal is that executives working at a central institution are more likely to act in the union's collective interests than representatives of national authorities. Although there may well be some truth in this predication, centralization of decision-making does not automatically safeguard a union against regional biases. Signing a labor agreement at the ECB does not necessarily turn a person into a true unionist. In fact, centralization may simply push up the problem of regional representation to an upper level—namely to the issues of how and by whom executives are appointed.

Another approach, inspired by Walsh (1995), would be to alter the decision-makers' incentives by tying their personal incomes directly to the union's inflation performance, thereby prompting them to act as if they were true unionists. However, the design of optimal contracts of this kind is less

[46] For instance, Heinemann and Hüfner (2004) or Cancelo et al. (2011) find statistical support for the assertion that regional economic conditions influence the ECB's decisions beyond their impact on euro-zone aggregate values. On the other hand, Gorter et al. (2010) arrive at the opposite conclusion.

[47] Even nations with a distinct national identity, such as the U.S., may encounter problems of regional biases. For example, in their study on interest rate decisions by the Federal Open Market Committee, Chappell et al. (2008) report that the presidents of the regional reserve banks factor the respective regional economic conditions into their decisions although they should base their ruling solely on U.S. aggregate values.

[48] For an international comparison of the sizes and compositions of decision-making bodies at central banks, refer to Berger (2006). Therein one can also find a thorough discussion of the assets and drawbacks of regional representation in monetary policy committees.

straightforward in practice than in theory. For instance, one has a hard time arguing that the executives at the ECB should have suffered financial losses when inflation dropped sharply right after the financial turmoils of 2008. Moreover, trying to guide the decision-makers' behavior through a system of rewards and penalties bears other risks such as providing incentives for manipulating reference numbers or suppressing intrinsic motivation.

Since none of the above-mentioned indirect approaches to ensure unbiased policies is without drawbacks, it is worth checking whether the sources of diverging interests among union members can be tackled directly. Are there simple measures to enhancing the congruence of common and national interests?

With respect to the problem of business cycle heterogeneity the answer is negative. Although countercyclical fiscal policy could theoretically substitute for the stabilization function of monetary policy, its effective use is at least doubtful. Apart from politico-economic and technical obstacles,[49] Southern Europe's current fiscal position hinders the application of countercyclical measures. In fact, the governments of Europe's debt-strapped economies, currently find themselves forced to implement austerity measures that have a distinctly pro-cyclical effect on their economies. Thus, at least in the short run, there are no easy options available to boost the synchronicity of business cycles within the EMU, and there is little reason to expect a quick decline in business cycle heterogeneity. Certainly, political reforms such as the establishment of common fiscal and regulatory authorities are likely to boost economic integration in the mid and long run—it had actually been on the rise prior to the financial crisis.[50] In spite of this favorable long-term trend, however, an area as large and diverse as the euro zone will never be a perfectly economically homogeneous entity and its member countries have to accept that the ECB's interest rate policy is not tailored to their respective needs.

Regarding the problem of intra-Eurosystem balances, the answer to the question raised above is affirmative. All that is needed to do, is to cut the connection between the remuneration of these balances and monetary policy decisions. One way to achieve this goal is to convert the balances into

[49] Effective countercyclical fiscal policy requires a timely detection of demand shocks, a timely implementation of counteractions, and a timely impact of those on the economy.

[50] Cf. De Haan et al. (2008) for a survey of the empirical literature on the co-movements of business cycles in Europe prior to the crisis.

marketable securities.[51] This approach, however, would entail serious problems. First, assigning marketable securities of this magnitude from debtor to creditor central banks could hardly be done frictionlessly. Unless one wants to risk serious ramifications on the markets of those securities debtor central banks hold against their intra-Eurosystem liabilities—these are the only forms of securities available—the transferred securities would be barely liquid from the perspective of receiving central banks. Moreover, such a conversion would not entirely eliminate the debtor or creditor nations' incentives to vote for inflationary or deflationary policies, respectively. The creditor nations would still possess net claims against the rest of the union of the same magnitude. If these claims are held in the form of nominal marketable securities, the creditors will still suffer from *surprise* inflation. Considering the limited liquidity of large parts of a portfolio of this size, the creditors might even still suffer from anticipated inflation after their intra-Eurosystem claims had been converted into marketable securities.

A simpler and more applicable alternative is to fix the real return of intra-Eurosystem balances. This could be implemented in the form of annual payments by debtor to creditor central banks of the amount of $(\pi_u - i) \cdot T_j$.[52] In periods in which the short-term real interest rate is negative, debtor central banks would have to effect additional payments to creditor central banks. On the contrary, in periods in which the short-term interest rate surpasses the inflation rate, creditor central banks would have to transfer funds to debtor central banks. Payment provisions of this form would, de facto, index the real value of existing IEB to the union's inflation rate and, thus, uncouple their remuneration from interest rate decisions.[53] In order to have real compensatory effects, such payments have to be excluded from the collectively accounted *monetary income*. As was explained in section 4.2, symmetrical (i.e. matching credit and debit interest rates) interest rate payments on IEB do not lead to real effects as long as these payments are included in the joint account of monetary income. Since intra-Eurosystem balances sum up

[51] Sinn and Wollmershäuser (2012) assert this claim, albeit for a different reason. They intend to offer incentives for debtor central banks not to create more base money than is allocated to them.

[52] Of course, one could also include a premium on the rate of inflation in the payments, i.e. to introduce a real interest rate payment on intra-Eurosystem claims. If, for whatever reason, a real compensation of IEB is desirable, such a compensation should be democratically legitimized and determined independently of monetary policy decisions.

[53] As explained in section 4.2, intra-Eurosystem claims are de facto currently remunerated at the short-term nominal interest rate i. With the proposed additional payment of $(\pi - i) \cdot T_j$, the nominal return on IEB equals the union's inflation rate. Thus, the real value of these claims becomes independent of monetary policy decisions.

to zero, the total amount of monetary income in the union is not affected by interest rate payments on them. Thus, a necessary condition of payments aiming at the neutralization of the distributional effects of inflation is to exclude them from the allocation of monetary income. The specific design of such payments is of minor importance. For instance, they could be carried out by transfers of marketable securities[54] or simply by electronic transfers via the TARGET system. In contrast to a complete conversion of intra-Eurosystem balances into marketable securities, transfers of marketable securities equivalent to $(\pi_u - i) \cdot T_i$ would certainly lie within the bounds of possibility for debtor central banks. Moreover, creditor central banks would also be able to timely sell off the securities they received since trading securities in these magnitudes would hardly lead to disruptions in private capital markets.

Compared to the status quo, in which the EMU's inflation rate exceeds the EMU's short-term nominal interest rate, the proposed revision of ECB regulations would lead to transfers from intra-Eurosystem debtor to intra-Eurosystem creditor nations. The crucial point of this proposal, however, is not to redistribute wealth from one nation to another within the EMU. Quite the contrary, it aims at obviating the effects of inflation on the distribution of real wealth within the union that are present in today's situation. The indexation of IEB would remove these distributional effects of inflation and thereby effectively cut the connection between intra-Eurosystem balances and monetary policy. The proposal would disable the possibility to redistribute real wealth by means of monetary policy decisions and, thus, rescind incentives for policy-makers to vote for overly inflationary or deflationary policies, respectively.

This chapter dealt with two distinct problems of common monetary policy in the EMU that have emerged recently. The first is the observable increase in business cycle heterogeneity conditioned by the lopsided effects of the European Debt Crisis. The second is the formation of large nominal imbalances within the system of central banks, leading to antipodal exposure levels to the euro inflation rate. Both problems are potential sources of conflicting interests between members of the ECB's Governing Council. In the absence of policy-makers acting solely in the common interest, these frictions within the union give rise to distorted and inefficient collective mon-

[54]The types of securities eligible for such reimbursements had to be specified before a mechanism of this form comes into force. For instance, the regulations in this regard could be geared to those the ECB sets when lending to private financial institutions against collateral.

etary policy decisions. While there is no simple way to align the interests of countries finding themselves at different stages of the business cycle, the second source of regionally biased decisions can easily be removed. Indexing intra-Eurosystem balances to the union's inflation rate harmonizes the desired levels of inflation within the union and, thus, abates both the conflicts of interest within the Governing Council and the potential for distorted monetary policy decisions.

Chapter 5

Summary and Concluding Remarks

Deliberating the connection between foreign indebtedness and inflation, I arrive at three main findings, corresponding to the three main parts of this thesis.

First, even small increases of the dollar inflation rate lead to major wealth gains for the U.S. economy. An unanticipated increase of one percentage point in the USD inflation rate lasting one year would lead to U.S. net gains of at least 0.35 percent of U.S. GDP. If the period of additional inflation lasted five years, U.S. gains at the expense of foreign creditors would lie within the range of 1.12 and 1.99 percent of GDP, with U.S. gains decreasing at the speed of the adaptation of expectations. A permanent increase of the U.S. inflation rate—for instance, in the form of a credible, announced increase in the target inflation rate—would trigger U.S. windfall gains of at least 1.56 percent of U.S. GDP. About 60 percent of these gains would be at the expense of Asian countries, first and foremost the two large creditor countries China and Japan. Losses by European nations would also be substantial, comprising about 30 percent of total foreign losses in the case of a surprising increase in U.S. inflation.

Second, nominal indebtedness amplifies the time-consistency problem of monetary policy. Nominal external debt in general, and external debt overhangs in particular, enhances incentives for policy-makers to create surprise inflation. Since this cannot be sustained as an equilibrium, these incentives result in additional anticipated instead of unanticipated inflation in the long run. To avoid an inflation bias of this form, monetary policy should be delegated to cosmopolitan individuals with a long planning horizon. As these characteristics are not to be expected from politically dependent decision-makers, the existence of external debt fortifies the case for central bank independence. An alternative, yet less applicable, solution is to internalize the external effects of surprise inflation by creating currency unions between creditor and debtor nations.

Third, under the current institutional framework, intra-euro-zone indebtedness bears the risk of unsound monetary policies in the European Monetary Union. In the course of the European Debt Crisis, national central banks of Southern European nations have built up sizable liabilities against their Northern European counterparts.[1] Since these claims or liabilities are de facto remunerated at the ECB's short-term interest rate, they lead to a divergence of national interests concerning common interest rate policy. Thus, in addition to the recent surge in business cycle heterogeneity in the euro zone, these novel forms of external debt entail the risk of regional biases in the ECB's decisions on monetary policy. Indexing the aforementioned claims and liabilities to the euro-zone inflation rate would remove this source of conflicting interests between euro-zone member countries and, hence, diminish the potential for distorted collective decisions on monetary policy.

At least in Western industrialized countries, the institutional division of an independent central bank and the rest of the executive has promoted monetary policy to serve common interests in the past. Whether independent central banks also ensure sound monetary policies when a nation's common interest differs from the world's common interest remains to be seen. In any case, as long as there are large imbalances in holdings of nominal assets, both investors and researchers should carefully monitor monetary policies of affected countries. Unless proven otherwise, however, the hope remains that—contrary to the Bretton Woods example—contemporary policy-makers will opt for cooperative ways of dealing with global imbalances.

[1] As explained in section 4.2.2, both claims and liabilities are, in fact, against the Eurosystem and thus not against other national central banks. However, this difference only becomes relevant in case of a dissolution of the Eurosystem.

Appendix

This appendix serves as a supplement to the main text. For each of the three main chapters, I provide additional material to enhance the traceability of my results.

A Appendix to Chapter 2

This most voluminous part of the appendix includes a discussion of classification issues, some exemplary calculations, and additional information on some of the data used for the assessment of redistributional effects.

The Treatment of Different Asset Classes

In the following paragraphs, I briefly explain whether certain miscellaneous asset classes are treated as nominal or not. The discussion does not include conventional, marketable debt securities since classifying these securities as nominal is obvious.

Equity, Direct Investment and Investment Funds

All holdings of equity and direct investments abroad are treated as non-nominal and are thus left aside. Although direct investments may include debt components, it is unclear whether these components should be classified as nominal. On the one hand, the currency-denomination is unknown, on the other hand, it is ambiguous whether intercompany contracts in fact feature fixed and non-contingent payment streams. Concerning foreign-residents' ownership of U.S. fund shares, I follow the categorization of the TIC system by classifying these holdings as equity and thus non-nominal. Since the volume of the debt component, let alone the maturity structure, of these indirect debt holdings is unknown, I decided in favor of the conservative option of not accounting for these claims. Although there is no reason to believe that the ROW's exposure to shifts in the U.S. inflation rate is altered substantially as a result of this proceeding, it emphasizes that the estimation results can be regarded as a lower bound on actual losses in case of a surprise inflation of the specified forms. Holdings of foreign investment fund shares by U.S. residents are also treated as entirely real.

Foreign-Currency-Denominated and Inflation-Indexed Debt

The real value of cash flows from debt securities denominated in other currencies are invariant to U.S. inflation rates. Thus, the estimations do not account for holdings of these instruments. Furthermore, inflation-indexed debt has to be subtracted from total holdings of debt securities. This particularly pertains to foreign holdings of TIPS. As the market for inflation-indexed USD bonds almost exclusively consists of government bonds, all other debt securities denominated in USD are assumed to be nominal.

Currency and Checkable Deposits

These assets are treated as entirely nominal. Although it cannot be ruled out that some of the ROW's holdings of check money in the U.S. are denominated in foreign currencies, it is very likely that the vast majority of these claims are in fact in USD. These positions have a duration of zero, which is why they do not play a role in scenarios I, II, or IV, which feature immediately understood, one-time inflation surprises.

Time Deposits

Foreign time deposits at U.S. banks and custodians are also assumed to be entirely nominal. Since penalties for early withdrawals are common and interest rates are normally fixed in advance, investors bear some inflation risk. Therefore foreign time deposits are treated as nominal claims.

The classification of the 769 billion USD U.S. residents held in deposits abroad at the end of June, 2012 is more difficult. On the one hand, it is unknown how this number is split up into checkable and time deposits. On the other hand, the currency denomination of these claims is also missing. The baseline assumptions are that time deposits comprise one-half of total U.S. foreign deposits and that three-quarters of these deposits are dollar-denominated. Since the total amount of money held in deposits abroad is dwarfed by cross-border holdings of other debt securities and the comparatively low interest rate sensitivity of deposits, the overall results are robust against alternations of these assumptions.

Loans

Loans to U.S. citizens or corporations from the ROW and loans to the ROW from U.S. banks or other U.S. institutions are treated as entirely nominal. Although some of these loans might be denominated in foreign currencies, it seems realistic that the majority of these claims consist of conventional nominal contracts.

Trade Payables and Trade Receivables

FoF data exhibits that outstanding amounts of both trade payables and trade receivables, have fluctuated around values of roughly 100 billion USD for the U.S. over the last years. Due to the very short duration of these claims and the small volumes of gross and net holdings, they are left aside in the calculations.

Interbank Debt

TIC banking data (U.S. Treasury (2013d)) shows that U.S. financial institutions hold large long and short positions against foreign counterparts. Data also shows, however, that net cross-border interbank holdings have been close to zero for most of the last decade. Only at the height of the financial crisis, foreign banks temporarily had significant net claims on U.S. banks (with a peak of about 400 billion USD). Since interbank debt consists mostly of short-term instruments and net holdings seldomly reach triple-digit values in billion USD, it does not enter the estimations.

Repurchase Agreements

FoF tables exhibit the ROW's *net* holdings of repurchase agreements (repos) to have fluctuated around a mean of roughly zero without exceeding absolute values above 120 billion USD over the last three years. Given these relatively small holdings and their very short maturity—the contract period is usually only a few days—repos are not included in the estimations.

Special Drawing Rights and U.S. Official Reserve Assets

Special Drawing Rights (SDRs) are a part of U.S. and foreign official reserve assets. As holdings of SDRs usually feature no interest payments, they are de facto equivalent to holding a basket of leading currencies in cash. Since the USD is one of the components in this basket of currencies, the real value of SDR might be affected slightly in a scenario of true surprise inflation, such as scenario III. Quantitatively, however, these effects are not noteworthy, which is why SDRs are treated as if they were entirely real.

In FoF tables, the ROW's liabilities include the item "U.S. official reserve assets." These assets predominantly represent the Fed's holdings of foreign cash or securities denominated in foreign currencies and are thus treated as non-nominal.

Convertible Bonds

According to U.S. Treasury (2012), U.S. investors held about seven billion USD in foreign convertible bonds. How the prices of these change following an increase in U.S. interest rates depends on the issuing corporation's stock price. If this is trading far below the conversion price specified in the convertible bond contract, it exhibits interest rate risks similar to that of conventional bonds. On the other hand, if the stock price exceeds the conversion price, the convertible bond behaves more like the stock price itself and is thus not expected to decrease following an unanticipated increase in inflation. In spite of these uncertainties, I classify these holdings as entirely nominal and treat them as if they were conventional foreign bonds. Due to the very low magnitudes of cross-border investment in this asset class, an alternative classification would not have a notable effect on the result. For instance, classifying these holdings as entirely real would increase U.S. net gains by less than a half a billion USD under scenario III.

Miscellaneous Assets and Liabilities

FoF tables also exhibit sizable gross holdings of "unidentified miscellaneous" assets and liabilities of the ROW. Owing to the lack of information, these positions are not taken into account. In June, 2012 unidentified assets (2,043 billion USD) and unidentified liabilities (1,671 billion USD) roughly counterbalanced each other. Provided that these long and short positions do not differ diametrically with respect to their interest rate sensitivity, these identification problems neither quantitatively nor qualitatively challenge the estimation's validity. Nevertheless, the large volume of unidentified or "other" claims exemplify that cross-border accounting of aggregate data and all studies based on this data—such as chapter 2 of this dissertation—cannot make a claim on exactness.

The Rest of the World

In general, I adhere to a classification according to residency and neglect possible indirect effects through foreign ownership. For instance, claims of a European bank's U.S. subsidiary on U.S. residents are not attributed to the ROW. Likewise, credit contracts between foreign subsidiaries of U.S. corporations and foreign banks are also not accounted for. This approach is in line with the general omission of potential indirect redistributional effects. The rationale behind this is a lack of sufficient data on ownership on the one hand and the high degree of uncertainty regarding intercompany financial streams on the other hand. Consider the example of a European bank's U.S. subsidiary holding U.S. mortgage debt and thus having an exposure to surges in the dollar inflation rate. A surprise inflation lowers the real value of its assets and thus decreases the subsidiary's equity. Under the assumption that the loss is not compensated by, for example, a reduction of the subsidiary's employees' variable salaries or a reduction of net tax payments, the parent company bears the loss. More precisely, the owners of the parent company bear the loss. In order to quantify the ROW's loss resulting from the aforementioned mortgage position, one would thus need assumptions about the degree to which the incurred losses are passed through to the owners of the parent company and know something about the residency of these investors. Theoretically, the omission of indirect effects could lead to either an over- or an underestimation of the redistributional potential. As can be seen in Doepke and Schneider (2006), who estimate direct and indirect effects for the ROW, the former dominate the latter by far. This is especially true for one-time surprise inflation episodes, for which Doepke and Schneider (2006) calculate the indirect effects to be close to zero for the ROW in 2004.

Projecting U.S. Holdings from End-2011 to Mid-2012

Since the two main data sources for cross-border holdings of marketable securities, U.S. Treasury (2013b) and U.S. Treasury (2012), refer to different reporting days, data on U.S. holdings have to be projected for half a year. With U.S. Treasury (2013a), the TIC system also provides up-to-date monthly estimates for U.S. holdings of foreign long-term debt. These preliminary reports, however, are much less detailed than the annual reports used in chapter 2. Moreover, as Brandner et al. (2012) point out, it cannot be ruled out that there are systematic differences between annual survey and monthly data. Therefore, the relative change of monthly data from December, 2011 to June, 2012 is used to project the figures from U.S. Treasury (2012) to mid-2012. For instance, according to monthly estimates, total U.S. holdings of non-ABS debt securities grew by about three percent from end of 2011 to mid-2012. Thus, holdings of non-ABS securities from the December, 2011 survey are multiplied by the factor 1,03 to arrive at mid-2012 values. This procedure implies that the distribution within foreign holdings of non-ABS is assumed to have remained constant. Particularly, it is implicitly assumed that the share of dollar-denominated assets within each subcategory has not changed over this period. Given the relatively small changes of U.S. holdings between the survey and the projection date, the potential for biases from this procedure is small.

As there is no timely information on the development of U.S. holdings of foreign short-term securities, it is assumed that these holdings have increased in line with U.S. holdings of conventional (i.e. non-ABS) long-term securities. As a result, holdings of short-term securities are expected to have increased by about nine billion USD over the contemplated period. Thus, in any case, the quantitative effect of this assumption on the overall results is negligible.

Durations of Different Asset Classes

For scenarios I, II and IV the estimated price change of a security depends on its duration. As far as possible, data on modified durations of marketable securities on the reference day are taken from Datastream (2013). For Treasury securities, modified duration of each maturity class is calculated as the average modified duration of all securities outstanding on the reference day. This procedure implies that the ROW's holdings within each maturity category is expected to be proportional to the total outstanding amounts of securities in this segment. For instance, the duration of foreign holdings of Treasury securities maturing between one and two years past the reference day is calculated as the market-value-weighted average modified duration of all conventional Treasury securities falling within this category. This strategy to assess a duration for each maturity category is also applied to foreign holdings of conventional agency and corporate bonds. First, all outstanding dollar-denominated securities are filtered by issuer type (i.e. Agency or corporate and financial), security type (i.e. ABS or non-ABS) and remaining time to maturity. For the subcategories of conventional debt (e.g. non-ABS corporate debt maturing in 3-4 years), durations are assessed by calculating weighted average durations of all securities outstanding. This procedure implies that foreign holdings within each subcategory do not differ from the market portfolio of each subcategory. In particular, this implies that foreign holdings of U.S. corporate debt are assumed to be equally risky as average (weighted by market values) U.S. corporate bonds. The riskiness of a bond is relevant here, since riskier bonds feature higher coupon payments and higher yields to maturity. Thus, these bonds exhibit lower durations than safe bonds of the same maturity. Assessing durations for U.S. holdings of foreign dollar-denominated securities requires the same procedure. Before weighted average durations are calculated, foreign issuers are screened from the multiplicity of issuers in dollar-denominated bonds.

Some caveats with this procedure occur for securities with a low remaining time to maturity. The problem is that Datastream's historical data on securities that have already expired at the time of information retrieval seems to be incomplete. For many of these securities, market values and modified durations are not available. Thus, capitalization-weighted average modified durations are potentially biased for securities with a remaining time to maturity of 15 months or lower, which is the difference between the reference date and the time of the latest data retrieval. To avoid these biases, modified durations of securities with a remaining time to maturity of less than two years are taken from different sources, namely broad market indices of the respective bond classes provided by Bank of America Merrill Lynch. In particular, I refer to the "The BofA Merrill Lynch Treasury Master Index" (Bank of America Merrill Lynch (2013k)),"The BofA Merrill Lynch 0-1 Year US Treasury Index" (Bank of America Merrill Lynch (2013d)), and the "The BofA Merrill Lynch US Treasury Bill Index" (Bank of America Merrill Lynch (2013j)) for Treasury securities, "The BofA Merrill Lynch US Corporate Index" (Bank of America Merrill Lynch (2013i)) for Corporate Securities and "The BofA Merrill Lynch US Composite Agency Index" (Bank of America Merrill Lynch (2013h)) for Agency securities. Further problems occur by assessing durations of foreign holdings of long-term U.S. corporate and agency securities maturing within one year and U.S. holdings of foreign securities with remaining times to maturity below two years, as there are no indices exclusively covering these categories. To come up against this lack of data, it is assumed that average duration of U.S. corporate securities matches those of U.S. Treasury securities in this category. Moreover, foreign securities' modified durations are assumed to match those of U.S. corporate securities for the two maturity classes 0-1 years and 1-2 years. Since durations of conventional bonds with very low remaining time to maturities do not differ strongly by issuer types, this assumption is not critical with respect to redistributional effects. For short-term (i.e. securities with an original term to maturity of less than one year) securities issued by U.S. agencies, U.S. corporations, or foreign issuers, data on average durations is also missing. For all three asset classes, modified duration is assumed to be 0.25, implying an average remaining time to maturity of slightly more than a quarter of a year. Although this assumption lacks scientific underpinnings, it is not very critical. With U.S. holdings of short-term foreign securities of about 295 billion USD and foreign holdings of U.S. short-term securities (excluding Treasury bills) of only about 168 billion USD, the exact value of the assessed duration does not matter for the overall effects. For instance, if average duration of foreign short-term securities were 0.5 instead of 0.25 years, this would only lower U.S. net gains by about 0.7 billion USD under scenarios I, II and IV.

The above-described procedure results in a matrix of durations consisting of four columns for the issuer types and 16 rows for the different maturity categories. Table 1 displays modified durations for each of the 64 subcategories. The data used to assess these values can be found in the spreadsheet "Duration Matrix.xls" which is among the supplements of this thesis. For the majority of maturity categories (i.e. within most rows), Treasury securities exhibit the highest durations and, thus, also the highest inflation sensitivities. The reason for this is that U.S. Treasuries are considered to be particularly safe and liquid investments. Thus, coupons and yields of Treasury securities are lower than in other debt instruments of the same maturities. As a result, the present values of cash flows due in the near future comprise comparatively small parts of the prices of Treasury securities. This low importance of near cash flows or high importance of distant cash flows, respectively, leads to high durations indicating high interest rate sensitivities. With the exception of the longest maturity category, market-value-weighted average durations increase with remaining time to maturities. The reason for this seemingly puzzling result is the comparatively high share of floating rate bonds in this category. These exhibit very low durations and thus lower average inflation sensitivities in this category. Another peculiarity is the comparatively low value for Agency securities maturing between eight and nine years from the reference date. The reason for this result are two very large bonds issued by the Resolution Funding Corporation falling within this category. These were issued in the late 1980s in the course of the

U.S. Savings and Loan Crisis. Due to their very high coupon payments, they exhibit rather low durations and thus decrease weighted average duration of this category.

Table 1: Durations of Conventional Marketable Securities by Issuer and Remaining Time to Maturity

Maturity	Treasury	Agency	Corporate	Foreign
ST	0.33	0.25	0.25	0.25
0-1y	0.52	0.52	0.52	0.52
1-2y	1.47	1.32	1.47	1.47
2-3y	2.47	2.43	2.26	2.33
3-4y	3.43	3.31	3.10	3.18
4-5y	4.30	4.32	3.92	4.02
5-6y	5.11	4.90	4.57	4.46
6-7y	6.05	5.71	5.16	5.28
7-8y	6.53	6.45	5.86	5.76
8-9y	7.37	6.55	6.63	6.38
9-10y	8.36	8.21	7.48	7.23
10-15y	9.11	9.91	8.29	8.21
15-20y	11.80	11.56	10.32	10.53
20-25y	15.89	14.89	12.38	12.17
25-30y	17.97	17.80	14.15	14.47
>30y	—	18.26	13.54	12.34

Unfortunately, datastream does not provide data on (modified) durations for single ABS and convertible bonds. The reason for this is that for most ABS future cash flows are not known. For instance, prepayments rights held by debtors of the underlying loan or mortgage contracts add uncertainty to the actual timing and, in some cases, also the level of payments. Thus, assessing durations or interest rate sensitivities of ABS requires modeling expected future cash flows. This can either be done using historical data of comparable securities, or using theoretical models assuming that options are exercised optimally. Both methods require data on features of the underlying loan contracts, which are not available for cross-border holdings of these securities.

Another main problem is that—in contrast to conventional bonds—there must not be a close link between a security's remaining time to maturity and its interest rate sensitivity for ABS. Since principle repayment structures between ABS of a certain maturity can vary fundamentally, effective fixation of cash flows and thus interest rate sensitivities also show significant variation. Owing to lack of data, it is not possible to derive market-value-weighted durations for different maturity categories. Thus, assessing interest rate sensitivities of these asset classes requires an alternative approach. For the interest rate sensitivities of ABS, I refer to ratios compiled for broad market indices of these assets. More precisely, I use effective durations (and the distributions of effective duration within the components of the index) calculated for major market indices intending to cover specific segments of ABS markets. Employing these implies that cross-border holdings in these asset classes match the market portfolios in these asset classes. In the case of foreign holdings of U.S. Agency ABS, I use "The BofA Merrill Lynch US Mortgage Backed Securities Index". Consisting of more than 400 single Agency ABS with a total market value of about 5 trillion USD, the index covered about 90% of the total outstanding volume in this asset class on the reference date (Cf. Securities Industry and Financial Markets Association (2013b)). Historical data can be found in Bank of America Merrill Lynch (2013f), details on the composition of the index and the methodology to calculate the relevant ratio can be found in Bank of America Merrill Lynch (2013b) or Galdi et al. (2012), respectively. Effective durations for "The BofA Merrill Lynch US Asset Backed Securities & Commercial Mortgage Backed Securities Index" are used to assess interest rate sensitivities of foreign holdings of U.S. corporate ABS (cf. Bank of America Merrill Lynch (2013g) and Bank of America Merrill Lynch (2013c)). This index is intended to cover the market of U.S. corporate ABS, including commercial mortgage-backed securities. On the reference day it included about 3900 single corporate ABS with a total market value of about 900 billion USD, which is more than 50% of the total outstanding amount in this asset class (Cf. Securities Industry and Financial Markets Association (2013a) and Securities Industry and Financial Markets Association (2013c)). Lastly, the price changes of U.S. holdings of foreign dollar-denominated ABS are estimated using data on effective duration for "The BofA Merrill Lynch Global Collateralized Index" as found in Bank of America Merrill Lynch (2013e). According to Bank of America Merrill Lynch (2013a) this index is intended to represent the entire global market of ABS. On June 30, 2012, it comprised about 4500 individual ABS with a total outstanding amount of more than 7 trillion USD. Since U.S. ABS are included, this index does probably not match U.S. holdings of foreign ABS very well. However, since U.S. holdings of foreign ABS are only about 160 billion USD, the potential for incorrect estimates from this source is not very large.

With this procedure, the distribution of cross-border ABS holdings by remaining time to maturity is ignored. Instead, it is assumed that the duration distribution of cross-border holdings of these securities equals those of the total market portfolios in these segments as measured by the respective indices. I use the distributions of the indices' constituents by effective duration to assess average durations to different parts of cross-border ABS holdings. Historical data on these distributions is provided by Bank of America Merrill Lynch (2013f), who derive effective durations for individual securities using an unpublished cash-flow model and Monte Carlo simulations. Tables showing the distributions of cross-border holdings of U.S. agency, U.S. corporate, and foreign ABS by effective duration on the reference day can be found in the spreadsheet "ABS Holdings by Effective Durations.xls", which supplements this thesis.

For non-marketable securities, data on durations is not available. Thus, interest rate sensitivities of these assets have to be specified by assumptions. In the case of foreign holdings of U.S. currency and checkable deposits this is a plain task. Both of these do not feature any nominally fixed payments in the future. Their average remaining time to maturity and thus their duration is zero. Since interest rate payments in time deposits are usually fixed for some time, these assets do bear some inflation risk. Typically, contract periods of time deposits range between three months and five years. Under the broadly simplifying assumptions that the weighted average original time to maturity of time deposits is one year and the outstanding amounts are constantly being rolled over, I arrive at an average duration of half a year. This value is assumed for both foreign time deposits in the U.S. and U.S. time deposits in the ROW. Since cross-border investment in these asset classes is comparatively small, these assumptions do not have a major effect on the overall results.

Information on the maturity structure of cross-border loan contracts is also lacking. In general, loans are predominantly granted to small corporations lacking access to bond markets. Contract periods of these debt instruments usually range between one and ten years. I assume that the mean original term to maturity of cross-border loans is five years and that they are perpetually rolled over. Contrary to conventional bonds, loan contracts often feature repayments of principal before maturity. Thus, the market or face values of loans decrease with maturity, resulting in a weighted average remaining time to maturity above the unweighted average of 2.5 years. However, premature payments of principal also decrease a loan's duration in comparison to a bond contract of the same maturity. Considering both effects, I assess a weighted average duration of two years for both loans granted to U.S. businesses by the ROW and loans granted to foreign businesses by the U.S. This number is highly uncertain but equally ineffectual in regard to the aggregate estimations as the net contribution of this asset class to the total redistribution of wealth is very small. Table 2 summarizes the assumed durations of non-marketable securities that are employed in the calculations.

Table 2: Assumed Durations on Non-Marketable Nominal Assets

Currency	Checkable Deposits	Time Deposits	Loans
0	0	0.5	2

Approximated vs. "True" Changes in Market Prices

As explained in section 2.3.2, in three of the four scenarios the distributional effect can be assessed by calculating hypothetical changes in the market prices of nominal securities. Since there is no information on the exact distribution of cash flows entailed by cross-border security holdings, the changes in market prices cannot be calculated exactly. Instead, the changes are approximated using equations 2.9, 2.14 and 2.21. As explained in greater detail in section 2.3.2, this procedure leads to some inaccuracies. To analyze these, the price changes of several hypothetical bonds with different maturities and coupon payments are calculated for scenarios I, II, and IV, starting from the actual yield curve on the reference day, which can be found in a dataset provided by Gürkaynak et al. (2007). The exact changes in the market prices of the exemplary bonds are confronted with the approximated changes used throughout the first section.

The tables below exhibit price changes for bonds maturing in exactly one year, in exactly five years, in exactly ten years and in exactly twenty years after the reference day. For each maturity category, the price changes of one bond paying a coupon of 1%, one of 3%, and one of 5% are calculated. All bonds pay coupons semi-annualy, i.e. the first half of the annual coupons is payed out in 0.5 years and the second in 1.0 years and so on. To arrive at the present values of each of the twelve exemplary bonds, cash flows are discounted using the vector of forward rates on June 30, 2012, provided by Gürkaynak et al. (2007). As Treasury forward rates therein are calculated using continous compounding, the latter is also used to calculate the bonds' market prices under varying settings. All calculations can be reproduced using the spreadsheet "Example Bonds.xls" provided as a supplement to this dissertation.

Table 3: Price Changes of One-Year Bonds in Percent

Scenario	1% Coupon		3% Coupon		5% Coupon	
	ΔP_{exact}	$\Delta P_{appr.}$	ΔP_{exact}	$\Delta P_{appr.}$	ΔP_{exact}	$\Delta P_{appr.}$
I	-0.99	-0.99	-0.99	-0.99	-0.98	-0.98
II	-0.99	-0.99	-0.99	-0.99	-0.98	-0.98
IV	-0.99	-0.99	-0.99	-0.99	-0.98	-0.98

Table 4: Price Changes of Five-Year Bonds in Percent

Scenario	1% Coupon		3% Coupon		5% Coupon	
	ΔP_{exact}	$\Delta P_{appr.}$	ΔP_{exact}	$\Delta P_{appr.}$	ΔP_{exact}	$\Delta P_{appr.}$
I	-0.99	-1.00	-0.99	-1.00	-0.98	-1.00
II	-4.77	-4.75	-4.58	-4.57	-4.42	-4.41
IV	-4.77	-4.75	-4.58	-4.57	-4.42	-4.41

Table 5: Price Changes of Ten-Year Bonds in Percent

Scenario	1% Coupon		3% Coupon		5% Coupon	
	ΔP_{exact}	$\Delta P_{appr.}$	ΔP_{exact}	$\Delta P_{appr.}$	ΔP_{exact}	$\Delta P_{appr.}$
I	-0.99	-1.00	-0.99	-1.00	-0.99	-1.00
II	-4.76	-4.88	-4.59	-4.88	-4.46	-4.88
IV	-9.05	-8.98	-8.35	-8.31	-7.86	-7.83

Table 6: Price Changes of Twenty-Year Bonds in Percent

Scenario	1% Coupon		3% Coupon		5% Coupon	
	ΔP_{exact}	$\Delta P_{appr.}$	ΔP_{exact}	$\Delta P_{appr.}$	ΔP_{exact}	$\Delta P_{appr.}$
I	-0.99	-1.00	-0.99	-1.00	-0.99	-1.00
II	-4.73	-4.88	-4.57	-4.88	-4.49	-4.88
IV	-16.03	-15.94	-13.76	-13.78	-12.57	-12.62

The results document that the inaccuracies arising from the use of the approximation equations are very minor for bonds maturing in five or fewer years. For both one-year and five-year bonds the approximated price change under scenarios I, II, and IV are very close to the hypothetical, exact price changes under these scenarios. In general, the accuracy of approximations is high throughout all settings in scenario I and IV. The only cases in which there are major discrepancies between approximated and exact changes in the present values are those of high-coupon-paying bonds maturing in more than five years under scenario II. In these cases, the assumption implied by the approximation that these bonds consist entirely of cash flows due in more than five years does not accord with reality. For instance, a ten-year bond with a coupon of 5% is approximated to decrease by $(1 - e^{-0.05}) \approx 4.88\%$ in value, while the "true" loss of market value is only about 4.46%. With respect to the overall results, however, these inaccuracies are not very important. Consider the extreme case that price changes of all bonds with a remaining time to maturity of six or more years are overestimated by one-half a percentage point, which is more than the largest discrepancy calculated for the twelve exemplary bonds; the total ROW's loss would only be overestimated by about ten billion USD (the ROW's net position in bonds of this categories is about two trillion USD). The actual overestimation of foreign losses due to using the approximations is likely to be far lower, as the error of estimation for long-term bonds is probably only a fraction of 0.5 percentage points. Moreover, as the example calculation show, the approximations slightly underestimate losses in case of bonds exhibiting a duration of less than five years, which—at least in parts—compensate the overestimation for long-term bonds.

List of Assumptions in the Baseline Calculation

To enhance transparency, table 7 reveals all assumptions underlying the calculations, including those discussed in section 2.4.3. Although this list is supposed to be comprehensive, it cannot be ruled out that some assumptions are inadvertently missing.

Table 7: List of Assumptions under the Baseline Calculations

Assumption	Type	Variations
All cross-border holdings of nominal assets are covered in TIC and FoF data.	General	No
The real values of assets classified as "real" are not affected by the inflation scenarios.	General	No
Real exchange rates are not affected by the inflation scenarios.	General	No
Holdings attributed to the ROW in TIC data are holdings of foreign investors.	General	Yes[a]
The maturity structure of foreign holdings of TIPS equals that of conventional Treasury securities	Marketable Securities.	Yes
The USD share in foreign holdings U.S. corporate ABS equals that of foreign holdings of U.S. corporate non-ABS.	Marketable Securities	Yes
The USD share in holdings of U.S. corporate debt is equal for all countries	Marketable Securities.	Yes
The maturity structure of ABS holdings equals that of non-ABS holdings in the respective category.	Marketable Securities	Yes
Foreign Holdings of agency and corporate ABS are proportional to total outstanding volumes in the respective subcategory.	Marketable Securities	Yes
Holdings of conventional bonds within each asset class and maturity category are proportional to total outstanding volumes in the respective subcategory.	Marketable Securities	No
Holdings of ABS within each asset class are proportional to total outstanding volumes in the respective category.	Marketable Securities	No
Foreign Deposits at U.S. banks are entirely denominated in USD.	N.-marketable securities	No
75% of U.S. deposits at foreign banks are denominated in USD.	N.-marketable securities	No
U.S. deposits at foreign banks are split up evenly into checkable and time deposits.	N.-marketable securities	No
Average duration of checkable deposits is 0.	N.-marketable securities.	No
Average duration of time deposits is 0.5 years.	N.-marketable securities	No
Average duration of loans is 2 years.	N.-marketable securities	No

[a] The discussed variation only concerns holdings attributed to Caribbean banking centers.

B Appendix to Chapter 3

Since chapter 3 is a purely theoretical treatise, this part of the appendix comprises derivations of equations only.

Derivations

Equation (3.3)

If the policy-maker adheres to the rule, expected inflation matches realized inflation and his loss is $L_1(\pi_1 = \hat{\pi}) = bu_n + \frac{1}{2}\hat{\pi}^2$. If he deviates from the rule by choosing $\pi_1 = ab$ instead of $\pi_1 = \hat{\pi}$, his loss is

$$L_1(\pi_1 \neq \hat{\pi}) = bu_n - ab(ab - \hat{\pi}) + \frac{1}{2}(ab)^2 = bu_n - \frac{1}{2}(ab)^2 + ab\hat{\pi}.$$

Hence, the gain from a deviation, $L_1(\pi_1 = \hat{\pi}) - L_1(\pi_1 = ab \neq \hat{\pi})$, is

$$bu_n + \frac{1}{2}\hat{\pi}^2 - (bu_n - \frac{1}{2}(ab)^2 + ab\hat{\pi}) = \frac{(ab - \hat{\pi})^2}{2}.$$

Equation (3.4)

Given the public's expectations specified in equation (3.2), there never is surprise inflation in the second period. After a deviation, expected and realized inflation are those of the one-shot game. In this case, the policy-maker's second-period loss is $L_2(\pi_2 = ab = \pi_2^e) = bu_n + \frac{1}{2}(ab)^2$. When the policy-maker adheres to the rule, expected and realized inflation equal the best-enforceable inflation rule. Thus, the policy-maker's loss then is $L_2(\pi_2 = \hat{\pi} = \pi_2^e) = bu_n + \frac{1}{2}\hat{\pi}^2$. Hence, the present value of the policy-maker's net loss due to a deviation in the first period, $\beta[L_2(\pi_2 = ab = \pi_2^e) - L_2(\pi_2 = \hat{\pi} = \pi_2^e)]$, is

$$\frac{\beta}{2}((ab)^2 - \hat{\pi}^2).$$

Equation (3.5)

The best-enforceable rule is calculated by equalizing equations (3.3) and (3.4) and solving for $\hat{\pi}$:

$$\frac{(ab-\hat{\pi})^2}{2} \overset{!}{=} \frac{\beta}{2}[(ab)^2-\hat{\pi}^2]$$
$$\Leftrightarrow$$
$$(ab-\hat{\pi})^2 = \beta(ab-\hat{\pi})(ab+\hat{\pi})$$
$$\Leftrightarrow$$
$$\hat{\pi}(1+\beta) = ab(1-\beta)$$
$$\Leftrightarrow$$
$$\hat{\pi}^* = ab\frac{1-\beta}{1+\beta}$$

Equation (3.7)

The policy-maker's gain from a deviation in the presence of cross-border holdings of nominal securities, $L_1(\pi_1 = \hat{\pi}_1) - L_1(\pi_1 = ab \neq \hat{\pi}_1)$, is calculated in analogy to equation (3.3). It is

$$bu_n + \frac{1}{2}\hat{\pi}^2 - (bu_n - \frac{1}{2}(ab-cR_1)^2 + (ab-cR_1)\hat{\pi}_1) = \frac{1}{2}(ab-cR_1-\hat{\pi}_1)^2.$$

Equation (3.8)

The present value of the policy-maker's second-period loss in the open economy, $\beta[L_2(\pi_2 = ab - cR_2 = \pi_2^e) - L_2(\pi_2 = \hat{\pi}_2 = \pi_2^e)]$, is calculated in analogy to equation (3.4). It is

$$\beta[bu_n + \frac{1}{2}(ab-cR_2)^2 - (bu_n + \frac{1}{2}\hat{\pi}_2^2)] = \frac{\beta}{2}[(ab-cR_2)^2 - \hat{\pi}_2^2].$$

Equation (3.9)

Under the assumption that R is constant over time, it immediately follows that the best-enforceable inflation rate is also constant ($\hat{\pi}_1 = \hat{\pi}_2$). It can be calculated in analogy to equation (3.5):

$$\frac{1}{2}(ab - cR - \hat{\pi})^2 \stackrel{!}{=} \frac{\beta}{2}[(ab - cR)^2 - \hat{\pi}^2]$$
$$\Leftrightarrow$$
$$(ab - cR - \hat{\pi})^2 = \beta(ab - cR - \hat{\pi})(ab - cR + \hat{\pi})$$
$$\Leftrightarrow$$
$$\hat{\pi}(1 + \beta) = (ab - cR)(1 - \beta)$$
$$\Leftrightarrow$$
$$\hat{\pi}^* = (ab - cR)\frac{1 - \beta}{1 + \beta}$$

Equation (3.12)

Starting with the condition to derive the best-enforceable rule, stated in equation (3.11), the following steps are taken to solve for $\hat{\pi}_1^*$:

$$\frac{1}{2}(ab - cR_1 - \hat{\pi}_1)^2 \stackrel{!}{=} \frac{\beta}{2}[(ab - cR)^2(1 - (\frac{1 - \beta}{1 + \beta})^2)]$$
$$\Leftrightarrow$$
$$(ab - cR_1 - \hat{\pi}_1)^2 = \beta[(ab - cR)^2\frac{(1 + \beta)^2 - (1 - \beta)^2}{(1 + \beta)^2}$$
$$\Leftrightarrow$$
$$(ab - cR_1 - \hat{\pi}_1)^2 = ((ab - cR)^2\frac{4\beta^2}{(1 + \beta)^2}$$
$$\Leftrightarrow$$
$$ab - cR_1 - \hat{\pi}_1 = (ab - cR)\frac{2\beta}{1 + \beta}$$
$$\Leftrightarrow$$
$$\hat{\pi}_1^* = ab(1 - \frac{2\beta}{1 + \beta}) - cR_1 - +cR\frac{2\beta}{1 + \beta}$$
$$\Leftrightarrow$$
$$\hat{\pi}_1^* = \frac{1 - \beta}{1 + \beta}ab - c(R_1 - \frac{2\beta}{1 + \beta}R)$$

Inequation (3.13)

Inequation (3.13) states that the best-enforceable inflation rate under scenario one is higher than in case of the basic model. The following rearrangements show that this condition is equivalent to $R > R_1$.

$$\frac{1-\beta}{1+\beta}ab - c(R_1 - \frac{2\beta}{1+\beta}R) > \frac{1-\beta}{1+\beta}(ab - cR)$$

$$\Leftrightarrow$$

$$-(cR_1 - c\frac{2\beta}{1+\beta}R) > -\frac{1-\beta}{1+\beta}cR$$

$$\Leftrightarrow$$

$$R\frac{2\beta + 1 - \beta}{1+\beta} > R_1$$

$$\Leftrightarrow$$

$$R > R_1$$

Equation (3.15)

The rearrangements start with the condition for the best-enforceable inflation rule in period t, specified in general terms.

$$\frac{1}{2}(ab - cR_t - \hat{\pi}_t)^2 = \frac{\beta}{2}[(ab - cR_{t+1})^2 - \hat{\pi}_{t+1}^2]$$

$$\Leftrightarrow$$

$$(ab - cR_t - \hat{\pi}_t) = \sqrt{\beta}\sqrt{(ab - cR_{t+1})^2 - \hat{\pi}_{t+1}^2}$$

$$\Leftrightarrow$$

$$\hat{\pi}_t = ab - cR_t - \sqrt{\beta}\sqrt{(ab - cR_{t+1})^2 - \hat{\pi}_{t+1}^2}$$

Taking the square root of the left-hand side of the equation actually requires to distinguish two separate cases, one in which $(ab - cR_t - \hat{\pi}_t)$ is positive and one in which it is negative. With the knowledge that $ab - cR_t$ is the upper bound of $\hat{\pi}_t$, the second case can be neglected.

C Appendix to Chapter 4

The final part of the appendix begins with the derivation of an important proposition. Subsequently, it discusses some properties of median interest rates brought up in the course of section 4.3 by the means of numerical examples.

Derivations

Inequation (4.16)

$$\frac{1}{2}l^2\sum_{j=1}^{n}\alpha_j(\mu_{j,t}-\mu_{M,t})^2 > \frac{1}{2}l^2\sum_{j=1}^{n}\alpha_j(\mu_{j,t}-\bar{\mu}_t)^2$$

$$\Leftrightarrow$$

$$\sum_{j=1}^{n}\alpha_j[(\mu_{j,t}-\mu_{M,t})^2-(\mu_{j,t}-\bar{\mu}_t)^2] > 0$$

$$\Leftrightarrow$$

$$\sum_{j=1}^{n}\alpha_j[\mu_{M,t}^2+2\mu_{j,t}(\bar{\mu}_t-\mu_{M,t})-\bar{\mu}_t{}^2] > 0$$

$$\Leftrightarrow$$

$$\mu_{M,t}^2-\bar{\mu}_t{}^2+2(\bar{\mu}_t-\mu_{M,t})\sum_{j=1}^{n}\alpha_j\mu_{j,t} > 0$$

With $\bar{\mu}_t=\sum_{j=1}^{n}\alpha_j\mu_{j,t}$, this can be written as $(\bar{\mu}_t-\mu_{M,t})^2>0$, which is true whenever $\bar{\mu}_t\neq\mu_{M,t}$.

Weighted Median vs. Median Interest Rates

Figure 1: Comparison of Weighted Median and Median Interest Rates

Case 1: W. Median Superior

Country	α_j	i_j^*	$\mid i_j^*-i_u^*\mid$
A	0.1	1	8
B	0.1	1	8
C	0.8	11	2
Union	1	9	0
Median		1	**8**
W. Median		11	**2**

Case 2: Median Superior

Country	α_j	i_j^*	$\mid i_j^*-i_u^*\mid$
A	0.1	1	8
B	0.1	9	0
C	0.8	10	1
Union	1	9	0
Median		9	**0**
W. Median		10	**1**

The two cases illustrate that in principle either the median or the weighted median interest rate can be closer to the weighted average (i.e. the union's optimal) interest rate. Thus, the superiority of the weighted-vote regime against the one-country-one-vote regime is not clear. It depends on the specific distribution of optimal interest rates and the distribution of country weights.

Numerical Simulations of Median Interest Rates

The policy-dependent part of the union's welfare is influenced by the properties of the distribution of optimal interest rates in one period, which is a function of the joint distribution of a country's demand shock and its IEB. The larger the (absolute) difference between the collectively chosen median interest rate $i_{\tilde{M},t}$ and the union's optimal interest rate i_u^*, the larger is the union's welfare loss. Remembering equation (4.21), a country's optimal interest rate in the presence of heterogeneous inflation targets is

$$i_{j,t} = r^* + \frac{1+lv}{lv}\pi_t^e - \frac{1}{lv}\pi_{j,t}^* + \frac{1}{v}\mu_{j,t}.$$

Since the first two summands of the expression are shared by all countries, a country's preferred interest rate can be written as $i_{j,t}^* = A - (lv)^{-1}\pi_{j,t}^* + v^{-1}\mu_{j,t}$. The following simulations aim at exploring how the two elements of heterogeneity, $\pi_{j,t}^*$ and $\mu_{j,t}$, interact with respect to the median interest rate in one period. Particularly, it is of interest whether the i.i.d. shock μ influences the expected value of the median interest rate. Intuitively, one would expect that adding a symmetrically distributed random shock with mean zero to a deterministic element ($\pi_{j,t}^*$) does not to affect the first moment of the distribution of median interest rates. In other words, one would expect the mean of median interest rates to converge to $A-(lv)^{-1}\pi_{M,t}^*$ with an increasing number of random draws of the shock vector μ, at which $\pi_{M,t}^*$ is the median inflation target. This hypothesis, however, could not be validated for asymmetric distributions of π_j^*.

The following simulations refer to a group of five countries (subscripts 1-5), of which each has the same voting power. Thus, with a voting procedure such as that described in section 4.3.1, theory predicts the simple median interest rate to get implemented. For simplicity, the parameters l, v, π^e, and r^* take on the same fixed values for all simulations and all countries ($l = v = 1$, $\pi^e = r^* = 2$). Thus, the homogeneous element of the optimal interest rates is $A = 6$. The value of A is arbitrary, yet as an additive element inconsequential for the analysis.

Table 8 exhibits three different distributions of the deterministic element π_j^*, for which median interest rates are simulated. Distribution I is perfectly symmetric around zero, for distribution II the median value is below the average and for distribution III the median value is above the average. The median inflation target is that of country number three in all settings. To keep the calculations easy, the union's preferred inflation rate is defined as the simple average of inflation targets (i.e. the five countries are of uniform size). It is zero in all settings.

Table 8: Distributions of Target Inflation Rates

Setting	$\pi_\mathbf{1}^*$	$\pi_\mathbf{2}^*$	$\pi_\mathbf{3}^*$	$\pi_\mathbf{4}^*$	$\pi_\mathbf{5}^*$	$\pi_\mathbf{u}^*$
I	-6	-4	0	4	6	0
II	-10	-6	-2	4	14	0
III	-14	-4	2	6	10	0

The stochastic element of a country's preferred interest rate, the demand shock, is modeled as a normally distributed random variable for each scenario and each country ($\mu_j \sim (0, 2)$). Due to the stochastic element, country number three is not always the median country although it always exhibits the median inflation target. For each of the three distributions, country-specific, random shocks are drawn one million times. For each draw, the median interest rate is calculated as the interest rate that divides the five countries into two subgroups of equal sizes. In table 9, the first two moments of the distributions of the one million median interest rates are compared to those of country three's preferred interest rates as well as those of the union's optimal interest rates.

Table 9: Simulated Median Interest Rates

Setting	$\mathbf{i}_{\tilde{\mathbf{M}}}^*$		$\mathbf{i}_\mathbf{3}^*$		$\mathbf{i}_\mathbf{u}^*$	
	Mean	StD	Mean	StD	Mean	StD
I	6.000	1.754	6.000	2.000	6.000	0.894
II	7.915	1.867	8.000	2.000	6.000	0.894
III	4.087	1.863	4.000	2.000	6.000	0.894

Given the very large number of draws, the mean of country three's preferred interest rate is approximately equal to its expected value for all three settings. In each setting, the expected value is equivalent to its constant part: $E[i_3^*] = 6 - \pi_3^* + E[\mu_3] = 6 - \pi_3^*$. The standard deviation of country three's preferred interest rate equals the standard deviation of its demand shocks. The results for the properties of the union's optimal interest rates are also straightforward. Since the union's optimal interest rate here is simply the average value of the five countries' preferred interest rates, of which each are normally distributed around a constant, its expected value is equal to the average value of the constants. Its standard deviation is only a fraction of the standard deviations of the country-specific preferred interest rates. This result is a replication of the well-known fact that the sample averages of normally distributed variables are also normally distributed around the same mean, yet with a standard deviation reduced by the factor $\sqrt{n}^{-1}$. Here, the sample size is $n = 5$, which leads to a standard deviation of the union's optimal interest rate of $\sqrt{5}^{-1} * 2 \approx 0.894$.

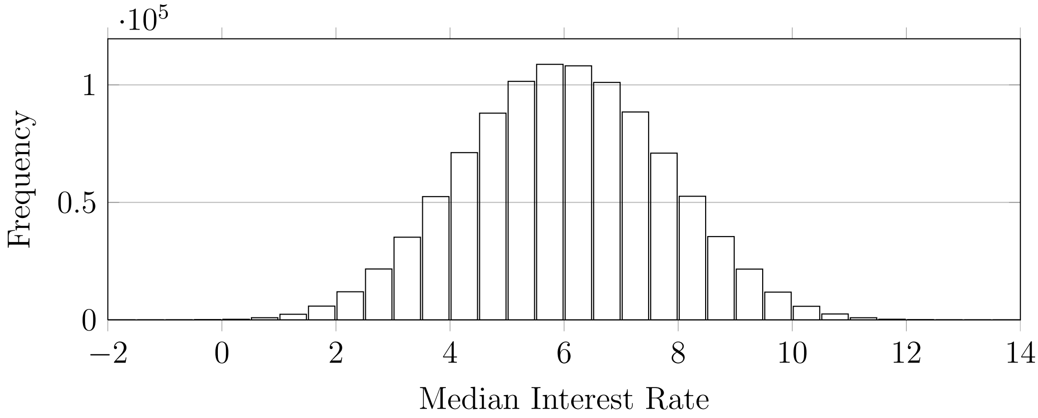
The properties of the median interest rate revealed by the simulations are more interesting. In the case of symmetrically distributed inflation targets, the expected median interest rate is equivalent to country three's average preferred interest rate. Since it is equally probable that a country with a higher or a lower preferred inflation rate becomes the median country in this setting, this result is not surprising. Compared to the standard deviation of a single country's preferred interest rate, the standard deviation of the median interest rate is somewhat lower. The reason for this result is that the probability that country three is the median country is lower if it exhibits extreme realizations of the demand shocks. Thus, compared to the distribution of a single country's preferred interest rate, extreme deviations from the mean are less probable, which leads to a lower standard deviation of median interest rates.

In the case of asymmetric distributions of preferred inflation rates, there is a systematic deviation of median interest rates from the expected value of country three's preferred interest rate. Put differently, adding a random element with mean zero to each country's preferred interest rate influences the expected value of the median interest rate. For this numerical specification, adding random shocks leads to a slight reduction of the difference between the median and the mean preferred inflation rate. Both means of median interest rates, that of setting II (7.915) and that of setting III (4.087), are closer to the expected value of the union's optimal interest rate than the mean of country three's preferred inflation rate. An explanation for this somewhat puzzling result is that the probability that the country with the median inflation target (country three) is also the median interest rate country decreases if the deviation of its shock from the union shock is in the same direction as the deviation of its inflation target from the union's inflation target. For instance, in setting II country three prefers a lower rate of inflation translating into a higher preferred interest rate. If country three is hit by an extremely positive demand shock (which strongly exceeds the union's demand shock), its preferred interest rate in this setting is particularly far from the union's optimal rate. On the other hand, if country three is hit by a particularly adverse demand shock, its preferred interest rate is closer to the union's optimal interest rate as the two effects—a lower target inflation rate and a higher stabilization term—run in opposite directions. The results suggest that—although both cases are equally probable—the probability that country three is the median country in the latter case is higher than in the former case. For a more complete picture of the simulation results, histograms of the simulated median interest rates for all three settings are added below.

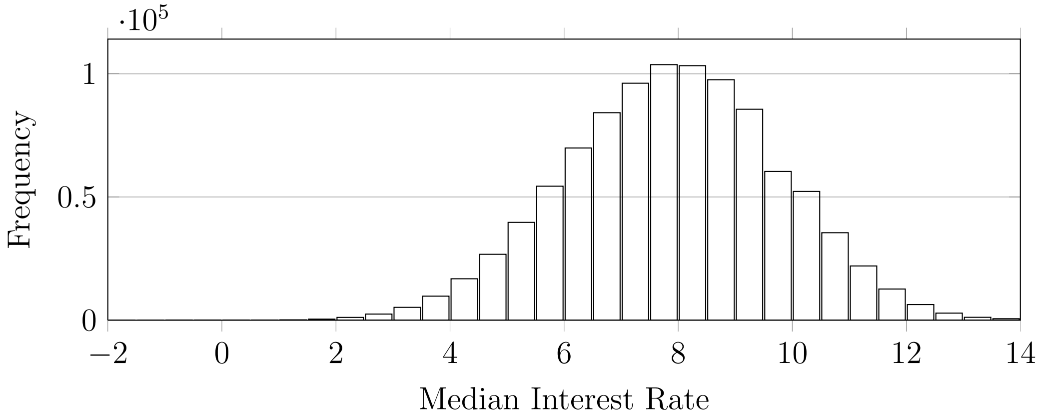
Conveyed to the model, this result means that the negative welfare implications of asymmetric distributions of target inflation rates might be slightly mitigated through the effects of random shocks. For the numerical examples above, this secondary effect is quantitatively of minor importance. To draw more general conclusions on the behavior of median values of stochastically fluctuating variables, more systematic simulations are required. Answering this specific mathematical question, however, goes beyond the scope of this thesis.

Figure 2: Distribution of Median Interest Rates

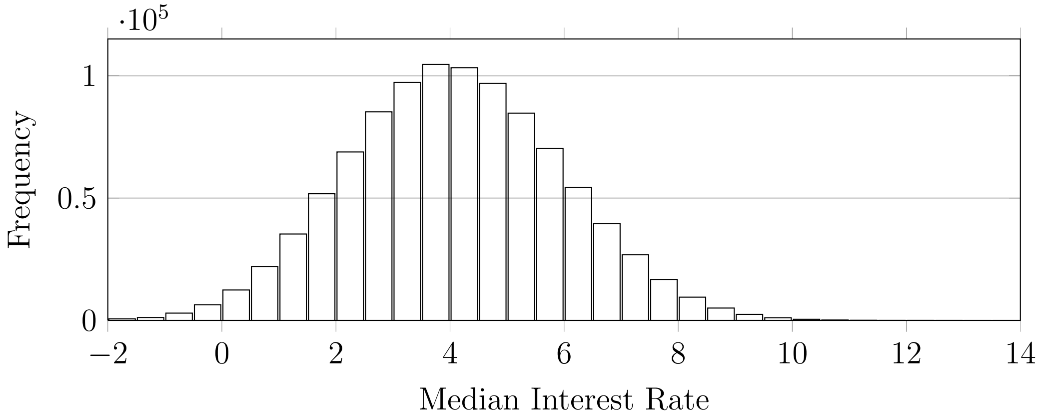
(a) Setting I



(b) Setting II



(c) Setting III



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