Essays on Money Demand and Monetary Policy Transmission in Europe

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The thesis consists of the following three working papers:

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0.1 German summary - Zusammenfassung

In dieser Arbeit beschäftige ich mich mit der empirischen Analyse unterschiedlicher Aspekte der Geldpolitik: der Geldnachfrage, dem Transmissionsmechanismus der Geldpolitik durch Bankkredite auf die Realwirtschaft und dem Einfluss der von den Zentralbanken bereit gestellten Liquidität auf die Zinsen. Der regionale Schwerpunkt liegt auf Europa, bzw. dem Euroraum und der Schweiz.

Die Dissertation ist unter dem Eindruck der Weltwirtschaftskrise entstanden. Die Krise hat die Konjunkturzyklen und die zumeist regionalen Finanzmarktkrisen der vorangegangenen Jahrzehnte relativiert: die globalen Geldmärkte trockneten aus, Großbanken gingen Pleite und brachten so das weltweite Finanzsystem nahe an einen Zusammenbruch; die Kreditversorgung der Wirtschaft geriet in Gefahr und die Produktion fiel in dramatischem Ausmaß. Die Regierungen sahen sich dazu veranlasst zu handeln. Sie verabschiedeten umfangreiche Konjunkturpakete und stützen das Bankensystem. Aber auch die Zentralbanken ergriffen neben Zinssenkungen zahlreiche zusätzliche Maßnahmen und weiteten so ihre Bilanzsumme massiv aus.

Mein erstes Forschungsprojekt wurde durch den "Credit Crunch" und seinen möglichen Auswirkungen auf die Konjunktur motiviert. Ich untersuche, ob das Wirtschaftswachstum in der Eurozone signifikant von einer Veränderung der bereitgestellten Bankkredite beeinflusst wird. Der in der Fachliteratur als "Credit View" bekannten Auffassung zufolge investieren Firmen weniger, wenn sie weniger Kredite erhalten und diese nicht durch andere Finanzierungsquellen wie etwa Anleihen ersetzen können. Ein geringeres Investitionsvolumen führt dann zu geringerem Wachstum der gesamten Wirtschaft. Für die US-Wirtschaft kann Driscoll (2004) keinen signifikanten Einfluss der Bankkredite auf das Wachstum feststellen, da die Mehrzahl der Firmen nicht von der Finanzierung durch Banken abhängig zu sein scheint. Dieses Ergebniss kann man jedoch nicht einfach auf Europa übertragen, da die Strukturen im Finanzsystem sehr unterschiedlich sind.

Meine Arbeit baut auf Driscoll (2004) auf und wendet seine Methoden an, um die Bedeutung von Krediten in Europa zu untersuchen. Da das Kreditvolumen nicht als unabhängig vom Wachstum angesehen werden kann, sondern seinerseits vom Wirtschaftwachstum beeinflusst wird, werden Geldnachfrageschocks als instrumentelle Variable für das Kreditangebot verwendet. Um jedoch Geldnachfrageschocks zu identifizieren, benötigt man zunächst eine Geldnachfragefunktion. Die bestehende Literatur zeigt, dass dies für die Eurozone keine leichte Aufgabe ist. Die meisten Volkswirte würden vermutlich zustimmen, dass das Standardmodell der Geldnachfrage instabil geworden ist, ohne dass man sich auf einen Grund für diesen Sachverhalt geeinigt hätte.

In dem ersten Artikel dieser Dissertation wird eine Geldnachfragefunktion mit Hilfe eines Paneldatensatzes der nationalen Geldmengen geschätzt. In dem zweiten Artikel wird dann untersucht, inwiefern die Unternehmen im Euroraum von der Finanzierung durch Banken abhängen und sich daher Veränderungen des Kreditvolumens auf das Wirtschaftwachstum auswirken. Beide Artikel greifen auf denselben Datensatz zurück: sie verwenden Daten aus den Gründungländern der Europäischen Währungsunion von 1999 bis zum zweiten Quartel 2008.

Ziel des ersten Artikels - *The (in)stability of money demand in the euro area: lessons from a cross-country analysis* - ist es, die Gründe für die Instabilität der europäischen Geldnachfrage genauer zu beleuchten. Die empirischen Untersuchungen haben sich bisher vor allem auf die aggregierten Geldmengen konzentriert und haben daher Zeitreihenverfahren angewandt. Eine Querschnittsanalyse könnte potenziell das Konzept einer stabilen Geldnachfrage in der Eurozone retten, wenn die empirische Instabilität nicht durch eine tatsächliche Abkopplung der Geldmengenaggregate von Inflation und Realwirtschaft begründet ist, sondern in einer falschen Spezifikation des Modells.

Die Verwendung des Querschnittsverfahren hat den Vorteil, dass es nicht notwendig ist, den Faktor zu identifizieren, der die Präfenzen der Agenten verändert und somit die Instabilität verursacht hat. So lässt sich dieser Faktor aus der Funktion kürzen, wenn man jeweils nur die Abweichungen vom Mittelwert aller Länder berücksichtigt und annimmt, dass er alle Länder in gleichem Maße beeinflusst. Die relativ kurze Zeitperiode seit der Euro-Einführung ist für eine Panelschätzung im Gegensatz zur Zeitreihenanalyse gleichfalls unproblematisch. Daher muss diese Arbeit nicht auf synthetische Daten aus der Zeit vor der Währungsunion zurückgreifen.

Aus den Schätzungen lässt sich eine Geldnachfragefunktion ableiten, die sogar sinnvolle Koeffizienten für die Einkommenselastizität und die Semielastizität der Zinsen aufweist. Aus den Ergebnissen lässt sich schließen, dass die beobachtete Instabilität der Geldnachfrage wohl auf nicht berücksichtigte Faktoren wie zum Beispiel technischen Fortschritt, Konsumentenvertrauen, Aktienmarkt- oder andere Vermögensentwicklungen zurückzuführen ist.

Der zweite Artikel - *Are bank loans important for output growth? A panel analysis of the euro area* - verwendet die Residuen der zuvor geschätzten Geldnachfragefunktion als instrumentelle Variable für Kredite. Es wird untersucht, ob das Kreditvolumen immer noch eine entscheidende Einflussgröße für das Wachstum der Euro-Wirtschaft darstellt.

In den vergangenen Jahrzehnten haben die Finanzmärkte weltweit rapide an Bedeutung gewonnen. Eine zunehmende Zahl von Unternehmen hat Zugang zu alternativen Finanzierungsmöglichkeiten wie Anleihen und ist somit nicht mehr von der klassischen Finanzierung durch einen Bankkredit abhängig. Möglicherweise kann man daher Kredite und verbriefte Verbindlichkeiten als annährend perfekte Substitute betrachten, wie dies auch in den meisten makroökonomischen Modellen getan wird. In diesem Fall würde die Fluktuation der Kreditvergaben keine Konjunkturschwankungen verursachen, da Firmen einfach andere Finanzierungsquellen nutzen würden.

Für die US-Wirtschaft liegen Hinweise vor, dass der Einfluss der Kredite im Verlauf der 90er Jahre durch die Liberalisierung der Finanzmärkte signifikant zurückgegangen ist, siehe Perez (1998). In Europa läuft jedoch immer noch etwa 85% der externen Finanzierung von Unternehmen über Banken. Dies zeigt, dass es im Euroraum wesentlich wahrscheinlicher ist, dass Bankkredite eine Bedeutung für das Wachstum haben als in den USA, wo die Bankabhängigkeit traditionell geringer ist.

Die wechselseitigen Einflüsse zwischen Krediten und Wachstum in den Griff zu bekommen, ist eine Herausforderung für jede empirische Arbeit zu diesem Thema. Ähnlich wie Driscoll (2004) verwende ich Geldnachfrageschocks als Instrument für Kredite. Mit Hilfe von Panelschätzverfahren wird der Transmissionsmechanismus von geldpolitischen Impulsen durch den Bankensektor untersucht: nach einem Geldnachfrageschock passen die Agenten ihre Geldmenge, über die sie jederzeit verfügen können, an. Diese Veränderung der Einlagen kann zu einer Veränderung der Kreditvergabe führen, wenn die Banken von diesen Einlagen abhängig sind. Im ersten Schritt des zweistufigen Schätzverfahrens zeigt sich, dass dies tatsächlich der Fall ist. Im zweiten Schritt wird dieser Zusammenhang genutzt, um festzustellen, ob diese Veränderung der Kreditvergaben einen Einfluss auf das Wirtschaftswachstum hat.

Die Analyse kommt zu dem Ergebnis, dass das Wachstum in der Eurozone anders als in den USA auf eine Veränderung der Kredite reagiert. Daraus lässt sich die Schlußfolgerung ziehen, dass die Geldpolitik auch durch eine Anpassung der Banken bei der Kreditvergabe übertragen wird und Kredite und Anleihen daher nicht als perfekte Substitute behandelt werden sollten.

Das zweite Forschungsprojekt beschäftigt sich mit den unkonventionellen Maßnahmen, die von den Zentralbanken weltweit während der Finanzmarktkrise beschlossen wurden. Die Zentralbanken sahen sich mit großen Herausforderungen konfrontiert: Die Geldmärkte trockneten aus und die Deflationsgefahren stiegen mit dem Einbruch der Wirtschaft rapide an. Nachdem die Leitzinsen auf nahezu null gesenkt worden waren, erhöhten die Zentralbanken daher deutlich die Liquidität, die sie den Geschäftsbanken zur Verfügung stellen. Die Schweizerische Nationalbank bildet hier keine Ausnahme. Sie weitete die Geldbasis vor allem durch Devisenmarktinterventionen, die eine weitere Auswertung des Schweizer Franken verhindern sollten, massiv aus.

Das Paper - *The liquidity effect on the Swiss franc Libor during the financial crisis* - untersucht, ob die durch die Schweizerische Nationalbank geschaffene Liquidität dazu beigetragen hat, die Zinsen im Schweizer Interbankenmarkt zu senken. Darüber hinaus soll bestimmt werden, welche weiteren Faktoren den Schweizer 3-Monats-Libor in diesen außergewöhnlichen Zeiten beeinflusst haben, in denen die Zinsen für die Repo Operationen der Zentralbank bei fast null lagen und die Leitzinsen nicht mehr weitergesenkt werden konnten.

Diese Arbeit ist daher in die Literatur einzuordnen, die sich mit den Auswirkungen der Liquiditätsprogramme der Zentralbanken beschäftigt. Bisher konzentriert sich diese Forschung fast ausschließlich auf die USA. Es gibt jedoch auch erste Arbeiten zu anderen Ländern wie zum Beispiel Japan, vergleiche Hirose und Ohyama (2010). Die Auswirkungen von Liquidität auf die Zinsen in der Schweiz zu analysieren, hat den Vorteil, dass die Liquidität hier vor allem durch Interventionen am Devisenmarkt geschaffen wurde, welche in diesem Kontext als exogen betrachtet werden können.

Die Ergebnisse zeigen, dass die bereitgestellte Liquidität zu dem Rückgang des Schweizer Libors begetragen hat. Des Weiteren hatte die Veränderung des Ausfallrisikos von Banken und der globalen Unsicherheit einen signifikanten Einfluss auf den Libor.

Alle Themen meiner Dissertation befassen sich mit den Auswirkungen der Geldpolitik. Sie konzentrieren sich auf den Einfluss von geldpolitischen Entscheidungen auf Zinsen, die Kreditvergabe und die Realwirtschaft. Die

Ergebnisse bestätigen, dass es unzureichend ist, lediglich die Transmission der Geldpolitik über die Zinsen zu berücksichtigen, da ebensfalls eine Übertragung durch Bankkredite stattfindet. Durch diesen weiteren Kanal werden geldpolitische Schocks auf die Wirtschaft übertragen, indem die Banken ihr Kreditangebot anpassen.

Meine Arbeit beschreibt, wie die Geldpolitik in der Krise funktioniert hat und wo sie möglicherweise ihre Grenzen erreichte. Das dritte Paper zeigte, dass die enorme Liquidität, die die Schweizerische Nationalbank durch ihre Devisenmarktinterventionen geschaffen hat, einen entscheidenen Beitrag dazu geleistet hat, die Zinsen im Interbankenmarkt zu senken.

Weltweit haben die Zentralbanken alles in die Waagschale geworfen, um die Krise zu bekämpfen: die Zinsen wurden auf quasi null gesenkt und zusätzliche Liquidität in einem bisher nicht gekannten Ausmaß zur Verfügung gestellt. Einen Einbruch der Kreditvergabe können diese Maßnahmen jedoch nicht verhindern, falls die Transmission der Geldpolitik in die Wirtschaft gestört ist. Die massiven Abschreibung im Bankensystem und die hohe Unsicherheit über die weitere wirtschaftliche Entwicklung hatten den Geldmengenmultiplikator in der Krise fallen lassen. Meinen Ergebnissen zufolge leidet das Wirtschaftwachstum zumindest in Europa unter einem Rückgang der Bankkredite, da hier im Gegensatz zu den USA die Firmen in viel größeren Maße von der Finanzierung durch Banken abhängig sind.

0.2 English summary

This dissertation addresses different aspects of monetary policy: money demand, the transmission of monetary policy through bank loans on the real economy and the impact of liquidity supplied by central banks on interbank lending rates. Regionally the focus is on Europe or rather the euro area and Switzerland. The work was written under the impression of the worst economic crisis since the great depression, including the collapse of money markets, the bankruptcy of major banks, the slump of production, governments designing fiscal stimulus packages and central banks bloating their balance sheets.

The credit crunch and its potential impact on output growth motivated the first research project. It is explored whether changes in the volume of supplied bank loans have a significant effect on economic growth in the euro area. According to the well known credit view - that goes back to Bernanke and Blinder (1988) - a reduction of loans leads to less investment and therefore less growth if firms cannot substitute other sources of finance for loans. Driscoll (2004) finds no evidence for this "credit channel" in the US. However, this result possibly cannot be transferred to Europe given the different structure of the financial systems.

My work builds on Driscoll (2004) and applies his methodology to investigate the existence of the credit channel in the euro area. Money demand shocks are used as an instrumental variable for the loan supply as loans cannot be regarded exogenous to output. To identify monetary demand shocks, a monetary demand function for the euro area has to be estimated first. Taking into account the existing literature, this is not a trivial task. Most economists would presumably agree that standard money demand models have become unstable in the euro area without the reason for this instability being agreed upon.

In the first paper of this dissertation, a money demand function is estimated with panel data of the country-specific monetary aggregates. The second paper then analyses whether the volume of bank loans influences output growth using monetary demand shocks. Both papers rely on the same data set: they use national macro-data from the founding members of the

European Monetary Union from 1999 to the second quarter of 2008.

The first work - *The (in)stability of money demand in the euro area: lessons from a cross-country analysis* - aims to shed more light on the economics behind the instability of euro area money demand. So far, the empirical money demand literature almost exclusively focused on aggregated data and followed a time series approach. A cross-country estimation could potentially rescue the concept of a stable money demand function for the euro area if the instability detected by the empirical literature is not due to a general decoupling of monetary aggregates from inflation and the real economy but caused by a misspecification of the function. The cross-sectional approach to money demand has the advantage that one does not necessarily has to identify factors that changed the preferences of money holders and possibly caused the instability. By using the deviations of the variables from their cross-sectional mean, macroeconomic factors cancel out if we assume that they effect all countries equally.

In contrast to traditional time series studies on money demand, the relatively short euro area period is not a problem for panel estimation. As a result, the analysis does not have to rely on synthetic euro area data. We identify a money demand function with panel estimation techniques and obtain reasonable estimates for the long-run (semi)elasticities of interest rates and income. The results indicate that the observed instability of standard money demand functions could be explained by omitted variables like technological progress, international stock market indices or consumer sentiment.

The second paper - *Are bank loans important for output growth? A panel analysis of the euro area* - uses the residuals from the previous estimated money demand function as instruments for bank loans. It aims to investigate whether the volume of bank loans is still important for output growth in the euro area.

Over the last decades financial markets have gained importance for financing of firms in Europe as it has worldwide. An increasing number of firms have access to other sources of finance like corporate bonds and do not solemnly depend on bank financing any more. Therefore it might be possible that debt securities and bank loans can be regarded as quasi perfect substitutes as incorporated by most macroeconomic models. In this case one would not expect an impact of a change in bank lending on economic growth because firms could substitute other sources of finance for loans.

There is evidence for the US that the “credit channel” has disappeared somewhere in the 90s due to the liberalisation of financial market, see Perez (1998). However, in Europe still roughly 85% of the external finance of non-financial corporations is covered by bank loans. This shows that it is far more likely that bank loans still matter for output growth in the euro area where the bank-dependency has traditionally been higher than in the Anglo-American economies.

The main challenge in the empirical work measuring the influence of loans is to tackle the endogeneity problem of banks loans as they most likely also react to changes in output. Following Driscoll (2004), money demand shocks are used as an instrumental variable for the loan supply. Applying a cross-country panel estimation, the transmission process of monetary policy through banks is investigated. Following a money demand shock, agents will adjust their bank deposits. If the banks depend on these deposits, bank loan supply will react to these changes. In the first step of the two stage estimation procedure it is found that this is indeed the case. In a second step the impact of bank lending on the economic activity is estimated using the instrumented loans.

The results support the credit view as there is evidence that changes in loans lead to a response of output in the euro area in contrast to the United States. Consequently, bonds and bank loans should not be treated as perfect substitutes and the monetary policy is transmitted through changes in bank lending.

The second research project relates to the unconventional measurements adopted by the central banks worldwide during the financial crisis. Central banks faced extraordinary tasks with interbank markets running dry and increasing deflationary pressure as the economic production was in free fall. They significantly increased the liquidity they supply to the corporate banks, especially after the key interest rates had reached the zero interest rate boundary. The Swiss National Bank was no exception as far as it also dramatically increased the monetary base, especially through the currency market interventions that it adopted in March 2009.

The paper - *The liquidity effect on the Swiss franc Libor during the financial crisis* - investigates whether this liquidity created by the Swiss National Bank has helped to lower the interbank lending rates during the financial crisis. Additionally, it aims to determine what else drove the three-month Swiss Libor in these unusual times with repo rates at zero and the leeway to lower the key interest rate being exhausted. Thereby it contributes to the recent literature that is concerned with the effectiveness of the liquidity programmes adopted by the central banks in the crisis. For now most of this research has focused on the US facilities but the measurements in other countries have also been investigated, for example in Japan by Hirose and Ohyama (2010). Focusing on Switzerland has the advantage that the liquidity is mainly supplied through currency market interventions that can be regarded as exogenous in this context.

The results reveal that the liquidity supplied contributed to the fall of the Libor. Additionally, the changes in credit default risk of banks and the global uncertainty had a significant impact on the Libor.

All addressed topics deal with the implications of monetary policy. They focus on the impact of monetary policy decisions on interest rates, corporate bank lending and the real economy. The findings reveal that it is insufficient just to consider the transmission of monetary policy through the interest rates as bank lending is affected as well. Through this additional channel monetary shocks are transmitted to the real economy caused by a change in loan supply.

The results of my work show how monetary policy might have functioned in the crisis and where it reached its limits. In the third paper I investigate how the Swiss National Bank conducted its monetary policy after the operational interest rate had been lowered to zero. According to the analysis the enormous liquidity supplied to corporate bank played a crucial role to decrease the interbank interest rate.

Worldwide the central banks put in all their potential tools and more to face the crisis: they cut interest to virtually zero and supplied extra liquidity which might have led to lower interbank interest rates. However, if the transmission of liquidity into the economy does not function in the usual way, these actions do not prevent loans supply from collapsing. The massive writedowns and the increased uncertainty caused money multipliers to fall in the crisis. My work shows that economic growth suffered from the decline in bank loans at least in Europe where firms depend on the financing by banks to higher extent than in the United States.

The (In)stability of Money Demand in the Euro Area: Lessons from a Cross-Country Analysis

Abstract

The instability of standard money demand functions has undermined the role of monetary aggregates for monetary policy analysis in the euro area. This paper uses country-specific monetary aggregates to shed more light on the economics behind the instability of euro area money demand. Our results obtained from panel estimation indicate that the observed instability of standard money demand functions could be explained by omitted variables like e.g. technological progress that are important for money demand but constant across member countries.

1.1 Introduction

While most economists would agree that standard money demand functions have become unstable in the euro area, the economics behind money demand instability are still under debate. On the one hand, the instability of empirical money demand functions are seen as ultimate proof of the decoupling of monetary aggregates from inflation and the real economy. From this perspective, money demand instability undermines the information content and usefulness of money growth data for the ECB's monetary policy. On the other hand, empirical money demand functions might have been unstable simply because the estimated models were misspecified due to the omission of important variables.

The empirical literature has proposed several plausible candidates as additional regressors in order to reestablish money demand stability. Examples include proxies for wealth (Boone and van den Noord 2008, Beyer 2009) and macroeconomic uncertainty (Greiber and Lemke 2005, de Bondt 2009), the prices of stocks (Dreger and Wolters 2009, 2010) and their volatility (Carstensen 2006). Empirical results, however, have been mixed and the causes and consequences of money demand (in)stability are still under-researched. This paper re-investigates money demand (in)stability by estimating a euro area money demand function from cross-country data.

The empirical money demand literature is almost exclusively based on aggregated data for the whole euro area. For most applications, this is the natural choice because cross regional money holdings may be important and the common monetary policy in the euro area should depend on euro area wide aggregates and not on country-specific developments. Yet, money demand functions obtained from a panel analysis of regional data may still contain useful information. For example, Driscoll (2004) estimates the regional money demands of U.S. states to assess the relevance of the bank lending channel.[1]

In the current paper, we estimate a panel money demand function of the euro area to shed more light on the causes of money demand instability. Since the panel estimation is based on national deviations from the euro area wide means, all variables that are constant across countries cancel out, including those who are probably responsible for the instability of the aggregate money demand, like technological progress, international stock market indices, con-

[1] Rondorf (2010) and Cappiello et al. (2010) adopt Driscoll's approach to explore the impact of bank loans on output growth in the euro area. A further panel estimation of euro area money demand is provided by Setzer and Wolff (2009).

sumer sentiment etc. Put differently, evidence in favour of stable regional money demand functions indicate that the observed instability of the aggregate money demand might be explained by some missing macro variables. In this case, stable euro area money demand functions may be obtained by augmenting money demand by those omitted variables and research directed to find these variables is promising.

The cross-sectional approach to money demand has been introduced by Mulligan and Sala-i-Martin (1992) who estimated U.S. money demand using data from the federal states. They already emphasised that a cross-country analysis of money demand can overcome the stability problems of standard time series approaches, because omitted variables may drop out. Advancing on Mulligan and Sala-i-Martin (1992), we follow Driscoll's (2004) analysis of regional U.S. money demand by exploiting the panel structure of the data.

The following empirical analysis employs data from the founding members of the European Monetary Union (EMU) from 1999 to the second quarter of 2008. In contrast to traditional time series studies on money demand, the relatively short euro area period is not a problem for panel estimation. As a result, the analysis does not have to rely on synthetic euro area data. Our empirical results support the notion of structural stability of money demand in the euro area. In particular, we obtain reasonable estimates for the long-run (semi)elasticities of interest rates and income.

The paper is structured as follows: In Section 2 we briefly review the main findings of the literature on the European money demand. Section 3 discusses the features and problems of the cross-sectional approach to money demand estimation. Section 4 describes the data set and presents the empirical results. Finally, Section 1.5 offers some concluding remarks.

1.2 The (in)stability of European money demand

Since the start of the EMU in 1999, the European Central Bank has repeatedly emphasised the prominent role of monetary aggregates for its monetary policy analysis. Especially in the early years of the century, inspired by the monetary targeting strategy of the German Bundesbank, the ECB tried to explain the course of monetary policy by the development of money growth. However, compared with former evidence on German money demand (Lütkepohl et al. 1999), the empirical link between money growth and inflation appeared to be less close and predictable in the euro area. Referring to the published reference value for money growth, naive forecasts of the ECB's interest rate decisions would have typically been misleading in the short-term. In May 2003, the ECB responded to these communication problems by abandoning the reference to the value from its monthly bulletins and with a clarification of its monetary policy strategy, see ECB (2003). Since then, the ECB's monetary analysis puts more emphasis on the long-term relation between monetary aggregates and inflation.

The money demand function provides the predominant theoretical concept for the empirical relationship between monetary aggregates, inflation, and the real economy. The (in)stability of euro area money demand functions has therefore always been an important theme in the recent debate on the role of money for monetary policy. Among others, Brand and Cassola (2004), Coenen and Vega (2001), Hayo (1999) and Funke (2001) confirmed the stability of euro area money demand. These early contributions employed standard specifications of money demand and performed cointegration analysis to identity the long run relationship between real money supply, income and an interest rate variable.

Following this first round of supportive evidence on money demand stability, several studies including Carstensen (2006) and Gerlach and Svensson (2003) fail to find a stable long-run money demand in the euro area. They conclude that money demand has become unstable implying that the informational content of monetary aggregates for monetary policy gets dubious. Carstensen (2006) provides a first attempt to explain the observed instability. He augments the standard money demand specification by stock prices and stock market volatility to capture the massive re-allocations of liquidity observed in 2001. He shows that the sharp increase in money growth rates after 2001 can partly be explained by falling stock prices and high stock market volatility.

In the same vein, the recent literature tries to reestablish the stability of euro area money demand by including additional regressors in the money demand equation. Boone and van den Noord (2008) include stock prices and also house prices in their empirical money demand model to capture wealth effects. Greiber and Lemke (2005) investigate whether macroeconomic uncertainty can explain the portfolio shifts that lead to high money growth in the past decade. By incorporating financial markets characteristics and economic sentiment indicators in a money demand equation, they are able to explain the movements of M3, at least until 2004. For a similar sample period, Dreger and Wolters (2009) suggest that the apparent instability of money demand can be explained by the strong movements in the stock markets. After 2004, however, economic sentiment indicators increased and financial markets recovered, but the growth rates of M3 even increased further.

Even 10 years after the introduction of the euro, the empirical literature on euro area money demand has to rely on synthetic euro area data where national data starting from the early eighties have been converted into a single synthetic currency. As a consequence, the resulting data and, thus, the money demand estimates, crucially depend on the choice of the exchange rate. In the literature, current exchange rates, fixed rates of a base period as well as the PPP exchange rates have been applied.[2] Moreover, the time series approach to euro area money demand implicitly assumes a common European monetary policy even for the pre-euro period. Following Arnold (1994) , the stability of euro-area wide money demand equations found for the pre-euro period might be spurious, because negatively correlated idiosyncratic shocks to money demand in individual countries. Since the adoption of a common monetary policy leads to a greater degree of synchronisation of shocks across countries, money demand in the euro area might be less stable than that estimated using area-wide data for the pre-euro period. In the view of these problems, it is a further advantage of a cross-country panel approach to euro area money demand that estimates can be based completely on data from the euro area.

1.3 Cross-sectional perspective

The cross-sectional approach to money demand has been introduced by the work of Mulligan and Sala-i-Martin (1992). They estimate the US money demand year by year using cross-sectional data from the individual states. Following Mulligan and Sala-i-Martin (1992), cross-sectional estimation of money demand avoids many problems of the standard time series approach. In particular, structural breaks over time or instability of money demand due to time-varying coefficients are more likely to occur in a time series analysis due to the longer time horizon needed.

More importantly, a cross-sectional money demand function can reveal information about the sources of money demand instability. From a purely time series perspective, the omission of relevant variables can lead to biased

[2]Beyer et al. (2001) discuss the alternative ways to construct synthetic euro area data.

and presumably unstable estimates of in fact stable money demand functions. By contrast, cross-sectional money demand estimations are unaltered by the omission of variables provided that those are constant across units. Since cross-section estimation is based on deviations from cross-sectional means those (probably omitted) variables simply drop out. Mulligan and Sala-i-Martin (1992) view the variable "technological process" as a typical example for a variable that affects US money demand but is constant across states.

While a pure cross-sectional analysis might be feasible for 50 US federal states, the number of euro area member countries is relatively small. Following Driscoll (2004), we therefore augment the cross-sectional perspective by the time dimension and shall estimate a euro area money demand using panel econometrics. Estimating a cross-sectional or panel money demand function does not only require the availability of regional data, see Section 1.4.1. For the US, the cross-sectional approach to money demand is feasible because federal states are (i) highly decentralised but (ii) still within a federal system having a common monetary policy.

Both assumptions also apply to the member countries of the euro area. In fact, the cross-sectional approach to money demand might work even better in the euro area than in the US. Firstly, in the euro area distortionary cross-border holdings are of minor importance. For Europeans, it is far less common to have an account in another Euro area country than it is for an US citizen to have an account in a different federal state.[3]

Secondly, in the US regional monetary aggregates are problematic because the states New York and Illinois (Chicago) are dominant financial centres that attract a lot of money from other states. By contrast, the role of financial centres, like Frankfurt, is comparably week in the euro area. In fact, the main European financial centre is London which is outside the euro area. Luxembourg is the only euro area country where the financial sector accounts for a very high fraction of the gross domestic product. As a result, the inclusion of Luxembourg could be a problem for the estimation of a cross-country euro area money demand. However, in the following empirical analysis, this country cannot be considered anyway because national monetary aggregates are

[3]If a European household invests money abroad, it will mainly be for portfolio reasons. On average cross-border holdings from other EMU members account for only 8% of deposits of non-monetary financial institutions, see ECB bank balance sheet statistics. Note that 8% is a stock and not a flow value such that flows could still be important within one period. Unfortunately, however, the availability of flow data on cross-country business is very limited. Cross-border holdings usually tend to be higher in smaller countries. Thus, cross-border holdings are more important in the US partly because the cross-sectional units (the states) are relatively small.

not available for Luxembourg.

Finally, the use of cross-country data may ameliorate the critical issue of money supply endogeneity.[4] Endogeneity might be of particular importance for the euro area where monetary aggregates play a role for the communication and the conduct of monetary policy. Suppose, for example, that a money supply shock leads to an increase in the interest rate governed by the central bank. If higher interest rates imply lower income, then the resulting correlation between money supply shocks and income will bias the estimated money demand coefficients. Therefore, as long as euro area wide monetary policy does not react to country-specific shocks, cross-sectional estimation mitigates the endogeneity problem of aggregate money supply.

1.4 A panel estimation of euro area money demand

1.4.1 Data

Monetary aggregates

Our panel analysis of euro area money demand employs quarterly data from the founding members of the EMU including Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal and Spain.[5] We use quarterly data from the introduction of the euro in 1999 until the second quarter of 2008 which gives us $10 \times 38 = 380$ observations.

In accordance with Mulligan and Sala-i-Martin's (1992) and Driscoll's (2004) analysis of US money demand, we use country-specific monetary aggregates supplied by the national central banks. In the euro area, these country-specific monetary aggregates can be interpreted as the national contribution to the euro zone-wide aggregate. Currency is excluded in these series as it cannot be unambiguously assigned to a specific country.[6] Following the empirical money demand literature, we focus on the demand for M3. Figure 1.1 displays M3 for the euro area as a whole and the sum of the national contributions over all euro area countries under consideration. Confirming the reliability of the country-specific monetary aggregates, the differences between the two series is small and mainly due to the entry of further countries to the euro area.[7] The average annual growth rate of M3

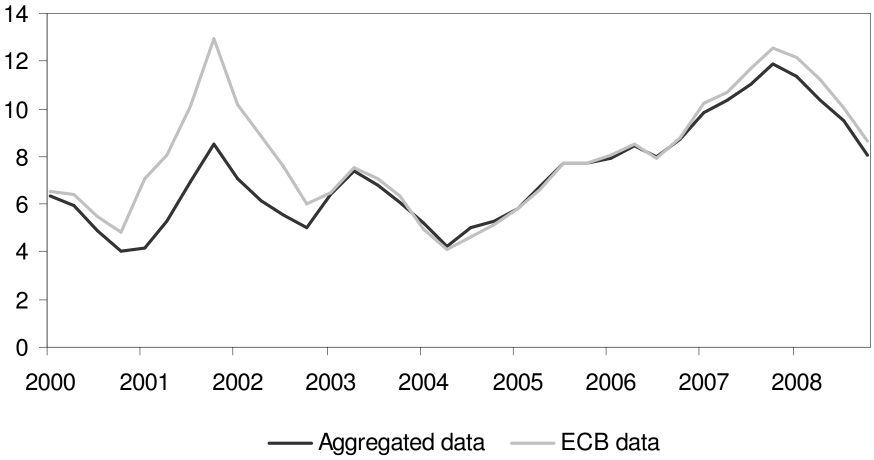
[4]The time-series literature addresses the endogeneity issue by estimating VARs and testing for weak exogeneity, see e.g. Hayo (1999).

[5]The only exception is Luxembourg which is not included because of data availability.

[6]Currency accounts on average for 6.7% of M3 over the whole sample horizon.

[7]Greece joined the euro in 2001, Slovenia, Cyprus, Malta and Slovakia followed.

Figure 1.1: M3 growth rates



Notes: The line labelled "ECB data" shows the growth rates of the monetary aggregate M3 minus currency for all current member countries as published by the ECB. "Aggregated data" denotes growth rates of M3 derived from the sum of the national M3 contributions of the ten countries under considerations.

less currency amounts to 7.2% from 1999 to 2008.

While Mulligan and Sala-i-Martin (1992) assume that the price level is the same in all US states, we obtain real money supply referring to country-specific GDP deflators. Although our approach might have the drawback that money movements between two countries do actually change the area wide real monetary aggregates when using regional deflators, the assumption of identical price levels across euro area countries seems too restrictive.[8] The seasonally adjusted series of country-specific GDP and its deflator are obtained from Eurostat.

Interest rates

The cross-sectional approach to money demand is based on cross-sectional demeaned variables. Therefore, a variable can only be used in a panel estimation of euro area money demand if it differs across countries. This requirement has important implications for the choice of the interest rate variable in the money demand function. In particular, short-term money market rates are not feasible in our application because the degree of integration of euro area interbank money markets is extremely high. As a consequence the Euribor

[8] In Mulligan and Sala-i-Martin (1992) the price indices cancel out when demeaning the data. Therefore they basically estimate a nominal demand function.

replaced the national interest rates as a reference rate after 1999 in the three month segment of the money market. In order to account for both, the opportunity costs for holding money and the own rate of money, we consider two different sets of country-specific interest rates.

In contrast to interbank rates, the interest rate on the deposits of non-financial corporations have converged but constraints are still in place, see the financial integration report by the ECB (2008). From 2003 onwards, national deposit rates for deposits with a maturity up to one year are published monthly in the ECB-statistics, see Section "interest rates by monetary financial institutions". Before 2003, the series are obtained directly from the national central banks. Due to the maturity mismatch between the (up to) one year deposit rate and M3 which contains deposits up to only three month, the available deposit rates are not a perfect measure for the own rate of money. Driscoll (2004), for example, estimates a negative relationship between deposit rates and US money demand implying that deposit rates capture the opportunity cost of money rather than the own rate of interest.

According to the empirical money demand literature, a natural choice for a variable measuring the opportunity cost of money is the interest rate for long-term government bonds. Country-specific spreads between long-term interest rates are driven by the indebtedness and the economic situation in that country. In the current financial crisis, spreads have increased dramatically for some euro-area countries. In our sample, cross-country deviations from the average euro area bond rate were typically about eight basis points, compare Figure 1.2.

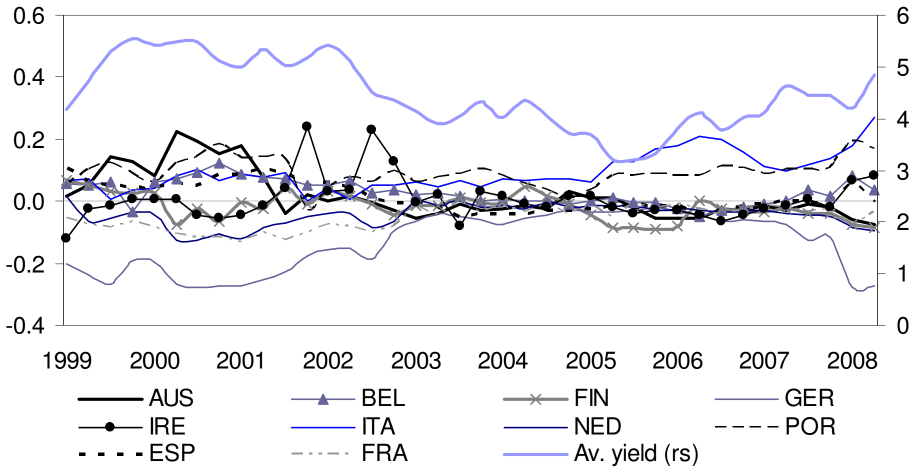
We tested the stationarity of the variables using the panel unit root test introduced by Pesaran (2007) that allows for cross-sectional dependence. The results clearly indicate that the levels of all variables, including real money supply, income, and both interest rates under consideration, follow I(1)-processes, see Table 1.4 in the Appendix.

1.4.2 The benchmark specification for money demand

In accordance with Driscoll (2004), our empirical analysis is based on the following standard specification for the long-run money demand,

$$\tilde{m}_{it} - \tilde{p}_{it} = \beta_1 \tilde{y}_{it} + \beta_2 \tilde{r}_{it} + \varepsilon_{it} \tag{1.1}$$

Figure 1.2: Spreads between long-term interest rates in the euro area



Notes: The figure shows the national deviations of the ten year government bond yields from the cross-country average (left hand side y-axis) and the cross-country average yield itself (right hand side y-axis).

where real money demand depends on income and an interest rate variable. In the panel estimation, all variables are demeaned from their cross-sectional average, i.e. $\tilde{x}_{it} = x_{it} - ({}^{1}\!/\!{}_{N}) \sum_{i=1}^{N} x_{it}$ and are given in logs and per capita (except for the interest rates). In order to account for short-run dynamics of money demand, we follow e.g. Pesaran and Shin (1999) and estimate the long-run income and interest rate elasticities in an error correction framework,

$$\begin{aligned} \triangle\left(\tilde{m}_{it} - \tilde{p}_{it}\right) &= \delta\left(\tilde{m}_{it-1} - \tilde{p}_{it-1}\right) + \alpha_1 \tilde{y}_{it} + \alpha_2 \tilde{r}_{\,it} + \\ & \sum_{j=1}^{p-1} \lambda_j \triangle\left(\tilde{m}_{it-j} - \tilde{p}_{it-j}\right) + \sum_{j=0}^{q-1}\left(\theta_j \triangle \tilde{y}_{it-j} + \phi_j \triangle \tilde{r}_{\,it-j}\right) \\ & + d_i + \varepsilon_{it}, \end{aligned} \tag{1.2}$$

where d_i denotes a country-specific fixed effect and the long-run (semi)elasticities are obtained as $\beta_1 = -{}^{\alpha_1}\!/\!{}_{\delta}$ and $\beta_2 = -{}^{\alpha_2}\!/\!{}_{\delta}$, respectively. Similar to an estimation of an aggregate euro area money demand based on a purely time-series perspective, our benchmark specification assumes in a first step that the short-run dynamics are the same across countries. Applying standard information criteria, we choose the lag orders p and q equal to two.

Table 1.1 presents the estimation results for the benchmark specification of euro area money demand using three different interest rate variables for measuring the opportunity cost of money. In the three columns of the table

Table 1.1: The benchmark specification of euro area money demand using alternative interest rates

Interest rate:		r^{l}_{it}	$r^{l}_{it} - r^{d}_{it}$	r^{d}_{it}
Long-run money demand:	$\tilde{y}_{it}$	1.44*** (2.64)	1.41** (2.06)	1.55** (2.38)
	$\tilde{r}_{it}$	-0.58** (-2.11)	-0.18 (-1.01)	0.03 (0.16)
Error correction term:		-0.09*** (-4.21)	-0.07*** (-3.73)	-0.07*** (-3.65)
Short-run dynamics:	$\Delta\tilde{y}_{it}$	0.56*** (3.51)	0.50*** (2.84)	0.47*** (2.61)
	$\Delta\tilde{y}_{it-1}$	0.58*** (3.66)	0.49*** (2.78)	0.45** (2.51)
	$\Delta\tilde{r}_{it}$	0.16*** (4.71)	0.09*** (4.97)	-0.05*** (-2.67)
	$\Delta\tilde{r}_{it-1}$	0.06** (2.08)	-0.01 (-0.31)	0.02 (1.22)
	$\Delta(\tilde{m}_{it-1} - \tilde{p}_{it-1})$	-0.01 (-0.18)	0.05 (0.40)	0.04 (0.79)
R^2		0.17	0.16	0.13
Prob. of cointegration test		0.00	0.16	0.25

Notes: The estimation is based on Equation (1.2). r^l and r^d denote the long-term and the deposit interest rate. Sample: 1999Q1 - 2008Q2; *,**,*** indicate significance at the 10%, 5%, 1% level, respectively; t-statistic in parentheses. The p-value of the cointegration test refers to the null of "no cointegration" against the alternative that the majority of cross-sectional units are cointegrated, see Westerlund (2005).

we show the estimates obtained for long-term government bond yields (r^{l}_{it}), the interest rate for deposits up to one year (r^{d}_{it}), and their spread ($r^{l}_{it} - r^{d}_{it}$). The results suggests two main conclusions. First, for all interest rate measures under consideration the estimated long-run income elasticity of euro area money demand is highly significant and plausibly signed. In line with earlier contributions on euro area money demand based on a pure time series approach, the panel estimates of income elasticities are clearly above one, ranging from 1.41 to 1.55. Therefore, the cross-country analysis of money demand supports the evidence of a declining income velocity in the euro area.

Second, as expected, the results obtained for the long-run interest rate (semi)elasticity strongly depends on the interest rate measure applied. In line with the interpretation of an opportunity cost variable, one obtains a negatively signed estimate for the long-term interest rate and the interest rate spread. In contrast, the positive coefficient of the deposit rate indicates that this interest rate is more closely related to the concept of the own rate of money. However, the long-run interest rate effect is only significant in case of $\tilde{r}_{it} = r^{l}_{it}$. Moreover, panel cointegration tests show that the inclusion of the long-term interest rate is required to obtain a cointegrated long-run money demand function for the euro area. This shows that the long-term interest rate is the most appropriate interest measure in our application. In the following, we therefore investigate the robustness of the results focusing on money demand functions incorporating the long-term interest rate.

Let us close this section by looking at the short-run dynamics, also displayed in Table 1.1. An increase in interest rates first leads to a rise in monetary aggregates. The initial positive response can be explained by portfolio shifts. The short-term assets that belong to M3 will attract more buyers and monetary aggregates increase.[9]

1.4.3 Sensitivity Analysis

Heterogeneous short-run dynamics: Pooled mean group estimation

Following e.g. Driscoll (2004) and Mulligan and Sala-i-Martin (1992), the benchmark specification presented in Table 1.1 assumed that money demand coefficients are homogeneous across euro area countries. This restriction may be particular severe for the short-run dynamics of a money demand function.

[9] Blaes (2009) analyses the dynamics after changes in the monetary policy in more detail.

Table 1.2: Euro area money demand with heterogeneous short-run dynamics

Dependent variable: $\tilde{m}_{it} - \tilde{p}_{it}$			
Long-run money demand:			
	Coeff.	Std. Err.	t-Stat.
$\tilde{y}_{it}$	1.53***	0.10	15.99
$\tilde{r}^{l}_{it}$	-0.40***	0.07	-5.76
Error correction term:	-0.15*	0.08	-1.88
	Test stat.	Prob.-value	
Hausman Test	7.1770	0.0276	
Cointegration test	5.9976	0.0000	

Notes: Results obtained from pooled mean group estimation (PMGE) based on Equation (1.3). The country-specific lag order is chosen using the Akaike criterium with maximum lag order eight. The interest rate measure is the long-term interest rate. The panel cointegration test rejects the null of "no cointegration" at the 1% level, compare Westerlund (2005). See Table 1 for further explanation.

In order to check the robustness of our results, we therefore re-estimate the euro area money demand function applying the pooled mean group estimation (PMGE) introduced by Pesaran, Shin and Smith (1999). In this model the short-run dynamics are allowed to differ between countries but the long-run relationships are restricted to be homogeneous. Advancing on our benchmark specification, the pooled mean group estimation is based on a ARDL-model with heterogeneous short-run dynamics:

$$\begin{aligned}\triangle\left(\tilde{m}_{it} - \tilde{p}_{it}\right) = \delta_i \left[\left(\tilde{m}_{it-1} - \tilde{p}_{it-1}\right) + \beta_1 \tilde{y}_{it} + \beta_2 \tilde{r}_{\ it}\right] + \\ \sum_{j=1}^{p-1} \lambda_{ij} \triangle\left(\tilde{m}_{it-j} - \tilde{p}_{it-j}\right) + \sum_{j=0}^{q-1}\left(\theta_{ij} \triangle \tilde{y}_{it-j} + \phi_{ij} \triangle \tilde{r}_{\ it-j}\right) \\ + d_i + \varepsilon_{it}.\end{aligned} \quad (1.3)$$

The standard Hausman test rejects the null hypothesis of homogeneous short run dynamics at the 5% but not at the 1% significance level. Therefore, it is not obvious that assuming heterogeneous short-run dynamics is actually helpful and that PMGE should be the preferred estimation technique. However, according to the results shown in Table 1.2, the main results obtained for the euro area money demand are not affected by the assumptions about short-run dynamics. The PMGE estimates for both, the long-run income and the interest rate (semi)elasticity are highly significant, plausibly signed and similar to those obtained for the benchmark specification. In fact, neither the somewhat higher point estimate of the income elasticity nor the slightly lower interest elasicity are significantly affected by the estimation procedure.

The role of wealth

Let us now investigate whether our results are also robust with respect to the inclusion of additional variables. According to the literature, wealth is the most critical factor that may have additional effects on long-run money demand. In particular, as Mankiw (1992) already emphasised, income elasticities higher than one could be explained by the omission of wealth in the estimated money demand function. Since both income and wealth increase the total volume of liquid assets that a household can possibly hold, wealth might be a relevant figure in portfolio decisions. Note, however, that it is not indisputable that the effect of wealth on the demand for money is positive, see Boone and van den Noord (2008). A rise in wealth can also cause a decline in money demand due to a substitution effect that is opposed by the positive income effect of wealth. If, for instance, equity prices go up, the households will probably move money into stock markets as the cost of the availability of liquid assets increase. This effect could be observed in the current financial crisis. Conditional on the slump in all asset prices at the trough of the downturn, the attractiveness of money compared to other investment rose.

In accordance with the recent literature, we re-estimate the benchmark specification for euro area money demand by including two different wealth measures, house and equity prices. From a cross-country perspective, the role of wealth can only be assessed if it varies across countries. For house prices country-specific differences are very pronounced. For example, while Spain and the Ireland have experienced a massive housing boom, house prices in Germany and Austria more or less stagnated, see Figure 1.3. In the following, we use the house price indexes published by the ECB and the German Bundesbank as proxies for the house prices in the 10 countries.[10] The second proxy of wealth refers to equity prices. Specifically, we employ the leading national stock price index of the euro area countries under consideration, as indicated by Bloomberg. In fact, there have been notable cross-country variations in stock prices in the euro area during the first years of the monetary

[10]Note that these indexes are only available from 2000 onwards. Not all of these indexes are constructed in the same way but this is the best we can do because there is no EU-harmonised index, yet.

Table 1.3: Wealth effects and the demand for money in the euro area

	Coefficient	Model specification		
		house prices	equity prices	equity prices (with break)
Long-run money demand:	$\tilde{y}_{it}$	1.51** (2.53)	1.51*** (2.82)	1.71*** (2.83)
	$\tilde{r}^{l}_{it}$	-0.42* (-1.72)	-0.71** (-2.35)	-0.89** (-2.49)
	$\tilde{w}_{it}$	0.09 (0.82)	-0.17 (-1.21)	-0.22* (-1.94)
	$\tilde{w}_{it} \times d_{2003}$			0.25 (1.13)
Error-correction term:		-0.11*** (-4.33)	-0.09*** (-4.29)	-0.08*** (-4.08)
Short-run dynamics:	$\Delta\tilde{y}_{it}$	0.65*** (3.06)	0.52*** (2.91)	0.50*** (2.75)
	$\Delta\tilde{y}_{it-1}$	0.61*** (2.76)	0.62*** (3.49)	0.62*** (3.44)
	$\Delta\tilde{r}^{l}_{it}$	0.19*** (4.74)	0.18*** (5.09)	0.19*** (5.33)
	$\Delta\tilde{r}^{l}_{it-1}$	0.08** (2.03)	0.07** (1.99)	0.08** (2.36)
	$\Delta(\tilde{m}_{it-1} - \tilde{p}_{it-1})$	0.04 (0.44)	0.05 (0.91)	0.03 (0.46)
	$\Delta\tilde{w}_{it}$	0.04 (0.37)	-0.02 (-0.59)	-0.02 (-0.87)
	$\Delta\tilde{w}_{it-1}$	-0.04 (-0.42)	0.05** (2.02)	0.05** (1.99)
R^2		0.18	0.18	0.18
Prob. of cointegration test:		0.02	0.03	0.00

Notes: Results obtained from the benchmark specification for money demand augmented by wealth. The time dummy d_{2003} is equal to one from 2003Q1 onwards and zero otherwise to capture a potential time break in the effect of equity prices, compare Figure 1.4. See Table 1 for further explanation.

union, particularly before 2003, see Figure 1.4. Following the suggestion of a referee, we controlled for a potential break in the impact of equity price variations in 2003 and allowed for a time-varying effect of equity prices on long-run money demand.

The results obtained for the wealth-augmented money demand functions are shown in Table 1.3. Apparently, none of our conclusions based on the benchmark specification of euro area money demand is distorted by wealth effects. In spite of the notable cross-country variations in both proxies for wealth, neither equity nor house prices affect the cross-sectional long-run money demand in a significant way, at least not from 2003 onwards.[11] The only significant coefficient refers to the lagged first difference of the cross-country deviation in stock prices. Overall, wealth does not seem to be a major determinant of the movements in the cross-country deviations of euro area money demand.

1.5 Concluding remarks

The (in)stability of the euro area money demand function plays a central role for the importance of money for the monetary policy of the European Central Bank. The current paper investigated the determinants of euro area money demand from a cross-country perspective. To that aim, we employed country-specific data including the national contributions to the euro-area wide monetary aggregates collected from the national central banks. In contrast to the partly mixed results of the empirical literature using aggregated time series data, panel cointegration tests provided evidence in favour of a stable long-run money demand function. In particular, irrespective from the interest rate measure, the estimation procedure, and the inclusion of wealth in the empirical money demand model, the estimated long-run income elasticity of money demand is clearly above one. This strongly confirms earlier evidence on the declining income velocity of money demand in the euro area.

The distinguishing feature of a cross-country perspective on money demand is that aggregated shocks like technological innovations or turmoils of financial markets that hit all countries equally cannot distort estimation results because the estimation is based exclusively on deviations from cross-

[11]We also checked the robustness of our results with respect to country-specific effects of house prices. Allowing different effects for countries with weak and strong growth in house prices shows, however, that house prices are insignificant for both groups of countries. For brevity, results are not presented but are available on request.

country averages. A stable cross-country money demand for the euro area thus indicates that the instability of standard euro area money demand functions could be explained by omitted macro variables. This finding has two important consequences. First, recent research directed to find these omitted macro variables is promising, compare de Bondt (2009). And, second, our results support the renewed interest in the development of monetary aggregates stirred by the recent financial crisis.

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Appendix

Table 1.4: Unit root tests by Pesaran (2007)

Null hypothesis: series contains an unit root		
Variable	Test-Statistic	Prob. value
Real M3	-2.111	0.165
GDP	-1.276	0.920
r^l	-1.131	0.965
r^d	-2.296	0.065
Δ (Real M3)	-5.486	0.010
Δ (GDP)	-5.575	0.010
Δr^l	-4.463	0.010
Δr^d	-5.905	0.010

Notes: This panel unit root test assumes individual unit root processes and allows for cross-sectional dependence; it is conducted using the original data (not cross-sectional demeaned); the selection of the maximum lags is done automatically based on Akaike, Schwarz criteria.

Figure 1.3: High diversity of house price indexes

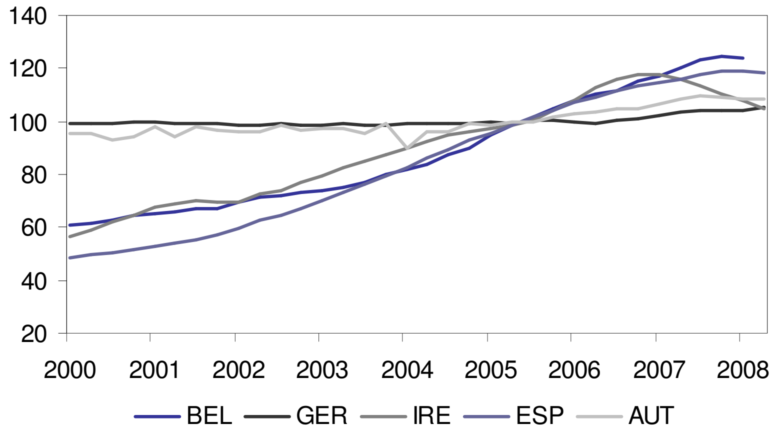
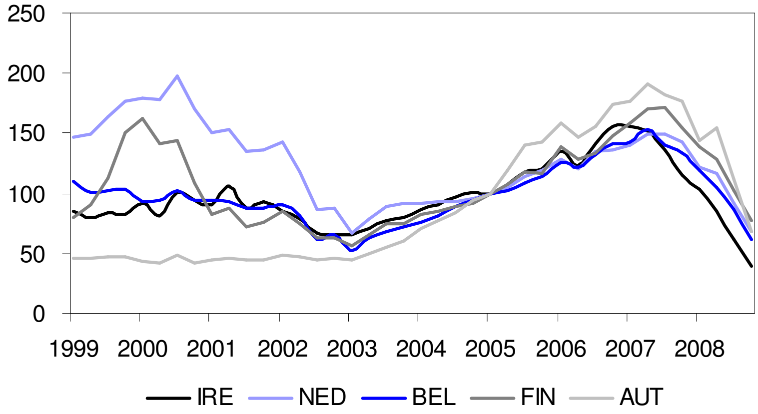


Figure 1.4: Equity leading indexes



Are Bank Loans important for Output Growth?

A Panel Analysis of the Euro Area

Abstract

This paper investigates whether changes in the volume of supplied bank loans have a significant effect on output growth in the euro area. After the significance of the bank lending channel is established, money demand shocks are used as an instrumental variable for loans, following Driscoll (2004). With the application of a cross-country panel estimation, the impact of a change in loan supply on output growth is tested. In contrast to the United States, there is evidence that fluctuations in loans lead to a response in output in the euro area, supporting the credit view.

2.1 Introduction

Is the amount of bank loans still important for output growth? According to the well-known credit view, a reduction of loans leads to less investment and therefore less growth. To the extent that firms can substitute other sources of finance for bank loans, the influence of loans on output is diminished. In the last decade the importance of financial markets has increased worldwide and there is evidence at least for the US economy that the "credit channel" has disappeared (see Perez, 1998).[1] This paper investigates whether bank lending matters for output growth in the euro area, where bank-dependency has traditionally been higher than in the Anglo-American economies (see Ehrmann et al., 2003).

According to Driscoll (2004), the bank-dependency of an economy has three major consequences: firstly, the monetary transmission mechanism works through the markets of bank loans, secondly, bank failures can cause recessions and thirdly, bank regulations may be a source of monetary policy shocks as important as changes in key interest rates.[2]

This paper analyses the impact of loan supply on personal income growth after the foundation of the European monetary union (EMU) until the second quarter of 2008. In extension to this initial sample, the financial crisis (2008Q3 - 2010Q4) is considered as well. Facing the collapse of major banks endangering the whole financial system, the potential influence of a slump in bank lending on the overall economy induced governments and central banks to adopt a number of extraordinary measures. In the past years the refinancing of firms did not only become difficult by the fact that credit conditions of standard bank loans had tightened but also because markets of securitised debt were not accessible for many companies. However, this work will only concentrate on the partial effect of bank loan supply.

The main challenge in the empirical work measuring the influence of loans is to tackle the endogeneity problem. In a model with output as dependent variable, loans are most certainly not exogenous. Following Driscoll (2004), money demand shocks are used as an instrumental variable for the loan supply. In the empirical analysis panel estimation techniques are applied using

[1]The importance of financial markets has also increased in the euro area as it has worldwide. Since the foundation of the monetary union the volume of debt securities has risen from 3.5% of GDP in 1999 to 7.7% in 2007. Financial markets have been strongly deregulated through the law enforcement of the EU with the aim to homogenise.

[2]Compare debate on macro prudential regulation that is gaining importance for the central banks and financial regulators in the aftermath of the financial crisis (e.g. Borio and Shim, 2007, Bini Smaghi, 2009 and N'Diaye, 2009).

the national data of the EMU member states.

In a two stage procedure it is first established whether banks adjust their lending following a money demand shock. These shocks are only a suitable instrument if monetary shocks are transmitted through the banking system. The results confirm the significance of the shocks.

In a second step, the impact of bank lending on the economic activity is estimated. The results of this paper provide strong evidence that changes in the loan supply cause output fluctuations in the euro area, in contrast to the US. Consequently, bonds and bank loans should not be treated as perfect substitutes as done by standard models of growth or business cycles, and monetary policy is transmitted through changes in bank lending, see Bernanke and Blinder (1988). This finding is confirmed when including the crisis period in the sample.

Given the characteristics of the European financial sector compared to the US, this result was expected. Bank loans to the corporate sector have a volume of 57% of GDP in the euro zone, while the ratio is only 11.9% in the US, where even small firms have access to the capital markets.[3] In Europe a lot of banks and companies still cultivate a long-term relationship. The financial markets are less accessible and small and medium-size companies in particular therefore depend on their so-called house bank that is more likely to grant them a credit (see Brissimis and Delis, 2008).

The structure of this paper is as follows. Section 2.2 reviews the literature on the bank lending channel in Europe and on the effect of loans on output growth. Section 2.3 analyses the European banking sector and compares it with the US. This part is followed by a description of the theoretical framework and the methodology of the empirical proceeding in Sections 2.4 and 2.5, respectively. Section 1.4.1 provides the data characteristics. Section 2.7 presents the results and Section 1.5 concludes.[4]

[3]Source: European Central Bank and Federal Deposit Insurance Corporation, see bank balance sheet statistic.

[4]Similar, but independently conducted work was done by Cappiello et al. (2010) and Melzer (2007). Their methodology also builts on Driscoll (2004). The analysis in Melzer (2007) is only based on data from 1999 to 2003 and concludes that economic growth in the euro area is not impacted by loans supply. Cappiello et al. (2010) uses the same data sample horizon as this work. However, they obtained the money demand shocks from national money demand function estimated separately for each country. Furthermore they adopt Driscoll's assumption that interest rates on bonds are equal in all countries and include credit standards from the ECB's Bank Lending Survey in the estimation.

2.2 Literature

Most theoretical approaches to the credit view go back to the work by Bernanke and Blinder (1988). They extended the standard IS/LM-model to an aggregate demand model that includes credit as an equally important variable as money. In their later work Bernanke and Blinder (1992) also found evidence for the importance of loans in the US.

The first part of literature that is introduced in Section 2.2.1 concerns the transmission of monetary policy through the banking sector. This section concentrates on the literature investigating the bank lending channel in Europe. A second branch of literature investigates the importance of bank loans for output growth, see Section 2.2.2. It is important to distinguish between this part of the literature and the first because banks might adjust their lending after a tightening of monetary policy, but if most firms can substitute other sources of finance for loans, the overall effect on the economy will be weak.

2.2.1 Bank lending channel

Whether a bank lending channel is operative and important for the transmission of monetary policy depends on the extent to which banks are reliant on the deposits of their clients. If banks have access to other means of finance through financial markets, the bank lending channel will be less important. The majority of papers aim to identify an operating bank lending channel in one individual country, but in consideration of the foundation of Economic and Monetary Union (EMU) more work recently has focused on monetary transmission in the euro area (e.g. Gambacorta, 2002).

In general, the results are quite mixed for many of the euro zone countries: a bank lending channel is found to be present in Italy, for example by Chiades and Gambacorta (2000), but not in France (Bellando and Pollin (1996)) or the Netherlands (Garretsen and Swank, 1998). In Germany, probably also in other countries, there is contradicting evidence: Barran et al. (1995) do not find evidence that German banks adjust their loan supply after a change in monetary policy. In contrast, Hülsewig et al. (2004) detect an operative bank lending channel.

In empirical work it is difficult to distinguish between loan supply and demand, as one can only observe the changes in the volume of loans and not the driving force. It is problematic because higher interest rates also reduce the loan demand due to increasing costs for the borrower. Therefore no conclusion can be drawn from purely showing that loans react to changes in monetary policy.

Hülsewig et al. (2004) use a vector error correction model (VECM) to estimate loan supply and demand separately.[5] Other researchers use bank-level panel data to circumvent the identification problem: they include bank characteristics to isolate the supply effects. In their regression models the variable that signals the monetary policy, mostly the key interest rate, is interconnected with different bank characteristics (liquidity, size and capitalisation). It is then possible to analyse how individual banks adjust their lending following a monetary policy change depending on factors that influence their supply change (see Kashyap and Stein, 2000).

This approach is also adopted by Ehrmann et al. (2003). They try to identify the reaction of loan supply to monetary policy changes in the euro area as a whole and in different major countries. They find that the influence of monetary tightening is negative and significant for the whole area as well as for the four countries Germany, France, Italy and Spain. The overall reaction of loans to a rise in interest rates by 1 percentage point is around 1%. In Spain and France the reaction is stronger. The characteristics "size" and "liquidity" influence the magnitude of a bank's reaction.

A recent work by Brissimis and Delis (2008) tries to solve the identification problem by estimating the loan supply function directly.[6] The authors test the existence of the bank lending channel in six countries – United States, United Kingdom, Germany, France, Japan and Greece – and conclude that only Greece and Japan have an operating bank lending channel. In France the existence of the channel cannot be completely dismissed.

In contrast to the work introduced above, this paper differentiates between loan demand and supply by regressing loans on regional money demand shocks as done by Driscoll (2004). Due to the fact that the ECB does not react to regional shocks and that the exchange rate between the countries is fixed, the demand shocks immediately take full effect. A positive shock will therefore lead to higher deposits. If the banks depend on their deposits, higher deposits will lead to an increase in bank loans and a lending channel is operative, assuming that the money demand shocks do not influence the loan demand.

[5]In their restrictions on the cointegration relations they impose that the loan supply depends on two different interest rates and the bank capital.

[6]They use bank level data supplied by Bankscope that was found to be problematic by Ehrmann et al. from 1996 to 2003.

While literature had focused on purely identifying the lending channel, the introduction of the euro raised the question whether monetary transmission would change in consequence of the new monetary union. Angeloni and Ehrmann (2003) try to come up with an answer by studying the reaction of bank interest rates for loans and deposits to changes in the money market rates. They conclude that the response to monetary policy in the euro area is increasingly homogeneous.

Altunbas et al. (2007) consider that the creation of EMU induced the growth of securitisation activity in the euro area and thereby reduced the importance of the bank lending channel. Asset securitisation theoretically enables banks to supply more loans relative to their capital and reduces their dependence on deposits for funding. Altunbas et al. (2007) find that a bank that is very active in the securitisation market reacts less to interest rate changes. Overall a 1 percentage point rise in the monetary policy rate leads to a decline in lending of 0.7%, which is lower than Ehrmann et al. (2003) estimated. Therefore the dependence of banks on their deposits decreases with the availability of securitisation.

In contrast to these approaches using bank-level data, this work aims to identify the effects of monetary policy on loan supply with macroeconomic cross-country data. Like Altunbas et al. (2007), it concentrates on post-euro-introduction data.

2.2.2 Bank loans and output growth

Most of the work on growth effects of bank loans concentrates on the US economy. Driscoll (2004) addresses the relevance of bank lending regarding output in the US states. In his panel data analysis he could not find any evidence that a higher supply of loans has a positive impact on output growth.

To circumvent the endogeneity problem of loans Driscoll uses money demand shocks as an instrument. His theoretical framework is a model of open economies under a fixed exchange-rate regime and with one central monetary policy. A state-specific money demand shock will therefore lead to a state-specific change in loans and maybe higher economic growth in that state. The equilibrium interest rate is viewed as exogenous because it is decided for all states by the Federal Reserve Bank. Therefore the real balances will rise in a state after a positive shock. With an active bank lending channel this will cause the volume of loans to rise. If enough firms depend on financing by banks, the higher supply of loans will increase income. This work closely follow his approach and transfer it to the euro zone.

In contrast to Driscoll (2004), Abrams et al. (2003) use a Mundell-Flemming-Model of the 50 US states to verify the influence of bank credit on growth. They arrive at the conclusion that the changes in loan supply have a significant effect on economic growth. It is perhaps problematic that Abrams et al. only account for the endogeneity of loans by lagging all explanatory variables by one period. It is difficult to compare their result with Driscoll's and extract any conclusion valid for today because they only use data up to 1994. The sample period potentially is highly important, as Perez (1998) suggests that loans did influence real income in the past but that this channel disappeared in the 90s.

Peek et al. (2003) are able to identify a significantly positive effect of the loan supply on GDP in the US economy from 1978-1998. They check for loan demand changes by using GDP forecasts. The forecasts are used to account for changes in aggregate demand and therefore also in loan demand.

Turning from the US to Europe, Anari et al. (2001) find evidence of the credit view in their study on Finland. They identify an impact of a bank credit shock on GDP by using a VAR model with GDP, consumer prices, bank credit, export and money supply.[7]

In the current paper, the influence of loans on output growth is investigated for the euro area as a whole: do European companies still depend on financing by banks or has the increase in debt securitisation led to an irrelevance of loan supply for output growth?

2.3 Financial structure in the euro area

The structure of the banking system is important in determining how bank lending responds to monetary policy and how strongly the corporate non-financial sector depends on financing by banks. Looking at the different characteristics of the banking sector in the euro area and the US gives some first indication how important bank loans might be in the monetary transmission process and for output growth.

In the United States banks are less important as financial intermediaries than in Europe. Looking at the ratio of total bank assets to GDP in Table

[7] The results could be influenced by their sample choice. The analysis starts in 1980 and ends 1996; a period in which the country suffered a severe banking crisis. Even in a country with low bank-dependency in general, financial markets cannot compensate a slump in bank loans above a certain threshold.

Table 2.1: Differences in financial structure between the Europe and the US (% of GDP, 2007)

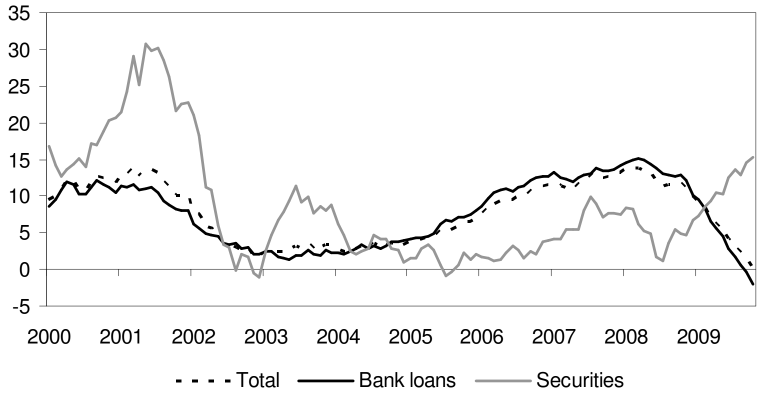
	USA	France	Germany	Italy	Spain	Euro area
Total assets	96.7	435.8	338.4	256.2	369.6	383.3
Bank loans	11.9	46.8	38.3	64.1	113.9	57.1
Debt securities	25.4	15.6	5.0	4.3	1.7	7.7
Market cap.	172.5	171.7	64.2	57.1	154.5	100.7

Notes: "Total assets" are the total assets of the banking sector, source: ECB and Fed; "bank loans" include all loans to the non-monetary financial institutions, source: ECB and Fed, "debt securities" incorporate all sources of external finance via financial markets like bonds, commercial papers, etc., source: ECB, BIS, Fed; "market capitalisation" as published by the International Federation of Stock Exchange; this table is an update of the Table 1 in Ehrmann et al. (2003).

2.1 shows that the US banks are not as active in the value creation process as European banks. In the euro area private corporations strongly depend on financing by their banks. Bank loans here account for 57.7 % of GDP compared with only 11.9 % in the US. By contrast, American companies finance themselves to a great extent via the financial markets, either with debt securities or the emission of shares. The market capitalisation of private companies is 70 per cent higher than GDP whereas in the euro area it is only about as large as output.

However, the importance of financial markets in corporate finance increased rapidly in the last decade in most of the industrial economies. EMU speeded up the liberalisation of financial markets and thereby increased their importance for firms. Therefore the increasing importance of financial markets is a global phenomenon that is intensified by the introduction of the euro as a single currency (see Altunbas et al., 2007). The ratio of debt securities to GDP in the euro area increased from 3.5 % in 1999 to 7.7 % in 2007 (see Ehrmann et al., 2003). EMU induced a process of convergence between the member countries enforced by harmonisation and the market of potential buyers grew through the financial integration: the shares of cross-border holdings of debt securities issued by euro area companies increased from roughly 20 % in 1999 to about 40 % in 2007 (compare ECB Financial Integration Report, 2008). The placement of debt securities, especially corporate bonds, also mitigates the reduction of external finance in periods when the volume of bank loans decreases or grows less dynamically. A large number of companies substituted bonds for loans in 2009, see Figure 2.1. In October 2009 the

Figure 2.1: External finance of non-financial corporations



Notes: data source: ECB; y-axis displays year on year percentage change of external finance; loans: loans from MFI to non-financial corporations in the euro area, securities: debt securities issued by non-financial corporations in the euro area, all currencies combined; total: sum of securities.

total volume of external finance therefore still grew slightly compared with the equivalent month the year before, although loans declined by 2 %. The fraction of finance that is covered by securities varied between 12 and 16 % in the last decade. In the current crisis it is rising again.

Furthermore, it became much easier for a European firm to issue shares, even for small firms, although access to this source of finance is still limited compared with the United States. Market capitalisation has increased especially in Spain and France since 1999, from 77 % to 154.5 % and 111 % to 171.7 % of GDP, respectively (compare Ehrmann et al., 2003).

The differences between the European countries concerning the structure of their financial sector are still sizable. Bank integration in retail and corporate banking is not advancing fast compared with the interbank or bond markets, see ECB Financial Integration Report 2008. The divergence in interest rates is still high. Furthermore, cross-border loans to non-banks only increased in the same way they did to countries outside the monetary union (see Angeloni and Ehrmann, 2003).

As apparent from Table 2.1, in Italy and Spain bank loans are far more important relative to debt securities than in France.[8] The ECB Financial Integration Report 2007 concludes that banks are relatively important in Austria, Belgium, Germany, Ireland and the Netherlands.

[8]The fact that the bank loans in Spain surpass GDP itself should not only lead to the conclusion that banks are very important but that the firms are highly indebted.

Overall, it seems to be far more likely that bank loans in the euro area still have a more significant impact on output growth than in the US, although this impact might have decreased in the past decade.

2.4 Theoretical Framework

The theoretical framework for this analysis is based on Driscoll (2004). He extends the model developed by Bernanke and Blinder (1988) to a panel framework. It is a model that incorporates loans.

He assumes that there are N states indexed by $i \in (1, ..., N)$, which have only one common central bank, consequently only one institution that controls the money market through open-market operations, etc. This central bank, here the ECB, does not react to monetary shocks in one single country but focuses on area-wide developments.[9]

The agents decide whether they want to save and therefore invest in bonds or hold liquid assets, m. The decision how much money (liquid assets) an individual wants to maintain depends on the opportunity costs and his income. The money demand function may be written in the following way:

$$m_{it} - p_{it} = \beta_1 y_{it} + \beta_2 r_{it} + \varepsilon_{it}. \tag{2.1}$$

In this equation all variables are displayed in logarithms apart from the interest rates. The left-hand side shows the dependent variable, the amount of real money in the different countries. The income y and the interest rates r determine demand. The specification of the demand function follows for example Nautz and Rondorf (2010). In the literature different interest rates are used: A long-term rate is included to capture the opportunity cost of holding money, whereas a short-term or deposit rate is accounted for as a proxy of the interest rate on money itself. When a cross-country approach is applied, it has also to be decided whether an interest rate is the same in all countries or varies across countries.[10] In contrast to Driscoll (2004) a long-term bond yield is incorporated as a proxy for the opportunity cost that differs from country to country. It should be fair to assume that the European financial markets are less integrated than in the US. National factors apart from the

[9]Gorter et al. (2010) do not find any evidence that regional developments have an impact on the ECB's monetary policy decisions.

[10]Depending on this decision the r is indexed by an small i or not. The interest rate does not have to be literally the same in all countries. It is sufficient that the capital mobility is high and the exchange rate is fixed because otherwise exchange rate movement influence the return.

common monetary policy are therefore still important and investments are home-biased (see ECB Financial Integration Report, 2008).

The model economy has the standard budget constraint: Total income Y is equal to total expenditure which can be divided into consumption C, investment I, government expenditure G and net exports NX. Consumption depends on the interest rate of bonds r, the interest rate of loans ρ and on income. The level of investment is a function of both interest rates, and government expenditure is assumed to be exogenous. Net exports are driven by the real exchange rate of the euro e, which is the same for all countries, and foreign output $y^{\star}$. The foreign worldwide output that generates the demand for a country's exports is approximately equal for all EMU countries. It only differs by the amount that a country's GDP contributes to worldwide output.

The aggregated demand can be described by:

$$y_{it} = \gamma r_{it} + \theta \rho_{it} + \varpi \, e_t + \xi \, y_t^{\star} + \mu_{it} \tag{2.2}$$

μ is the disturbance term. It models other influences on income like fiscal policy and changes in preferences.

The volume of real loans is determined by supply and demand:

$$l_{it}^{s} = \omega r_{it} + \psi \rho_{it} + \nu \left(m_{it} - p_{it} \right) + w_{it} \tag{2.3}$$

$$l_{it}^{d} = \tau r_{it} + \sigma \rho_{it} + \phi y_{it} + z_{it} \tag{2.4}$$

The banks decide on the loans they want to supply by taking into account the interest rates of bonds and loans and the amount of deposits. The deposits can be seen as a constraint to the total volume of loans that banks are able to grant. ν is therefore expected to have a positive sign. The coefficient of bond interest rate ω should have a negative sign because the higher r, the more money banks will invest in bonds and the less money is assigned to loans. The demand for loans, on the other hand, will increase if r rises as it becomes less attractive for a firm to issue a bond. And the interest rate on loans ρ, of course, has a negative influence on demand because a loan becomes more expensive. The demand for loans also essentially depends on total income.

To analyse the transmission of monetary policy in this economy, it is important to differentiate between the effect via interest rates, the liquidity preference channel, and the bank lending channel. Even if the bank lending channel is not operative (r and ρ are equal), bank loans will react to a change in interest rates but through an adjustment of loan demand.

All equations are specified in deviations from the cross-sectional mean to control for cross-sectional correlation. Factors that influence all countries equally, e.g. innovations, oil price shocks, etc., therefore disappear:

$$\tilde{x}_{it} = x_{it} - (1/N) \sum_{i=1}^{N} x_{it}. \tag{2.5}$$

The model economy can be described by the following four equations:

$$\begin{aligned}
\tilde{m}_{it} - \tilde{p}_{it} &= \beta_1 \tilde{y}_{it} + \beta_2 \tilde{r}_{it} + \varepsilon_{it} && (2.6)\\
\tilde{y}_{it} &= \gamma \tilde{r}_{it} + \theta \tilde{\rho}_{it} + \mu_{it} && (2.7)\\
\tilde{l}^{s}_{it} &= \omega \tilde{r}_{it} + \psi \tilde{\rho}_{it} + \nu \left(\tilde{m}_{it} - \tilde{p}_{it}\right) + w_{it} && (2.8)\\
\tilde{l}^{d}_{it} &= \tau \tilde{r}_{it} + \sigma \tilde{\rho}_{it} + \phi \tilde{y}_{it} + z_{it} && (2.9)
\end{aligned}$$

In equation (2.7) the real exchange rate e and foreign output $y^{\star}$ cancel out because those variables do not vary between the EMU member states. The equations (2.6) - (2.9) can be summarised by the following two equations:[11]

$$\begin{aligned}
\tilde{y}_{it} &= \eta \tilde{l}_{it} + \zeta \tilde{r}_{it} + \varphi z_{it} + \delta \mu_{it} && (2.10)\\
\tilde{l}_{it} &= \iota \tilde{y}_{it} + \kappa \tilde{r}_{it} + \pi \varepsilon_{it} + \varrho z_{it} + \chi w_{it} && (2.11)
\end{aligned}$$

Because this paper investigates whether bank loans determine output growth, the coefficient of loans η is the coefficient of interest. It is equal to $\frac{\theta}{\sigma + \theta\phi}$. The equations (2.10) and (2.11) show that the level of output in this economy depends on the volumes of loans. But the volume of loans is also influenced by the level of output. Loans are therefore endogenous in equation (2.10) as $\tilde{l}_{it}$ is correlated with the error terms μ_{it} and z_{it}. The demand for loans and therefore the volume of loans will be smaller in times when less is produced. But the loan supply might be influenced by output or at least by the expectations of future output, as well. If banks expect the economy to contract, the riskiness of lending money will increase from their point of view and they will tighten their conditions.

[11] For a detailed derivation of the equations (2.10) and (2.11) see Appendix.

2.5 Identification of the model

The aim is to investigate whether growth in the euro area depends on lending by banks. This relation holds to the extent that firms cannot readily substitute other forms of finance for bank loans. The theoretical framework introduced by Driscoll (2004) can easily be transformed to the euro area. Like the United States of America, the euro area can be viewed as a joint federation of open economies under a fixed exchange rate. EMU has one common currency, the euro, and one central bank, the ECB.

According to this framework, the goal is to know whether η in (2.10) is significant. The sign to be expected would be positive. But one cannot simply estimate this equation, as loans are endogenous. To isolate the effect of loans on output, country-specific shocks to money demand, ε_{it}, are used as an instrument for the supply of loans (following Driscoll, 2004). If a bank lending channel is operating, the supply of loans reacts to monetary shocks, ε_{it}, ceteris paribus.

The concept of a monetary union is crucial for the choice of instrument. After a shock to the money held in one country, the ECB will not adjust its monetary policy. A positive shock, for example, means that the deviation of the monetary aggregate from the area-wide average of that specific country increases. As the ECB focuses on the aggregated movements and the exchange rate is also fixed, this shock will translate into higher deposits. If a lending channel exists in the euro area, meaning that banks adjust their lending after changes to the monetary policy which leads to a rise or fall in deposits, banks will supply more loans. In the model framework this means that ν in equation 2.8 is positive and significant. This then causes output to increase if a significant number of firms depend on financing by banks (compare Driscoll, 2004), Section 2. η would be positively significant in this case.

For ε to be a suitable instrument, it is important that the shocks are not correlated with the error terms in equation (2.10), $cov(\varepsilon_{it}, z_{it}) = 0$ and $cov(\varepsilon_{it}, \mu_{it}) = 0$. If this assumption is violated, the estimators will be biased. On the one hand, the coefficients could be biased downward if the money demand shocks ε were correlated with the loan demand shocks z_{it}.[12] This correlation would not be too problematic if the coefficients are positive and

[12] Driscoll gives two examples how this correlation could be caused. First of all if banks tighten their lending conditions and require more deposits as a precondition for lending, the money demand and the lending behavior will be affected. Or it could be the case that the money demand directly affects the loan demand. Agents possibly demand more loans to be able to hold more money after a positive shock ε.

significant. But it is important to keep in mind that they are possibly even higher. On the other hand, the coefficients could also be biased upward if the shocks ε were correlated with future income (compare Driscoll, 2004). This could be the case because M3 contains assets related not only to transaction services and liquidity management but also to short-term investments.[13]

In the following, the methodological procedure is described: first of all, the money demand function of the euro area has to be estimated to obtain the money demand shocks. Following Nautz and Rondorf (2010), the long-term demand function is estimated from cross-country data using an error-correction framework with data from the foundation of EMU onwards. As an opportunity cost of holding money, a long-term interest rate - the yield of ten-year government bonds - is included.

The model is estimated with an Error Correction Model (ECM) including fixed effects based on an ARDL(p,q,q) model:

$$\begin{aligned} \triangle\left(\tilde{m}_{it}-\tilde{p}_{it}\right) &= \delta\left(\tilde{m}_{it-1}-\tilde{p}_{it-1}\right)+\alpha_1\tilde{y}_{it}+\alpha_2\tilde{r}_{\,it}+ \\ & \sum_{j=1}^{p-1}\lambda_j\triangle\left(\tilde{m}_{it-j}-\tilde{p}_{it-j}\right)+\sum_{j=0}^{q-1}\left(\theta_j\triangle\tilde{y}_{it-j}+\phi_j\triangle\tilde{r}_{\,it-j}\right) \\ & +d_i+u_{it}. \end{aligned} \tag{2.12}$$

The residuals of this equation are the shocks to money demand. These shocks are not persistent. They are calculated by subtracting the estimated monetary aggregates from actual.

$$\hat{u}_{it}=\Delta\left(\tilde{m}_{it}-\tilde{p}_{it}\right)-\Delta\,(\widehat{\tilde{m}_{it}-\tilde{p}_{it}}). \tag{2.13}$$

$\hat{u}_{it}$ are the estimated money demand shocks ε_{it} in the model. They should also have the same attributes as ε_{it}.

After the shocks are identified, I follow the two-stage estimation carried out by Driscoll. For that purpose, loans are first regressed on $\hat{u}_{it}$ to see whether there is a bank lending channel in EMU and, accordingly, the monetary shocks are a feasible instrument. If that is indeed the case, the influence of loans on output growth will be estimated using the instrument.

In both stages standard pooled panel estimation techniques are applied

[13] According to Driscoll it would be desirable that M3 contains only assets that pay less interest than the 3-month money market rate, for instance, which is often taken as a proxy for the opportunity cost in the money demand function, the interest rate of the assets that are outside the monetary aggregates.

using first differences because the series GDP and loans contain a unit root[14].

In general, it would not be advisable to use a panel approach in highly integrated markets because, if cross-border activities by banks and private agents are very common, loan supply changes, for example, of German banks could cause the Belgian GDP to grow more rapidly. Fortunately, for loans it is possible to obtain data that only include domestic businesses, see Section 1.4.1. But the cross-border business of banks is not very advanced in the euro area yet either. Although legislation has been harmonised there are still many non-tariff barriers in place such as language, different administration systems, etc. On average, loans to other EMU member states only account for 5.4 per cent of the loans supplied to non-monetary financial institutions.[15]

Concerning the estimation of money demand, cross-border holdings are less important in the euro zone than in the US. Furthermore, the euro zone has the advantage that no single financial center exists that attracts a lot of money from other countries which would potentially bias the estimated money demand function.[16] Driscoll's model can therefore be applied even better to the euro area than to the US.

2.6 Data

The sample consists of data from ten EMU member states on gross domestic product (GDP), loans, interest rates, monetary aggregates, and a measurement of inflation. The selected countries are Belgium, Germany, Ireland, Spain, France, Italy, Austria, Portugal, Finland and the Netherlands which are ten of the eleven founding members of the euro area. Luxembourg is not included because data on monetary balances are not available.[17]

The sample includes data from 1999Q1 to 2008Q2 because the model described in Section 2.4 can only be applied after the introduction of the euro

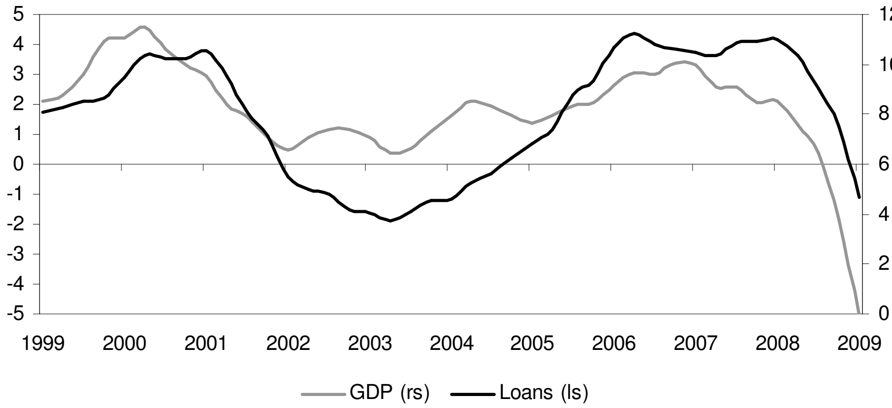
[14] See Appendix, Table 1.4 for results of the unit root tests.

[15] See ECB, national contributions to selected items of the aggregated balance sheet of euro area monetary financial institutions (excluding the euro-system). Data from the end of 2007.

[16] The main European financial center is London which is outside the euro area. Luxembourg – a country where the financial sector accounts for a very high fraction of gross domestic product – is not included in the panel due to data availability: it was not possible to obtain the national monetary aggregates. But the fact that Luxembourg attracts a lot of money from abroad could also be a reason to exclude the country, see Nautz and Rondorf (2010).

[17] A further candidate, Greece, that joined the third stage of the EMU on 1 January 2001 is also excluded due to data problems. The current members of the euro area Slovenia, Cyprus, Malta and Slovakia just recently adopted the common currency and are therefore not incorporated.

Figure 2.2: Loans and GDP move closely together in the EMU



Notes: data source: ECB; y-axis displays the annual growth rates; loans: loans from MFI to private sector in the euro area, GDP: real gross domestic product of the 10 EMU members that are in my sample.

and a common monetary policy. The financial crisis is initially excluded in the analysis because it affected EMU members differently, e.g. the spreads of government bond yields have dramatically increased, making the panel increasingly heterogeneous. Furthermore, including financial crises, in general, could cause an overestimation of the coefficient of bank loans because if markets of debt securitisation are distorted, as in the current crisis, firms can not substitute other forms of external finance for bank loans. However, in a variation of the estimation the sample is extended until the end of 2010.

The series on real GDP, chain-linked and seasonally adjusted, are obtained from the National Bureaus of Statistics.

For the estimation of the money demand the yield of a ten-year government bond is used as a proxy for the interest-rate levels in each country.[18] As series for the dependent variable the nominal monetary aggregates supplied by the national central banks are used. They are to be understood as the national contribution to the eurozone-wide aggregates. Currency is excluded in these series as it cannot be unambiguously assigned to one specific country. This also applies to Mulligan and Sala-i-Martin's (1992) and Driscoll's (2004) estimations.[19] As the demand function of real money is estimated, the nominal values of M3 has to be divided by a price index. For this purpose the national GDP deflators are employed.

[18]Source: Bloomberg

[19]For a more detailed discussion of the data, see Nautz and Rondorf (2010).

The data on loans are obtained from the ECB. The loans of euro area monetary financial institutions (MFI) to each country's national non-MFI are used which include loans to the government, non-financial corporations, and private households.[20] As an alternative, the contribution of the different countries to the area-wide MFI loans to euro area residents is considered. These series contain the cross-border businesses inside the EMU. Here the sub-category "loans to other euro area residents" is selected. These include loans to non-financial corporations, private households, non-monetary financial intermediaries, insurance corporations, and pension funds and therefore exclude loans to MFIs and the general government in contrast to the within-country loans. Unfortunately, it is not possible to obtain data on loans merely to non-financial corporations or households from 1999 onwards for all countries. The ECB only publishes them as of 2003. All loans series are discounted with the national deflators. In Figure 2.2 the annual growth rates of GDP and loans are displayed. They move closely together.

2.7 Empirical Results

Strictly following Nautz and Rondorf (2010), the money demand equation is estimated to obtain the shocks. The magnitude of the coefficients is in line with the literature. The resulting function of the long-term money demand can be written in the following way:[21]

$$\hat{\tilde{m}}_{it} - \hat{\tilde{p}}_{it} = 1.44\,\hat{\tilde{y}}_{it} - 0.58\,\hat{\tilde{r}}_{it}. \tag{2.14}$$

Then the volume of loans is regressed on the independent variables of original equation 2.10 and the instrumental variable, the shocks of money demand. In the estimation two lags of the variables are used following the Akaike criterion.

The results of this first-stage regression in Table 2.2 show that the bank lending channel is operating in the euro area in the period analysed. After a negative shock to money demand, banks adjust their lending as their deposits decline. The coefficients of $\hat{u}$ are positive and significant, regardless of whether loans to non-MFIs within one country or loans to other euro area residents

[20]The data is published in the category "Domestic and cross-border positions of euro area monetary financial institutions" and is described by "the national contributions to selected items of the aggregated balance sheet of euro area monetary financial institutions (excluding the euro-system), broken down into within-country business." See www.ecb.europa.eu.

[21]For detailed results, see Table 1.1 in the Appendix.

Table 2.2: First stage regression: Loans on instrumental variable

Ordinary least-squares with fixed effects		
Number of observations:	330	
Dependent variable:	$\Delta\tilde{l}_{it}$	
	Loans (within country)	Loans (euro area)
$\Delta\tilde{y}_{it-1}$	0.13 (1.041)	0.01 (0.103)
$\Delta\tilde{y}_{it-2}$	-0.036 (-0.278)	-0.087 (-0.851)
$\Delta\tilde{r}_{it}$	0.024 (1.112)	0.007 (0.426)
$\Delta\tilde{r}_{it-1}$	-0.002 (-0.08)	-0.013 (-0.751)
$\Delta\tilde{r}_{it-2}$	-0.006 (-0.261)	0.016 (0.941)
$\hat{u}_{it}$	0.125 (3.867)***	0.146 (5.674)***
$\hat{u}_{it-1}$	0.091 (2.41)**	0.099 (3.342)***
$\hat{u}_{it-2}$	0.064 (1.966)*	0.082 (3.138)**
R^2	0.347	0.394
F-test	9.88	11.84

Notes: l: loans; r: interest rate; y: income, GDP; u: shocks to money demand; "within country loans" contain loans to one country's national non-MFI which include loans to the government, non-financial corporations and private households; "Euro area loans" are defined as loans by MFI to "other euro area residents, these include the loans to non-financial corporations, private households, non-monetary financial intermediaries, insurance corporations and pension funds;*,**,*** indicate significance at the 10%, 5%, 1% confidence level, respectively; t-statistic in parentheses.

are included, see Section 1.4.1. For the within country loans, for example, a growth rate of one percentage point above the cross-country average for shocks to money demand would result in a loan growth rate which is 0.125 percentage points above the cross-country average.

The coefficients of the bond yields are all highly insignificant. Hence, differentiation between the liquidity preference and the bank lending channel is not necessary.[22]

Using the first-stage regression the volume of loans $\Delta\hat{l}_{it}$ is estimated and then the second-stage regression is carried out with the instrumental variable.

The main result of this regression is that loans have a positive impact on GDP no matter which loan series is used, see Table 2.3. If the volume of bank lending increases in one country relative to the average lending, the output growth will - other things being equal - positively deviate from the other countries mean. This implies that firms cannot readily substitute other forms of finance for bank loans. Looking at the coefficients, if loans made by banks within a country rise by one percentage point above the cross-sectional mean, output will grow by 0.206 percentage points. This effect is not negligible, as the standard deviation of loan growth relative to the average is higher than the standard deviation of real income growth: 7.2 percentage points annualised compared with only 3.2 percentage points. The coefficient of the first difference in loans is significant at least at a five per cent confidence level for both series. The first lag and the second lag are significant as well. [23]

In the two series of loans, different effects are operative. The loans to the whole euro area exclude loans to the public sector but include cross-border lending that should not contribute to output growth in the bank's home country. The intuitive conclusion is that public loans do not have such a strong impact on output as loans to the private sector. Cross-border businesses on the other hand still do not account for a high fraction of bank lending in the euro zone. Therefore it cannot ultimately be decided which series to favor.

To check the robustness of the results regarding the identification of the monetary shocks, the two-stage estimation procedure is repeated with different shocks obtained from an alternative specification of the money demand function, equation (2.12). The lag length of the short-term dynamics is ex-

[22] This does not mean that the loan supply does not react to changes in the bond yields in the Euro area countries but only that the country-specific deviations from the average yield do not explain the different lending behavior.

[23] The Hausman test confirms that the model with fixed effects is to be preferred over the standard pooled OLS.

Table 2.3: Second stage regression: GDP on loans (using the instrument)

Ordinary least-squares with fixed effects		
Number of observations:	310	
Dependent variable:	$\Delta\tilde{y}_{it}$	
	Loans (within country)	Loans (euro area)
$\Delta\tilde{y}_{it-1}$	-0.261 (-3.421)***	-0.236 (-3.246)***
$\Delta\tilde{y}_{it-2}$	0.12 (1.57)	0.136 (1.874)*
$\Delta\tilde{r}_{it}$	-0.024 (-0.319)	-0.022 (-0.301)
$\Delta\tilde{r}_{it-1}$	-0.011 (-0.142)	-0.006 (-0.089)
$\Delta\tilde{r}_{it-2}$	-0.015 (-0.195)	-0.016 (-0.217)
$\Delta\hat{l}_{it}$	0.206 (2.702)***	0.168 (2.302)**
$\Delta\hat{l}_{it-1}$	0.163 (2.136)**	0.138 (1.901)*
$\Delta\hat{l}_{it-2}$	0.173 (2.272)**	0.218 (2.994)***
R^2	0.186	0.195

Notes: r: interest rate; y: income, GDP; $\hat{l}$: estimated loans from the first stage regression; “within country loans” contain loans to one country’s national non-MFI which include loans to the government, non-financial corporations and private households; “Euro area loans” are defined as loans by MFI to “other euro area residents, these include the loans to non-financial corporations, private households, non-monetary financial intermediaries, insurance corporations, and pension funds; *,**,*** indicate significance at the 10%, 5%, 1% confidence level respectively; t-statistic in parentheses; to compute the t-statistic, the standard OLS residuals cannot be used but the residuals have to be calculated with the original loan series instead of the instrument.

tended to three as well as to four quarters. Tables 2.7 and 2.8 show that the loans still exert a positive effect on economic growth.[24]

2.7.1 The credit channel in the crisis

In a variation of the investigated time period, the sample is extended to the last quarter of 2010. Consequently, the new sample contains the financial crisis with interbank and debt security markets collapsing, bankruptcies of major banks and slump of production in almost all industrial countries. In Europe, the crisis turned into the government debt crisis in the peripheral countries leading to massively increased spreads of government bond yields in these countries relative to German Bunds.

Overall, the economic developments in the euro area have become increasingly heterogeneous in the last years. The EMU member states were differently affected by the economic crisis. And while some countries, for example Germany, recovered quickly afterwards, growth in other countries was slowed down by the process of unwinding old exaggerations, like housing market bubbles in Ireland and Spain.

Therefore, the panel used in this analysis can be considered less homogeneous than the initial panel. However, the estimation based on the extended sample adds evidence to the above results that suggest that the decline in bank loan supply contributed to the fall in personal income and can partly explain the unequal recovery in the different countries. The aggregated euro area loans to "other euro area residents" decreased by 1% from the last quarter 2008 to the equivalent quarter 2009. While bank lending in most euro zone countries had overcome the temporal drop by the end of 2010, the volume of credits in Ireland was still 18% below the level at the beginning of 2008.

In the empirical analysis the two-stage estimation process is carried out the same way as in Section 2.7. The results of the first-stage regression are displayed in Table 2.9 in the Appendix. The money demand shocks also exhibit a significant impact on bank loans in this extended sample and can therefore still be used as instrumental variable for loan supply. The second-stage regression, regressing economic output on the instrumented bank loans, reveals that the results do not change significantly when including the finan-

[24]Some of the estimated coefficients changed significantly. However, this is most likely not only due to the sensitivity of the results with regard to the residuals used as instruments but also caused by the reduced number of observations. To increase the lag length included in the money demand function, one looses observations at the beginning of the sample period.

Table 2.4: Second-stage regression: GDP on loans (1999-2010)

Ordinary least-squares with fixed effects		
Number of observations:	410	
Dependent variable:	$\Delta\tilde{y}_{it}$	
	Loans (within country)	Loans (euro area)
$\Delta\tilde{y}_{it-1}$	-0.138 (-2.492)**	-0.136 (-2.301)**
$\Delta\tilde{y}_{it-2}$	0.081 (1.465)	0.053 (0.894)
$\Delta\tilde{r}_{it}$	-0.006 (-0.101)	-0.005 (-0.088)
$\Delta\tilde{r}_{it-1}$	0.001 (0.004)	0.003 (0.047)
$\Delta\tilde{r}_{it-2}$	-0.002 (-0.039)	-0.002 (-0.036)
$\Delta\hat{l}_{it}$	0.055 (0.994)	0.211 (3.582)***
$\Delta\hat{l}_{it-1}$	0.298 (5.383)***	0.063 (1.071)
$\Delta\hat{l}_{it-2}$	-0.093 (-0.959)	0.237 (4.018)***
R^2	0.112	0.109

Notes: sample 1999Q1-2010Q4; further explanations see Table 2.3

cial crisis, see Table 2.4. According to the analysis, a change in supply of bank loans causes a change in GDP. Compared to the previous sample, the size of the impact does not vary notably either looking at the sum of coefficients of the estimated loans to euro area residents. However, the sum of coefficients of the domestic loans declined and only the first lagged difference continues to be significant. This could be due to the fact that this series also contains loans to the public sector.

2.8 Conclusion

This paper has investigated whether bank loans cause output growth in EMU. To circumvent the endogeneity problem of loans, money demand shocks are used as an instrumental variable, as in Driscoll (2004). This procedure can be applied because the euro member countries can be viewed as small open economies with fixed exchange rates. The ECB therefore does not react to regional shocks and the banks adjust their lending if they depend on deposits.

The first finding is that the bank lending channel is operative in the euro area. This confirms results of former research (e.g. Altunbas et al., 2007). The estimations show that bank lending reacts to money demand shocks. Here, these are regional shocks. They are used to be able to differentiate between changes in loan demand and supply. But this finding can be transferred to area-wide shocks such as a change in ECB monetary policy. It is therefore advisable that the ECB closely monitors the development of bank lending to analyse the monetary transmission process.

Secondly, the results reveal that changes in the loan supply have a positive impact on growth in the euro area. Thus money demand shocks have real effects under a fixed exchange-rate regime. This confirms the conclusions drawn from the circumstantial evidence given in Section 2.3. Bank loans still play an essential role in the financing of firms although debt securitisation has increased rapidly in the past decade. According to Driscoll (2004) this is different in the United States. There the bank-dependency of firms is lower and consequently the loan supply seems to be insignificant for output growth.

What consequences do my results have? In the current situation where loans are shrinking it suggests that economic recovery can be harmed because firms may not be able to finance profitable projects. Loans to non-financial corporations decreased by 1.9 per cent year-on-year in November 2009. Clearly, the demand for loans falls naturally in such a severe recession, but there is also evidence that the banks supply fewer loans, see monthly Bank Lending Survey by the ECB. To prevent a reduction in loans from decelerating growth in the coming years, everything possible should be done to solve the problems of the banking sector.

Furthermore, changes in regulation can have negative effects. New legislation that requires banks to hold more core capital for each loan granted or the emplacement of a leverage ratio will inhibit banks - other things being equal - from supplying as many loans as before and therefore decelerate growth. However, such regulations might be essential to prevent financial crises which most likely will have even worse effects.

Further work needs to be done to investigate the short and long-term effects of loan supply and to differentiate between the sub-categories of loans. Mortgage loans, for example, might have a positive effect in the short run but can cause housing price bubbles in the long run. As time passes, it will be possible to analyse the impact of loans to non-financial private corporations separately in a couple of years as the data sample of the ECB increases.

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Appendix

Table 2.5: Unit root tests

Null hypothesis: Unit root			
	Im, Pesaran and Shin test		Pesaran test
Variable	W-Statistic	Prob. value	Prob. value
Loans	1.661	0.952	0.725
GDP	4.699	1.000	0.920
Demand shocks	-8.866	0.000	0.010
Δ (Loans)	-4.471	0.000	0.010
Δ (GDP)	-8.249	0.000	0.010

Notes: Both panel unit root tests assume individual unit root processes, the selection of the maximum lags is done automatically based on the Akaike-criterion, Newey-West bandwidth selection is applied using Bartell kernel. The Im, Pesaran and Shin test is applied using the cross-sectional demeaned data. To check the robustness of the result the unit root test by Pesaran (2007) is used. It is conducted with the orginal data and allows for cross-sectional dependence.

Derivation of equation (2.10) and (2.11):

The model economy can be summarised by the following equations, see equations (2.6) - (2.9):

$$\tilde{m}_{it} - \tilde{p}_{it} = \beta_1 \tilde{y}_{it} + \beta_2 \tilde{r}_{it} + \varepsilon_{it} \tag{2.15}$$

$$\tilde{y}_{it} = \gamma \tilde{r}_{it} + \theta \tilde{\rho}_{it} + \mu_{it} \tag{2.16}$$

$$\tilde{l}^{s}_{it} = \omega \tilde{r}_{it} + \psi \tilde{\rho}_{it} + \nu \left(\tilde{m}_{it} - \tilde{p}_{it} \right) + w_{it} \tag{2.17}$$

$$\tilde{l}^{d}_{it} = \tau \tilde{r}_{it} + \sigma \tilde{\rho}_{it} + \phi \tilde{y}_{it} + z_{it} \tag{2.18}$$

Solve equation (2.18) for ρ_{it} and insert it together with equation (2.15) into equation (2.17):

$$\begin{aligned}
\tilde{l}_{it} &= \omega\tilde{r}_{it} + \frac{\psi}{\sigma}\left(\tilde{l}_{it} - \tau\tilde{r}_{it} - \phi\tilde{y}_{it} - z_{it}\right) + \nu\left(\beta_1\tilde{y}_{it} + \beta_2\tilde{r}_{it} + \varepsilon_{it}\right) + w_{it} \\
\tilde{l}_{it} &= \frac{\psi}{\sigma}\tilde{l}_{it} + \left(\omega - \frac{\tau\psi}{\sigma} + \nu\beta_2\right)\tilde{r}_{it} + \left(\nu\beta_1 - \phi\frac{\psi}{\sigma}\right)\tilde{y}_{it} - \frac{\psi}{\sigma}z_{it} + \nu\varepsilon_{it} + w_{it} \\
\tilde{l}_{it} &= \frac{\sigma}{\sigma-\psi}\left[\left(\omega - \frac{\tau\psi}{\sigma} + \nu\beta_2\right)\tilde{r}_{it} + \left(\nu\beta_1 - \phi\frac{\psi}{\sigma}\right)\tilde{y}_{it} - \frac{\psi}{\sigma}z_{it} + \nu\varepsilon_{it} + w_{it}\right] \\
\tilde{l}_{it} &= \kappa\tilde{r}_{it} + \iota\tilde{y}_{it} + \varrho z_{it} + \pi\varepsilon_{it} + \chi w_{it}
\end{aligned}$$

with $\kappa = \frac{\sigma}{\sigma-\psi}\left(\omega - \frac{\tau\psi}{\sigma} + \nu\beta_2\right)$, $\iota = \frac{\sigma}{\sigma-\psi}\left(\nu\beta_1 - \phi\frac{\psi}{\sigma}\right)$, $\varrho = -\frac{\psi}{\sigma-\psi}$, $\pi = \frac{\sigma\nu}{\sigma-\psi}$ and $\chi = \frac{\sigma}{\sigma-\psi}$.

Substitute ρ_{it} in equation (2.7):

$$\begin{aligned}
\tilde{y}_{it} &= \gamma_2\tilde{r}_{it} + \frac{\theta}{\sigma}\left(\tilde{l}_{it} - \tau\tilde{r}_{it} - \phi\tilde{y}_{it} - z_{it}\right) + \mu_{it} \\
\tilde{y}_{it} &= -\frac{\theta\phi}{\sigma}\tilde{y}_{it} + \frac{\theta}{\sigma}\tilde{l}_{it} + \left(\gamma - \frac{\theta\tau}{\sigma}\right)\tilde{r}_{it} - \frac{\theta}{\sigma}z_{it} + \mu_{it} \\
\tilde{y}_{it} &= \frac{\sigma}{\sigma+\theta\phi}\left[\frac{\theta}{\sigma}\tilde{l}_{it} + \left(\gamma - \frac{\theta\tau}{\sigma}\right)\tilde{r}_{it} - \frac{\theta}{\sigma}z_{it} + \mu_{it}\right] \\
\tilde{y}_{it} &= \eta\tilde{l}_{it} + \zeta\tilde{r}_{it} + \varphi z_{it} + \delta\mu_{it}
\end{aligned}$$

with $\eta = \frac{\theta}{\sigma+\theta\phi}$, $\zeta = \frac{\sigma}{\sigma+\theta\phi}\left(\gamma - \frac{\theta\tau}{\sigma}\right)$, $\varphi = -\frac{\theta}{\sigma+\theta\phi}$ and $\delta = \frac{\sigma}{\sigma+\theta\phi}$.

Table 2.6: Money demand function of the euro area

Dependent variable:	Real M3	
Long-run money demand:	$\tilde{y}_{it}$	1.44*** (2.64)
	$\tilde{r}_{it}$	-0.58** (-2.11)
Error-correction term:		-0.09*** (-4.21)
Short-run dynamics:	$\Delta\tilde{y}_{it}$	0.56*** (3.51)
	$\Delta\tilde{y}_{it-1}$	0.58*** (3.66)
	$\Delta\tilde{r}_{it}$	0.16*** (4.71)
	$\Delta\tilde{r}_{it-1}$	0.06** (2.08)
	$\Delta\left(\tilde{m}_{it-1}-\tilde{p}_{it-1}\right)$	-0.01 (-0.18)
R^2		0.17
Prob. of cointegration test		0.00

Notes: r: interest rate, 10-year yield of government bonds; y: income, GDP; *,**,*** indicate significance at the 10%, 5%, 1% confidence level respectively; t-statistic in parentheses; estimated model (equation 2.12): $\triangle\left(\tilde{m}_{it}-\tilde{p}_{it}\right)=\delta\left(\tilde{m}_{it-1}-\tilde{p}_{it-1}\right)+\alpha_1\tilde{y}_{it}+\alpha_2\tilde{r}^{\,l}_{it}+\sum_{j=1}^{p-1}\lambda_j\triangle\left(\tilde{m}_{it-j}-\tilde{p}_{it-j}\right)+\sum_{j=0}^{q-1}\left(\theta_j\triangle\tilde{y}_{it-j}+\phi_j\triangle\tilde{r}^{\,l}_{it-j}\right)+d_i+\varepsilon_{it}$; As cointegration test the Westerlund (2005) test is applied. It tests null hypothesis of no cointegration against the alternative that the majority of cross-sectional units cointegrated.

Table 2.7: Variation of the second stage regression (1)

Monetary demand shocks are used as an instrument for loans - money demand function with 3 lags		
Number of observations:	300	
Dependent variable:	$\Delta\tilde{y}_{it}$	
	Loans (within country)	Loans (euro area)
$\Delta\tilde{\mathrm{y}}_{\mathrm{it}-1}$	-0.257 (-3.572)***	-0.261 (-3.777)***
$\Delta\tilde{\mathrm{y}}_{\mathrm{it}-2}$	0.088 (1.214)	0.092 (1.331)
$\Delta\tilde{\mathrm{r}}_{\mathrm{it}}$	-0.020 (-0.281)	-0.022 (-0.312)
$\Delta\tilde{\mathrm{r}}_{\mathrm{it}-1}$	-0.013 (-0.178)	-0.011 (-0.162)
$\Delta\tilde{\mathrm{r}}_{\mathrm{it}-2}$	-0.021 (-0.297)	-0.019 (-0.286)
$\Delta\hat{\mathrm{l}}_{\mathrm{it}}$	-0.007 (-0.102)	-0.056 (-0.818)
$\Delta\hat{\mathrm{l}}_{\mathrm{it}-1}$	0.203 (2.821)***	0.099 (1.427)
$\Delta\hat{\mathrm{l}}_{\mathrm{it}-2}$	0.203 (2.822)***	0.248 (3.588)***
R^2	0.178	0.181

Notes: See Table 2.3.

Table 2.8: Variation of the second stage regression (2)

Monetary demand shocks are used as an instrument for loans - money demand function with 4 lags		
Number of observations:	290	
Dependent variable:	$\Delta\tilde{y}_{it}$	
	Loans (within country)	Loans (euro area)
$\Delta\tilde{y}_{it-1}$	-0.241 (-2.879)***	-0.252 (-3.702)***
$\Delta\tilde{y}_{it-2}$	0.085 (1.020)	0.104 (1.530)
$\Delta\tilde{r}_{it}$	-0.018 (-0.225)	-0.022 (-0.316)
$\Delta\tilde{r}_{it-1}$	-0.013 (-0.153)	-0.007 (-0.113)
$\Delta\tilde{r}_{it-2}$	-0.008 (-0.097)	-0.011 (-0.154)
$\Delta\hat{l}_{it}$	-0.134 (-1.605)	-0.002 (-0.035)
$\Delta\hat{l}_{it-1}$	0.353 (4.220)***	0.242 (3.555)***
$\Delta\hat{l}_{it-2}$	-0.264 (-3.154)***	0.072 (1.061)
R^2	0.189	0.179

Notes: See Table 2.3.

Table 2.9: First stage regression: Loans on instrumental variable (1999-2010)

Ordinary least-squares with fixed effects		
Number of observations:	430	
Dependent variable:	$\Delta\tilde{l}_{it}$	
	Loans (within country)	Loans (euro area)
$\Delta\tilde{y}_{it-1}$	0.081 (0.781)	0.035 (0.401)
$\Delta\tilde{y}_{it-2}$	0.128 (1.234)	0.125 (1.428)
$\Delta\tilde{r}_{it}$	-0.003 (-0.673)	-0.009 (-2.102)**
$\Delta\tilde{r}_{it-1}$	-0.006 (-1.056)	-0.006 (-1.342)
$\Delta\tilde{r}_{it-2}$	-0.017 (-2.647)***	-0.006 (-1.188)
$\hat{u}_{it}$	0.134 (4.014)***	0.147 (5.163)***
$\hat{u}_{it-1}$	0.151 (3.65)***	0.127 (3.631)***
$\hat{u}_{it-2}$	0.059 (1.767)*	0.079 (2.790)**
R^2	0.228	0.234

Notes: sample 1999 - 2010; further explanations see Table 2.2

The Liquidity Effect on the Swiss Franc Libor during the Financial Crisis

Abstract

This paper aims to determine what drove the three-month Swiss Libor in these unusual times with repo rates at zero and the leeway to lower the key interest rate being exhausted. It investigates whether the enormous liquidity created through the currency interventions by the Swiss National Bank has affected the interbank lending rates during the financial crisis. The results reveal that the liquidity supplied contributed to the fall of the Libor. Additionally, the changes in credit default risk of banks and the global uncertainty had a significant impact on the Libor.

3.1 Introduction

Since the turmoils in the money markets have started in August 2007 central banks around the world resolved a set of unconventional measures: they provided more liquidity and for longer periods as the interbank lending rates, for example the three-month Libor, had increased to an unusually high level compared to the overnight rates. The Swiss National Bank (SNB) was no exception as far as it also dramatically increased the monetary base, especially through the currency market interventions that it adopted in March 2009.

The aim of this paper is to identify the determinants of the Swiss franc Libor throughout the crisis from 2007 to 2010. It addresses the question whether the liquidity supplied by the Swiss National Bank helped to lower the Libor. Thereby this work contributes to the discussion in the literature about the impact of the liquidity facilities adopted by the central banks, e.g. Taylor and Williams (2009) and Fleming et al. (2010). The enormous amount of money directly provided by the central banks to the corporate banks possibly decreased the demand for interbank loans and could have additionally let to a higher supply, both resulting in lower interest rates, see Christensen et al. (2009).[1]

The Swiss three-month Libor has declined by over 300 basis points since the climax of the financial crisis in October 2008. This fall cannot solemnly be explained by the fact that the SNB lowered its target rate for the Libor - its key interest rate - from 2.75% to 0.25%. The central bank's main operational interest rate, the one-week repo rate, already reached zero in December 2008. Nevertheless, the Libor continued to decrease to roughly 0.10%, clearly below its monetary policy target rate, in June 2010. We explore whether the liquidity supplied by the SNB contributed to this fall.

The results in the literature concerning the effectiveness of the liquidity facilities adopted in the crisis are mixed. Most research, so far, analyses the impact of the Term Auction Facility (TAF) and other facilities by the US central bank on the short-term interest rates, e.g. Wu (2008), Taylor and Williams (2009) and McAndrews et al. (2009). According to Wu (2008) the different findings result from the discrepancy in the empirical method used:

[1] Those above papers build the literature regarding the liquidity effect, like Cochrane (1989), Christiano and Eichenbaum (1991), Lastrapes and Selgin (1995), etc. The existence of the broader liquidity effect - the short-term effect of money circulating in the economy on interest rate - is taken for granted by many economists and is therefore incorporated in business cycles models and models to explain the operating of monetary policy although its existence is not clearly proven. Kim and Ghazali (1998), for instance, investigate the effect of liquidity in five G7 countries and find an effect in only four of them.

some researchers, like Christensen et al. (2009) use factor models, others apply event-studies, e.g. Taylor and Williams (2009) and McAndrews et al. (2009). In contrast to the authors above Hirose and Ohyama (2010) use a structural model to investigate the effects of the commercial paper operations conducted by the Bank of Japan.

The difficulties to identify an impact of the money supplied in generous amounts to the banks could be caused by the endogeneity of money. The liquidity supplied could be endogenous if the central banks react to changes in the interest rates. This is not unlikely taking into consideration that the facilities like the TAF were designed to ease the tensions in the money markets which are generally reflected by an increase in the interest rates. Analysing the case of Switzerland has the distinguished feature that the liquidity is mainly generated through currency interventions. Here the SNB supplies liquidity depending on the movements of the Swiss franc exchange rate and not in response to the changes of the Libor. This allows to apply standard OLS estimation techniques treating the monetary base as exogenous.

This work builds on other research concentrating on the operating of Swiss monetary policy, like e.g. Jordan and Kugler (2004), Jordan et al. (2009) and Abbassi et al. (2010). This paper, however, focuses on the monetary policy in the extraordinary times with the SNB's main operational interest rate at zero. The empirical analysis confirms the result of former research that the target rate and the one-week repo rate are important drivers of the three-month Libor in the first part of the crisis including the Lehman breakdown. In a second sub-sample it is investigated what determined the Libor after these interest rates have dropped to their lower boundaries over the course of the crisis. According to the estimation, the massively increased monetary base decreased the Swiss interbank lending rate. Additionally, the three-month US-Libor, the credit default risk and global risk perception are detected to have a significant impact on the Libor.

The SNB also acknowledges the liquidity effect, compare SNB (2010): According to Hildebrand, the president of the SNB, the fall of interest rates clearly signals that the banking system had available a great amount of liquidity. Danthine, another member of the Swiss monetary policy council, added that the liquidity supplied to the market had caused the short-term interest rates to decline. This paper will deliver a prove for these claims.

The structure of this paper is as follows: Section 3.2 summarises how the Swiss monetary policy is implemented and describes the way the SNB conducted its monetary policy in the crisis. Section 3.3 is concerned with the liquidity effect on interbank interest rates and in Section 3.4 the potential drivers of the Swiss franc Libor are analysed. Then Section 3.5 presents the empirical results. Finally, Section 1.5 concludes.

3.2 The implementation of Swiss monetary policy

3.2.1 How the SNB steers the Libor

The Swiss National Bank adopted a new monetary policy framework in 2000. It moved from monetary targeting to the goal of price stability. Price stability is defined as an inflation rate above zero and below 2%. In contrast to the classical inflation targeting there is no exact time horizon assigned in which the inflation rate has to fulfil the definition of price stability. According to SNB (2007) that describes this concept with "constrained discretion", this gives the central bank more flexibility and political independence. The Swiss monetary policy framework and inflation targeting have in common that inflation forecasts by the central bank play a prominent role. The SNB conducts an inflation forecast for up to twelve quarters based on the assumptions of an unchanged key interest. This publicly available forecast is an important guideline for the monetary policy decision but there is no automatism that e.g. the central bank will rise interest rates in case the inflation rate is envisaged to increase above to 2% in the forecast period.

The SNB implements its monetary policy stance by announcing a target range of 100 basis points for the three-month interbank market rate (3m Libor). The central bank aims to hold the Libor close to the midpoint of the target range.[2] Usually the monetary policy meeting takes place every three months in March, June, September and December but there have also been extraordinary target changes between the standard SNB statements. The three month maturity of the key interest rate has the consequence that rate expectations (e.g. an expected increase of the target rate in three month time) influences the interbank market rate immediately after the previous meeting. Therefore deviations of the Libor from its target do not always reflect a mismanagement of expectations, see Abbassi et al. (2010).

Compared to other western central banks the maturity of the Swiss key interest rate is quite unusual. The European Central Bank (ECB), for in-

[2]In 2003 and 2009, respectively, the SNB scaled down the bandwidth of the target range from 100 to 75 basis points. In both cases the target range was 0-0.75% and exceptionally, the Libor rate aimed for was not the midpoint of the range but 0.25% .

stance, sets a minimum bid rate for the one week repo operation and the Federal Reserve System of the United States (Fed) announces a target rate for the federal funds rate, the overnight rate that banks charge each other. This unconventional target gives the SNB the ability to react to exchange rate, financial market or economic shocks flexible without changing the general monetary policy direction, see Jordan and Kugler (2004). According to Jordan et al. (2009) the targeting of the Libor has also the advantage that the Libor reflects the actual borrowing costs of the economy because the Libor is the rate of unsecured interbank lending and therefore is influenced by credit and liquidity risks.

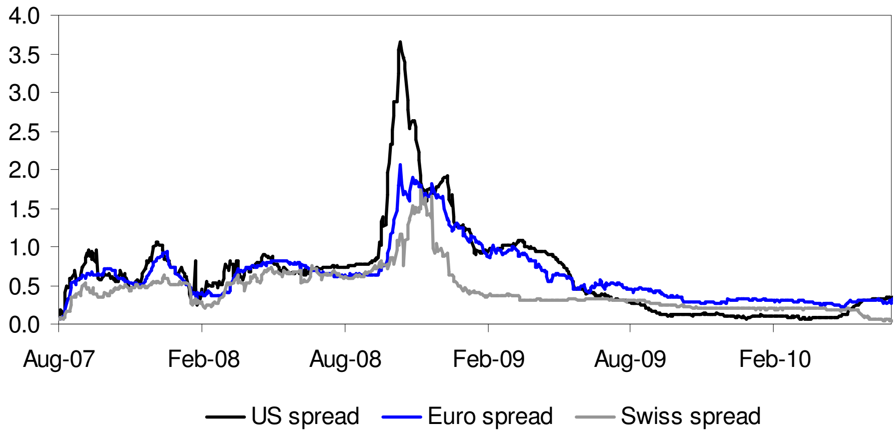
The SNB steers the Libor with daily monetary market operations with different maturities. In normal times the interest rates in these repo operations are the main determinants of the 3m Libor, see Jordan et al. (2009). From 2004 onwards the SNB mainly conducted one-week repo operations; roughly 90% of the auctions were done with one-week maturity. The SNB executes fixed rate tender auctions. In contrast to the ECB it has not experienced any problems with overbidding, see Nautz and Oechssler (2006).

The Libor is not solemnly driven by the repo rates. Jordan et al. (2009) among others find that the allotment ratio (ratio of bid amount in the repo operations to the allotted amount) has a significant impact on the Libor: a higher allotment ratio decreases the Libor, others thing being equal. Furthermore their results suggest that, in contrast to other countries, the VIX index has a negative impact on the three-month interbank rate caused by Switzerland's function as a safe haven. There also exists a "words channel", i.e. the announced target rate itself also has an influence on the Libor, see Jordan and Kugler (2004) and Abbassi et al. (2010). A special case of the words channel is the surprise of the market participants at the day of the monetary policy meeting which is found to be significant as well.

3.2.2 Crisis measurements

After the bankruptcy of Lehman Brothers in October 2008 and the uncertainty shock that went along with it, the interbank market broke down and Libor rates worldwide increased dramatically. The Swiss franc Libor rose from the target rate of 2.75% in mid September to 3.13% on October 10th. Contemporary, coordinated actions between the major central banks including the Swiss National Bank took place: on October 8th they cut the key interest rates and five days later they announced that the US-dollar repo

Figure 3.1: Swiss Libor-OIS spread comparatively low



Notes: The figure shows the Libor-OIS spreads of the US, euro area and Switzerland as published by Bloomberg. The Libor-OIS spread is the difference between the three-month Libor and the overnight indexed swap rate.

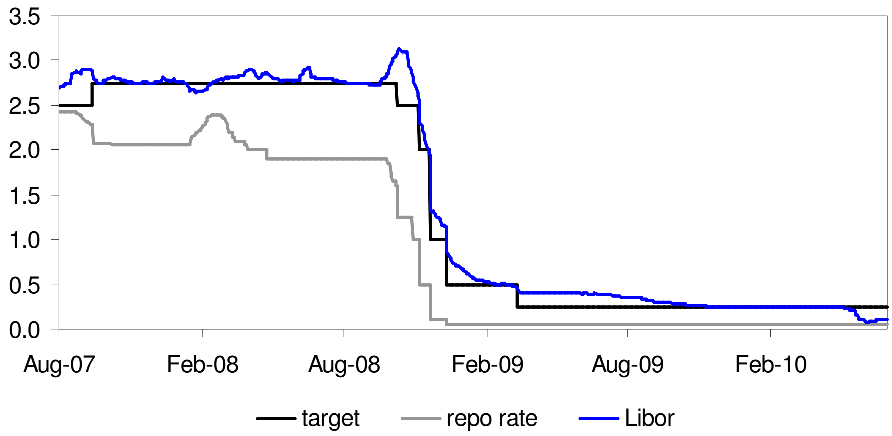
auctions initiated in December 2007 would be carried out with full allotment.

Compared to other central banks the SNB has been relatively successful in bringing down the Libor-OIS spread, see Figure 3.1. Furthermore the Libor only left the target range for a relatively short period of ten days. As pointed out by Abbassi et al. (2010), the SNB had the great advantage that it did not have to change its operational target in the crisis in contrast to other central banks, like the ECB which put more emphasis on the management of longer-term money market rates than usually. There was no confusion about the intentions of Swiss monetary policy and the market participants were used to the target rate as an orientation for the rates that they charge each other.

In the months following the Lehman bankruptcy the SNB lowered the mid of its target range from 2.75% to only 0.25% in March 2009, see Figure 3.2. To steer the Libor, the SNB cut the one-week (1w) repo rate from 1.9% to virtually zero (0.05%) in December 2008. The Libor fell to 0.86%. The widened spread between Libor and repo rate importantly contributed to this decline, see Abbassi et al. (2010). Their findings suggest that during the financial crisis the term-spread, i.e. the spread between the 3m Libor and the 1w repo rate, is an important determinant of the Libor.

Before the first tensions in the money markets in August 2007 the average term-spread was just 21 basis point, interbank market and repo rate moved along quite smoothly. During the crisis uncertainty and increased counter-party risk led to an increase of the Libor well above its target rate. On October

Figure 3.2: Main interest rates reflecting the monetary policy



Notes: The figure displays the three-month Swiss Libor, its target rate and the one-week repo rate of the repo auction by the SNB.

8th the SNB cut the key interest rate from 2.75% to 2.5% and lowered the repo rate from 1.6% to 1.25% in the following days, see Figure 3.2. The resulting term-spread of 185 basis points was higher than the premium required by the market and therefore helped to bring down the Libor to the value where the term-spread is equal again to the premium on the 1w repo rate that banks charge it each other for a unsecured loan of three month. The premium is determined by uncertainty, the different maturity, counter-party and liquidity risk. The Libor fell from 3.13% to 2.86% by end of October. This procedure continued till December 11th when it reached its natural limit - the zero interest rate boundary: the SNB cut the target rate to 0.5% and the repo rate to 0.05%. The Libor was at 0.86% by then and reached 0.70% in the following days. To steer the Libor the central bank could no longer hark back to set the repo rate lower.

On top of the interest rate cuts the Swiss central bank adopted unconventional measurements, also called quantitative easing, see SNB (2008). The repo tender operations have been proceeded with full allotment since the end of October 2008. The SNB also conducted extra repo auctions with non-standard maturities, from three month up to one year. Furthermore the SNB carried out currency swaps with the ECB and the Polish central bank from October and November 2008, respectively, till the end of January 2010 to ease the pressure on the franc and to calm down the European money market. The swap agreements and the full allotment most likely helped to lower the Libor, see Jordan et al. (2009).

In March 2009 the SNB announced that it would intervene in the currency market to prevent a further appreciation of the Swiss franc against the euro. The franc by then had appreciated roughly 9% against the euro since the beginning of the crisis and thereby increased the deflation risks.[3] These steps taken by the central bank are in line with the literature, e.g. Clouse et al. (2000), that regards currency interventions as on way of conducting the monetary policy more expansive when facing deflation risks with interest rate at zero. In the next 15 month the central bank's purchases of euro assets in exchange for the Swiss currency led to a massive boost of franc liquidity. This new money was available to the banks at zero interest rate. In the following we investigate the effect of this currency market interventions had on the monetary market and whether they have caused the drop of the Libor.

3.3 The effect of liquidity on the interbank rates

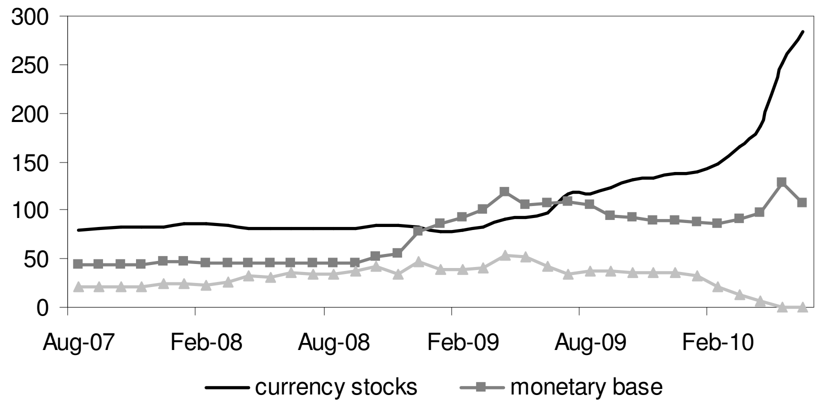
The main drivers of the 3m Libor detected by the literature cannot explain the fall of the Swiss interbank rate: the repo rate reached virtually zero in December 2008, the term-spread could therefore not be increased further and after the last key interest rate change in March 2009, the target rate remained constant at 0.25%. Nevertheless the Libor reached its target in November 2009 and even decreased further until June 2010 (0.11%). We explore to what extent this could be due to the massive liquidity created over the course of the unconventional policy adopted the SNB.

Compared to September 2008 the monetary base has increased by roughly 160%, at the peak. In the first phase of the crisis the repo operations primarily contributed to this rise. Due to the massive franc liquidity created by the currency market interventions, the foreign exchange holdings are responsible for the major fraction of the newly created liquidity after April 2009, see Figure 3.3.[4]

[3]Currency market interventions have an impact on consumer prices. One can differentiate between two channels. Firstly and most obvious, through stopping the appreciation of the own currency the central bank prevents that deflation is imported as an appreciation causes falling import prices. However, the exchange rate pass through on the consumer prices is quite small. An increase of the exchange rate by 1% only leads to a rise in prices of 0.18 percentage points, see Stulz (2007). Secondly, currency market interventions create franc liquidity and thereby increase the monetary base. If the monetary transmission is working properly, this will cause higher growth rates of the broader monetary aggregates and higher inflation in the long run.

[4]The interventions most likely crowed out the standard open market operations. The volume of the outstanding repo operations dropped below its pre-crisis level in February

Figure 3.3: Monetary base and its components



Notes: Monetary base (M0) and its components the currency stocks and the volume of outstanding open market operations (repos), in billion CHF.

How could the money supplied potentially lower the interest rates? Following Taylor and Williamson (2009), the interbank rates world wide increase in the financial crisis due to counter-party risks, liquidity risk and the increased importance of reporting numbers that enforced the bank's goal to show high liquidity reserves. The liquidity risk reflects the banks uncertainty how much liquidity they will need as the likelihood of a liquidity shock increased. Even healthy banks might face higher refinancing cost following such an external shock, so that they will hoard their money, see Eisenschmidt and Tapking (2009). The additional liquidity facilities adopted by the central banks could potentially ease the liquidity risk and thereby lower the Libor through two channels, compare Christensen et al. (2009). These measures might decrease the Libor rate because the money supplied in the interbank market increases as banks have a greater assurance that they will meet their own liquidity need. They know they can always get extra liquidity from the central bank, only restricted by their availability of collaterals. Therefore the demanded interest rates potentially drop. Furthermore the demand in the interbank market will be lower because the liquidity provided through the new facilities is a substitute for the financing through interbank loans.

Identifying the short-term effect of money supplied on interest rates - despite the potential long-term neutrality of money - has been the task of

2010 despite the interest rate of only 0.05% and full allotment. The total liquidity provided through open market operations - repo operation minus absorbing operations - even turned negative in March sterilising some of liquidity created by other operations such as the currency market interventions.

numerous research papers long before the crisis. There is some evidence for a liquidity channel in the Swiss interbank market in the literature. Kim and Ghazali's (1999) results suggest the presence of a liquidity channel in Switzerland at least from 1975 to 1995. Kugler (2002) shows that the liquidity created through the temporary exchange rate peg at the end of the 70s let to decline of the short-term interest rates. Kugler (2004) identifies a negative liquidity effect for interest rate up to four quarters using a VAR with data from 1974 till 1999.

In the light of the crisis several recent papers analyse the impact of the TAF (term auction facility) programme on the US-Libor. Taylor and Williamson (2009), for instance, concludes that there is no evidence that the additional liquidity has reduced the interest rates. However, the results of McAndrews et al. (2008), Wu (2008) and Christensen et al. (2009) suggest that the central bank liquidity facilities helped to lower interbank lending rates. Wu speculates that the different results are among others caused by the discrepancy in the estimations: Taylor and Williamson (2010) and McAndrews et al. (2008), for example, use different event-study approaches, whereas Wu himself analyses the influence of the liquidity programmes on all trading days with a time series approach. The studies also differ in regard to how or whether at all they control for counter-party risk, mortgage default risk or other uncertainties.

3.3.1 Endogeneity of the liquidity supplied

Furthermore, the difficulties to prove the existence of a liquidity impact could originate from the endogeneity of policy changes, see e.g. Hamilton (1997). If a central bank, for instance the Fed, supplies more liquidity to the market in case the Fed funds rate deviates from its target, the market will anticipate this change and the money supply cannot be assumed to be exogenous leading to biased coefficients in a standard OLS estimation. To solve this problem Hamilton uses reserve supply shocks. The Fed's staff forecasts the non-borrowed reserves every day and derives the amount of securities that they are going to sell or buy in the market from this estimation. If the Fed makes a mistake in its forecasts, the liquidity in the market will be higher than intended. According to Hamilton these shocks can be classified as exogenous. Thornton (2001) argues that Hamilton thereby only replaces one problem with another as the correct identification of the Fed forecasts is not a trivial task. He identifies the liquidity effect by analysing the behaviour of non-borrowed reserves when the Fed's fund rate target is changed. Recently, Judson and Klee (2009) detected a liquidity effect in the US with a similar method as Hamilton (1997) but using the actual, confidential forecasts made by the Fed. Others applied multivariate estimation models to circumvent the endogeneity problem, e.g. Kugler (2004) or Kim and Ghazali (1998, 1999).

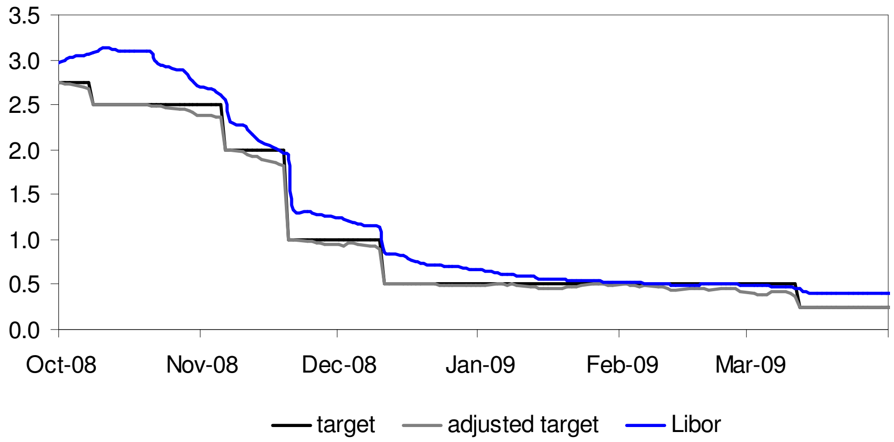
In this paper the endogeneity problem is less relevant because the increase of the monetary base in the sample can mostly be attributed to the movements in the currency reserves. The quantity of repo operations declined from 53 billion CHF in April 2009 to zero, while the currency reserves increased from 78 billion CHF at the beginning of 2009 to 283 billion CHF in June 2010 (roughly 50 per cent of GDP), see Figure 3.3. This suggests the Swiss National Bank does not consider the Libor, especially not the daily changes, when deciding on the quantity of euros it buys in order to prevent or slow down an appreciation of the Swiss franc. Instead, its reaction should depend on the exchange rate. Between March and December the bank even defended a certain EUR-CHF value of 1.51. Therefore the volume of the currency market interventions was more or less decided by the market.

Concerning the endogeneity of the volume of repo operations, the same holds in Switzerland as in the US: the money supplied to the banks cannot be assumed to be exogenous if the central bank sets the volume depending on the behaviour of interest rates. But since end of October 2008 the repo operations have been carried out with full allotment. The volume is therefore decided by the banks. Overall, both main components of the Swiss monetary base do not seem to be influenced by the changes of the Libor and can therefore be assumed to be exogenous.

3.4 Identifying the drivers of the Libor

To identify what determined the Swiss Libor in the crisis and whether the liquidity supplied through currency market interventions had an impact, daily data from August 2007 to June 2010 is used. The sample is divided in two sub-samples, one from August 2007 to December 2008 when the main policy rate, the 1w repo rate, reached zero and the other from January 2009 to June 2010 when the currency market intervention ended.

Figure 3.4: Adjusted target



Notes: Extract of the whole data sample to illustrate the difference between the adjusted target and the officially announced target rate; the Libor rate is the three-month Swiss franc Libor.

Interest rates

The first choice of independent variables are the 1w repo rate and the target rate, see e.g. Jordan and Kugler (2004). Following Abbassi et al. (2010), the mid point of the current target range is not used as target rate but an adjusted target rate taking into account interest rate expectations. As a consequence of the three month maturity the Libor is not only effected by the current target but also by future expected targets. Therefore the adjusted target $\tilde{r}^\star_t$ is a convex combination of the current target $r^\star_t$. The expected future target rate approximated with the three-month future f_t:

$$\tilde{r}^\star_t = r^\star_t + \omega_t(f_t - r^\star_t). \tag{3.1}$$

The weight ω linearly increases from zero on the day of a monetary policy meeting to one on the day prior to the next meeting. Figure 3.4 shows that the Libor moves closer towards the target over time. This does not only reflect the successful steering of the Libor by the SNB but also that their implicit target might not be the announced one because of envisaged rate changes. The adjusted target rate takes this into account. Therefore the deviation of the Libor from the adjusted rate is a better measurement of the SNB's success.

Additionally to the repo and the target rate, the 3m US-Libor is included following Kim and Ghazali (1998). They use the US interest rate as a proxy for the world interest rate to capture the effect of capital mobility. The fact that banks can easily transfer money from one country to another might reduce the impact of a domestic liquidity facility. Furthermore the US-Libor might have an influence on the Swiss Libor due to the high co-movement of interbank rates following the exceptional events in the aftermath of the sub-prime crisis. It is difficult to quantify the shocks that hit the financial markets during the crisis. Therefore the US-Libor might approximate these effects.

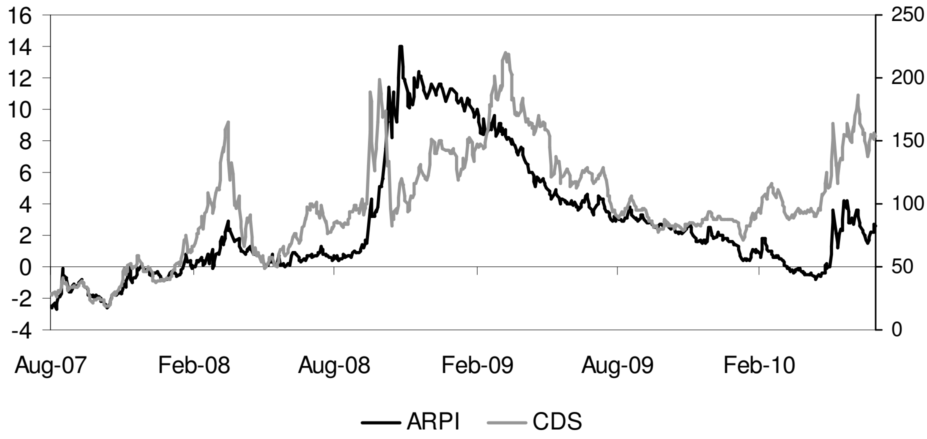
The 3m Swiss franc Libor and the other interest rates like the 3m US-Libor and the Swiss 1w repo rate are obtained from Bloomberg. The 1w repo rate chosen is the market rate and not the repo rate set by the SNB for its tender operations, compare Abbassi et al. (2010).

Credit risk

According to Christensen et al. (2009), one must control for fluctuations in the credit risk to analyse the impact of the liquidity on Libor rates as they are unsecured. The assessment of credit default risks of banks changed significantly through the course of the crisis and could have contribute thereby to the fall in the Swiss Libor 2009/10. The counter-party risks peaked following the bankruptcy of Lehman brothers and decreased after the governments worldwide designed banking sector rescue packages including capital injections and guarantees for bank liabilities. In spring 2009 the end of the global downturn and the recovery of equity and bond markets reduced the risk of a bank default further. However, the euro area debt crisis let to another increase of the credit default swaps (CDS), one measurement of the counter-party risk, see Figure 3.5. The supply of liquidity might actually influence the counter-party risk as well. Unconventional measurements of the central banks like the provision of long-term refinancing operations with full allotment rose the probability that a interbank loan will be re-payed, see Wu (2008). In the estimation the average five year CDS of the banks that determine the Swiss Libor rate is used as quoted by Bloomberg.

Changes in the credit default risk are also captured by the US-Libor as a certain fraction of the credit risk is not country or currency specific. The case of Lehman brothers has shown that the default of a major bank affects banks worldwide. Therefore the risk premia are correlated. Furthermore some banks do report the interbank rates they would be willing to pay to the British Banker's Association for the US-Libor as well as the Swiss Libor.

Figure 3.5: Risk measurements: ARPI and CDS



Notes: The ARPI (left scale on the y-axis) is the Aggregate Risk Perception Index by Commerzbank AG; CDS (right scale on the y-axis) is defined as the average 5 year credit default swap of the banks reporting their lending rates for the Libor fixing.

Uncertainty

Furthermore interbank rates might be influenced by uncertainty, especially during financial crises. As it is impossible to measure uncertainty itself, the Aggregate Risk Perception Index (ARPI) by Commerzbank AG is used. Some of the effects of global risk perception are possibly also reflected by the US-Libor but the Swiss Libor might react differently to a rise in uncertainty due to safe haven effects. The ARPI aims to capture the various risks perceived in the financial world. For this purpose it is based on a variety of market prices or price fluctuations across seven asset classes: the components are credit, emerging markets, foreign exchange, yield curve, equity, liquidity and commodity risks.[5] To calculate an index a principal component analysis is applied because the simply indicators are affected by a number of other factors that are unrelated to risk perception and therefore present only unreliable measures of risk perception by the market participants. The ARPI is the weighted mean of the data series using the loadings of the first principal components, see Figure 3.5.

[5]See Appendix, Table 3.4 for more details on the data series used to measure the risk perception in the different asset classes.

Liquidity

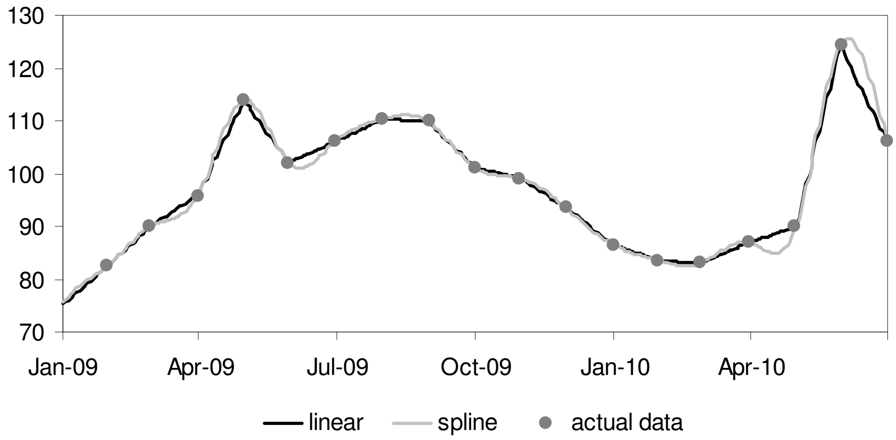
The liquidity provided by the Swiss National Bank is published monthly as the monetary base M0. M0 consists of the volume of currency reserves denominated in Swiss franc and the sum of financial securities, currency swaps, repo operations less others which also contains liquidity absorbing operations. To create daily data different interpolation techniques are used. The most straight forward method is a linear interpolation between the two data points known at end of each month. Additionally, cubic splines interpolation is applied. A spline is a function defined piecewise by polynomials between two existing data points. Here a spline of degree three is used.[6]

These data series created assume that the agents are somewhat forward looking regarding the dynamics in the month ahead. Here this assumption might not be too presumptuous as the liquidity flows into the systems and should immediately affect the pricing decision of banks if there is a liquidity effect. The aggregate data is not known to the market before it is released by the SNB but it could be argued that it is "felt" by the market. As a robustness check an alternative M0 series is used in a model specification where the next future data point is estimated with an ARIMA (2,2) model. At the last day of the month the actual liquidity supplied is inserted into the series, then the volume at the end of the next month is forecasted and the daily data during the month is obtained through linear interpolation, see Figure 3.6.

In general, interpolation can be viewed as problematic because it enforces the variable to develop quite steadily between two points in time which naturally might not be the case. Here it seems unreasonable to assume that the SNB buys roughly the same amount of euro against franc every day during a month. In contrast to the currency reserves, the repo operation exhibit quite steady dynamics - at least before the full allotment and the long-term tenders were introduced - due to the daily conducted tender auctions. In the estimations not only the daily changes of M0 are considered but also the month on month changes. They reflect the dynamics over a longer period and therefore take into account that new liquidity should not only have an impact on the day created but long thereafter.

[6]A spline interpolation is similar to a polynomial interpolation but has the advantage that it uses lower degree polynomials. The spline is the approximation of a polynomial function with the minimal curvature. The function has to be twice continuously differentiable and can be defined as follows between two data points: $s_i(x) = \alpha_i + \beta_i(x - x_i) + c_i(x - x_i)^2 + d_i(x - x_i)^3$; for $x_{i-1} \leq x \leq x_i$, $i = 1, \ldots, n$.

Figure 3.6: Different interpolation techniques for M0



Notes: Interpolated data series of the actual monthly data for the monetary base M0, shown by the dots. The black line displays the series conducted using linear interpolation, the grew line reflects the cubic spline interpolation.

3.5 Empirical results

3.5.1 First part of the crisis

Identifying the drivers of the Libor, an error-correction adjustment equation is estimated because it allows to consider relationships between the levels of variables despite the fact that all variables are I(1), see unit root tests in Table 1.4 in the Appendix. Similar to Abbassi et al. (2010) the spread between the Libor and the adjusted target rate is included as one error-correction term, reflecting the words channel. The second error-correction term contains the spread between the Libor and its US equivalent taking into account the convergence of interest rates.

The short-run dynamics include lagged dependent variables to control for autocorrelation. The lag length is chosen following the Schwarz criterion. In the first sub-sample the independent variables are the US-Libor, the adjusted target rate, the 1w repo rate, the ARPI, the aggregated CDS and the monetary base M0, both in logarithms.[7] The independent variables are considered

[7]As all explanatory variables can be assumed exogenous, their values at time t could potentially be entered into the equation. However, the time of publication is also considered. The individual results of the daily repo auctions are already announced at 9:20 a.m. CET; long before the Libor fixing takes place at 12 a.m. CET. The US-Libor fixing is published at the same time. Therefore the value of the US-Libor in period t =0 is not used. The CDS is also lagged by one period because it is the last price of the day. The ARPI is calculated using data available until 9:30 a.m CET. on Bloomberg. The results of the estimation do

with four lags to account for all working days in one week. However, for the monetary base no lagged values are used reflecting that the daily or monthly differences do not vary significantly due to the interpolation, especially the linear interpolation that is used in the baseline estimation.

Therefore the estimated equation can be written as follows:

$$\begin{aligned}\Delta(Libor)_t &= \alpha(Libor_{t-1} - (Libor_{US})_{t-1}) + \phi(Libor_{t-1} - \tilde{r}^{\star}_{t-1}) + \\ &\sum_{p=1}^{5} \beta_p \Delta(Libor)_{t-p} + \sum_{q=1}^{4} [\gamma_q \Delta(Libor_{US})_{t-q} \\ &+\mu_q \Delta(CDS)_{t-q}] + \sum_{q=0}^{4} [\delta_q \Delta \tilde{r}^{\star}_{t-q} + \nu_q \Delta(repo)_{t-q} \\ &+\eta_q \Delta(ARPI)_{t-q}] + \varphi((m_0)_t - (m_0)_{t-21}) + \varepsilon_t\end{aligned} \tag{3.2}$$

The results are summarised in Table 3.1 leaving out the error-correction terms; for more detailed results see Appendix Table 3.6. All variables but the CDS and M0 are significant.[8] This findings are broadly in line with former research, e.g. Jordan et al. (2009) and Abbassi et al. (2010): the target rate and the 1w repo rate have a positive impact on the 3m Libor. Additionally, the estimation identifies the global risk perception (ARPI) and US-Libor as significant drivers. The rise in uncertainty (ARPI) increases the risk premia of the Libor and thereby the Libor itself. The significance of the coefficients of the US-Libor reflect the high co-movement of interbank rates worldwide in first phase of the crisis. Even though the sample period is part of the worst crisis since the great depression, the model can describe the changes of the Libor rate quite well, R^2 is as high as 0.74.

The change in the liquidity supplied is added to the equation (3.2) in different specifications: once as the change month on month, $\log(\mathrm{M}_0)_\mathrm{t} - \log(\mathrm{M}_0)_{t-21}$, and in another specification as daily change, $\Delta(\log(\mathrm{M0}_t))$. But the monetary base does not seem to have an influence on the Libor. However, this result can not rule out any indirect impact because the liquidity created by the central bank could have an effect on the market rate of 1w repos and through that rate on the Libor as well. If there is excess liquidity in the market, the

not change significantly when all independent variables are lagged by one period.

[8]Seasonal dummies like the end of a month or quarter proved to be not significant. Following Abbassi et al. a proxy for the surprise of the market participants at the day of the monetary policy meeting was also included. It is measured by the change of three-month future rate after the announcement compared to the day before. The surprise variable was not found to be significant in the sample period.

Table 3.1: Determinants of the Libor in the first part of the crisis

Dependent variable:	Δ(Libor)	
Sample:	08/08/2007 - 12/31/2008	
Observations:	304	
Variable	Sum of coefficients	Prob.-value
Δ(Libor)	-0.108	0.001
$\Delta(\mathrm{Libor}_{\mathrm{US}})$	0.120	0.024
$\Delta\tilde{r}^{\star}$	0.744	0.000
Δ(repo)	0.104	0.005
ΔARPI	0.029	0.000
ΔCDS	-0.045	0.379
$(\mathrm{m}_0)_{\mathrm{t}} - (\mathrm{m}_0)_{t-21}$	-0.015	0.653
R^2		0.741
Autocorrelation test: p-value of LM5		0.542
Autocorrelation test: p-value of LM8		0.366

Notes: The table summarises the estimation of equation (3.2). The sum of the coefficients contains the sum of all coefficients of the particular variable up to five lags whether they are significant or not. The p-value comes from a standard F-test for omitted variables. It test the null hypothesis that the reduced model without all lagged values of the particular variable is performing better. To test for autocorrelation the Breusch-Godfrey Serial Correlation LM Test is used with 5 and 8 lags.

market rates might fall below the repo rates charged by the SNB in the open market operations. Furthermore the results could be biased due to the endogeneity of M0. Before the start of the full allotment in all tender operations in October 2008, the SNB possibly reacted to an unintended rise in the Libor by supplying more liquidity in the repo auctions.

3.5.2 Second part of the crisis

In December 2008 the Swiss National Bank lowered the 1w repo rate for its tender operations to 0.05% and thereby reached the natural boundary of its main policy instrument. With repo rates at roughly zero further liquidity could possibly have a direct impact on the longer-term interest rates now. To find whether the liquidity supplied played its part to bring down the Libor, the following equation is estimated for the second sub-sample from January 2009 to June 2010:

$$\begin{aligned} \Delta(Libor)_t &= \sum_{p=1}^{5} \beta_p \Delta(Libor)_{t-p} + \sum_{q=1}^{4} [\gamma_q \Delta(Libor_{US})_{t-q} \\ &\quad + \mu_q \Delta(CDS)_{t-q}] + \sum_{q=0}^{4} \eta_q \Delta(ARPI)_{t-q} \\ &\quad + \varphi((m_0)_t - (m_0)_{t-21}) + \varepsilon_t \end{aligned} \tag{3.3}$$

Equation (3.3) differs from equation (3.2) with respect to the consideration of the target and the repo rate. The repo rate stayed at 0.05% through out the sample period and therefore cannot explain the drop of the 3m Libor from around 0.80% to 0.11%. The target rate is not included because it was only changed once in this sample, from 0.50% to 0.25% in March 2009.[9] Furthermore in contrast to equation (3.2) no error-correction terms are included. They are not found to be significant. Like the change of the target rate the level of it is not a major determinant of Libor in this period. The insignificance of the Libor spread reflects the divergence of the Swiss and the US-Libor in the second part of the crisis.

The results are displayed in Table 3.2. They show that all variables are significant. Overall, the results decisively differ from the estimation of the first sub-period, compare Table 3.1, reflecting a breakpoint in the sample:

[9]To test whether this last target rate change had a significant influence on the Libor, the model is reestimated with a dummy that is one at the 03/12/2009 and zero otherwise. The dummy turns out to be insignificant.

Table 3.2: Determinants of the Libor in the second part of the crisis

Dependent variable:	Δ(Libor)	
Sample:	01/01/2009 - 06/30/2010	
Observations:	304	
Variable	Sum of coefficients	Prob-value
Δ(Libor)	0.579	0.000
$\Delta(\mathrm{Libor}_{\mathrm{US}})$	-0.035	0.002
ΔARPI	-0.007	0.000
ΔCDS	0.009	0.079
$(\mathrm{m}_0)_{\mathrm{t}} - (\mathrm{m}_0)_{t-21}$	-0.008	0.058
R^2		0.443
Autocorrelation test: p-value of LM5		0.256
Autocorrelation test: p-value of LM8		0.487

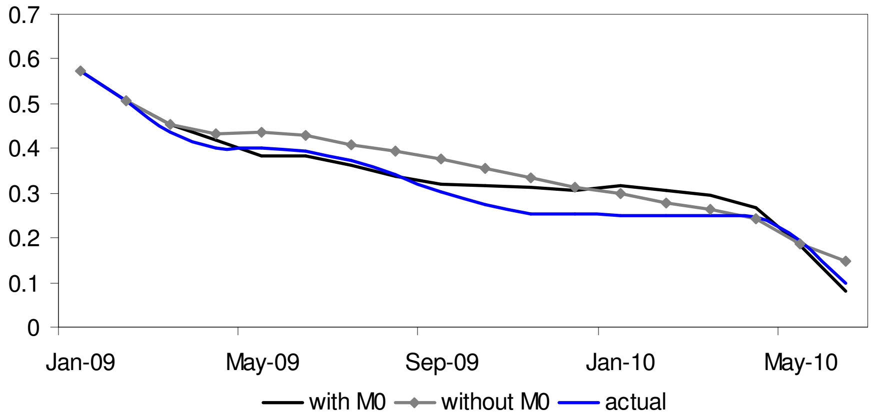
Notes: See Table 3.1. For more details see Table 3.7 in the Appendix.

the US-Libor and the ARPI, for instance, exhibit a different sign. After the uncertainty shock associated with the breakdown of Lehman Brothers ebbed away, the markets increasingly differentiated and the correlation between interbank rates became less strong. The negative influence of the US-Libor on the Swiss Libor in 2009/10 could be due to the safe haven attributes of Switzerland which seems to be the ultimate safe haven throughout the worries about the US property market, the sluggish recovery, the fears of a double-dip and the euro area debt crisis. This effect is also demonstrated by the negative coefficient of the ARPI. As expected, the aggregated credit default swap is a positive determinant of the Libor: when the prices to insure the default of banks fall, the credit risk premium that the interbank rate contains, falls as well. Furthermore the high coefficient of the lagged dependent variable shows that the Libor is highly persistent.

However, the main result of the empirical analysis is that the rise in the monetary base, not least due to the currency market intervention, significantly contributed to the decline of the Libor. Even though it was not the main aim of the SNB when deciding to intervene against the own currency, the interventions helped to reach the target rate for the 3m Libor supporting the central bank's goal to maintain price stability.[10]

[10] The Swiss franc exchange rate itself is not found to be significant. Former research on the Swiss monetary policy like Jordan and Kugler (2004) and Jordan et al. (2009) does

Figure 3.7: Counterfactual experiment for the course of the Libor



Notes: Monthly averages of the three-month Libor; the actual Libor and the estimated Libor once with and once without taking into account the changes of the monetary base M0.

3.5.3 Counterfactual experiment

The results show a statistically significant effect of M0 on the Libor; but is the effect economically significant? To verify how much higher the Libor would have been without the strong increase of M0, the developing of the Libor is dynamically simulated (multi-step forecast) by using the estimated coefficients displayed in Table 3.7. The simulation is once done with the actual changes of M0 and once without, assuming that the volume of the money supplied stayed at the level of 12 March 2009 where the currency interventions started.

According to the forecast, the Libor would have been on average six basis points higher in June 2010 without the interventions compared to the simulation with the changes in M0, and still five basis point higher than the actual average of the Swiss Libor in June 2010 was. At a level of only 0.11% a difference of five or six basis point can be regarded as economically significant. Especially the fall of the Libor dramatically below its target at the climax of the Greek crisis in May 2010 cannot be explained by the model not taking into account the currency interventions, see Figure 3.7.

not consider the exchange rate. However, following the concept of interest rate parity an appreciation of the Swiss franc could potentially influence the interest rates.

Table 3.3: Variation of interpolation techniques

Dependent variable:	Δ(Libor)		
Sample:	01/01/2009 - 06/30/2010		
Observations:	304		
Variable	M_0 d-o-d changes	M_0 splines	M_0 ARIMA
Δ(Libor)	0.460 (0.000)	0.427 (0.001)	0.532 (0.000)
$\Delta(\text{Libor}_{\text{US}})$	-0.024 (0.004)	-0.035 (0.002)	-0.046 (0.005)
ΔARPI	-0.007 (0.000)	-0.008 (0.000)	-0.008 (0.000)
ΔCDS	0.005 (0.097)	0.007 (0.086)	0.009 (0.089)
$(M_0)_t - (M_0)_{t-21}$		-0.007 (0.084)	-0.007 (0.034)
$\Delta(M_0)_t$	-0.088 (0.075)		
R^2	0.435	0.441	0.444

Notes: See Table 3.1. The value displayed for each variable is the sum of the coefficients; p-value of a F-test for omitted variables in parentheses; for more details see Table 3.8.

3.5.4 Robustness of the results

To test whether the result that the liquidity supplied has an impact on the interbank lending rates is robust, the model is reestimated applying different specifications of the change in the liquidity supplied, see Section 3.4.

First of all, the daily changes of M0 are used instead of monthly changes. As the daily changes do not vary over the course of a month due to the linear interpolation, no lags are inserted into the model. Table 3.3 shows that M0 is still significant although the coefficient of course differs. The coefficients of the other explanatory variables do not change notably.

Furthermore different interpolation methods are adopted in the second specification: the monthly M0 series is interpolated with cubic splines instead of the standard linear interpolation. The detailed results are represented in Table 3.8 in the Appendix. They allow to conclude the linear interpolation method is not the driver of the results in the baseline estimation in Section 3.5.

Last but not least, an ARIMA forecast model is utilised to estimate the next value of M0. This method basically extrapolates the past dynamics into the future. It assumes that the market participants are not aware of the actual amount of new liquidity in the market but make their decisions based on the past realisation. The estimated equation (3.3) is extended by a dummy variable to account for the jumps in the series at the end of each month, see Figure 3.6. The estimated coefficients presented in Table 3.3 demonstrate that even using estimated values for M0 does not alter the result significantly.

3.6 Conclusion

Central banks faced extraordinary tasks in the financial crisis and their standard toolkits exhausted quickly. Unconventional measurements were adopted: central banks provided the banks with as much liquidity as they demanded in the open market operations, bought government bonds, commercial papers and covered bonds. The currency market interventions by the Swiss National Bank can also be classified as such unconventional measurements. All these measurements have one in common; they bloated the central banks' balance sheets and led to a massive increase of the monetary bases. Did this liquidity alter the interbank lending rates reflecting decreased tension in this market?

This paper investigates what determined the Swiss franc three-month Libor in the crisis. It analyses whether the currency market interventions influenced the interbank lending rate.

My first finding is that the drivers of the 3m Libor changed through out the crisis. Until the end of 2008 the Libor can be fairly well explained by the changes in the repo rate, the target rate for the Libor set by the SNB, credit default risk as priced by the market and a proxy for the general risk perception in the financial markets. These results are broadly in line with former research, e.g. Jordan et al. (2009) and Abbassi et al. (2009). However, by 2009 the SNB had shot its wad concerning interest rate changes.

The second and main result of the analysis is that the liquidity supplied by the central bank mainly through its currency market interventions helped to lower the Libor in the course of 2009 and 2010. This impact is statistically as well as economically important and thereby supports the view that under a certain perspective currency market interventions are just another way of conducting the monetary policy more expansive. Furthermore the role of

Switzerland as a safe haven contributed to the decline of the Libor and the decrease of credit default risk is also reflected by the Libor rate.

Like Wu (2008) and Christensen et al. (2009), for instance, this paper detects a liquidity effect of the new liquidity facilities created in the current crisis. Can these results be transferred to other periods? They possibly can despite the insignificance of the monetary base in the estimation up to 2009. It might only be more difficult to detect the liquidity channel particularly because of endogeneity problems. This view is also supported by the findings of Kim and Ghazali (1999) and Kugler (2002, 2004).

From an empirical researcher's point of view the conditions in 2009/10 were very favourable in Switzerland: with SNB's operational interest rate at zero, full allotment which basically transfers the decision how much liquidity is provided from the central bank to the private banks and currency market interventions that are conducted independently from the current Libor levels, the effect is easier to identify. Obviously, there is more research needed to clarify whether a liquidity effect exists in general in Switzerland and not just under specific circumstances, e.g. above a certain threshold of liquidity.

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Appendix

Table 3.4: ARPI components: broad coverage

Component	Description
Credit risks	Credit spreads of corporate bonds, iTraxx
Emerging markets risks	EM government bond spreads, implied volatility of exchange rates of various EM currencies versus the USD
FX risks	Implied volatility of the exchange rates of various G10 currencies versus the USD
Yield curve risks	Implied volatility of forward swaps and short-term interest rate futures contracts
Equity risks	Implied volatility of stock indices
Liquidity risks	TED spread, swap spreads, OIS spread
Commodity risks	Implied volatility of energy futures contract

Source: Bloomberg

Table 3.5: Unit root tests

Null hypothesis: series contains an unit root		
Variable	Prob. value	
	Level	1st difference
ARPI	0.17	0.00
Libor	0.68	0.01
Libor_{US}	0.69	0.00
log(CDS)	0.25	0.00
log(M0)	0.54	0.00
repo	0.64	0.00
adj. − target	0.68	0.01

Notes: Augmented Dickey-Fuller unit root test; the lags are selected with the Schwarz Info criterion using a maximum of 23 lags.

Table 3.6: Complete results of the estimated equation (3.2)

Dependent variable:	Δ(Libor)	
Sample:	08/08/2007 - 12/31/2008	
Variable	Coefficient	t-Statistic
$(\text{Libor} - \text{Libor}_{\text{US}})_{t-1}$	-0.001	-1.808
$(\text{Libor} - \tilde{\text{r}}^{\star})_{t-1}$	-0.027	-2.711
$\Delta(\text{Libor})_{t-1}$	-0.249	-1.288
$\Delta(\text{Libor})_{t-2}$	0.015	0.137
$\Delta(\text{Libor})_{t-3}$	0.045	1.002
$\Delta(\text{Libor})_{t-4}$	0.041	1.008
$\Delta(\text{Libor})_{t-5}$	0.040	1.418
$\Delta(\text{Libor}_{\text{US}})_{t-1}$	0.049	1.649
$\Delta(\text{Libor}_{\text{US}})_{t-2}$	0.026	0.911
$\Delta(\text{Libor}_{\text{US}})_{t-3}$	0.015	0.565
$\Delta(\text{Libor}_{\text{US}})_{t-4}$	0.030	1.318
$\Delta\tilde{r}^{\star}_{t}$	0.084	0.792
$\Delta\tilde{r}^{\star}_{t-1}$	0.587***	6.045
$\Delta\tilde{r}^{\star}_{t-2}$	0.114	1.023
$\Delta\tilde{r}^{\star}_{t-3}$	-0.019	-0.319
$\Delta\tilde{r}^{\star}_{t-4}$	-0.020	-0.654
$\Delta(\text{repo})_{\text{t}}$	0.011	1.357
$\Delta(\text{repo})_{\text{t}-1}$	0.009	0.835
$\Delta(\text{repo})_{\text{t}-2}$	0.029***	2.606
$\Delta(\text{repo})_{\text{t}-3}$	0.040**	2.215
$\Delta(\text{repo})_{\text{t}-4}$	0.017	0.954
$\Delta\text{ARPI}_{\text{t}}$	0.008**	2.156
$\Delta\text{ARPI}_{\text{t}-1}$	0.012***	3.228
$\Delta\text{ARPI}_{\text{t}-2}$	0.010	1.963
$\Delta\text{ARPI}_{\text{t}-3}$	0.003	0.740
$\Delta\text{ARPI}_{\text{t}-4}$	-0.001	-0.140
R^2		0.743
Autocorrelation test: p-value of LM5		0.542
Autocorrelation test: p-value of LM8		0.366

Notes: *,**,*** indicate significance at the 10%, 5%, 1% level, respectively. $\tilde{r}^{\star}_{t}$ denotes the adjusted target rate for the 3m Libor; to test for autocorrelation the Breusch-Godfrey Serial Correlation LM Test is used with 5 and 8 lags. The absolute t-statistics are computed according to Newey-West adjustment.

Table 3.7: Complete results of the estimated equation (3.3)

Dependent variable:	$\Delta(\mathrm{3M-Libor})$	
Sample:	01/01/2009 - 06/30/2010	
Observations:	304	
Variable	Coefficient	t-Statistic
$\Delta(\mathrm{Libor})_{t-1}$	0.401***	5.727
$\Delta(\mathrm{Libor})_{t-2}$	0.172	1.652
$\Delta(\mathrm{Libor})_{t-3}$	-0.029	-0.332
$\Delta(\mathrm{Libor})_{t-4}$	-0.164**	-2.149
$\Delta(\mathrm{Libor})_{t-5}$	0.084*	1.811
$\Delta(\mathrm{Libor})_{t-21}$	0.044***	4.546
$\Delta(\mathrm{Libor_{US}})_{t-1}$	-0.001	-0.042
$\Delta(\mathrm{Libor_{US}})_{t-2}$	0.046	1.287
$\Delta(\mathrm{Libor_{US}})_{t-3}$	0.009	0.211
$\Delta(\mathrm{Libor_{US}})_{t-4}$	-0.083***	-3.002
$\Delta\mathrm{ARPI_t}$	-0.002**	-2.228
$\Delta\mathrm{ARPI_{t-1}}$	-0.002	-1.605
$\Delta\mathrm{ARPI_{t-2}}$	-0.001	-1.014
$\Delta\mathrm{ARPI_{t-3}}$	-0.000	-0.051
$\Delta\mathrm{ARPI_{t-4}}$	-0.002**	-2.165
$\Delta\mathrm{CDS_{t-1}}$	0.013***	2.697
$\Delta\mathrm{CDS_{t-2}}$	0.004	0.704
$\Delta\mathrm{CDS_{t-3}}$	-0.007	-1.311
$\Delta\mathrm{CDS_{t-4}}$	-0.001	-0.401
$(\mathrm{M0_t - M0_{t-21}})$	-0.008*	-1.875
R^2		0.443
Autocorrelation test: p-value of LM5		0.256
Autocorrelation test: p-value of LM8		0.487

Notes: See Table 3.6.

Table 3.8: Variations of equation (3.3)

Dependent variable:	Δ(3M − Libor)		
Sample:	01/01/2009 - 06/30/2010		
Observations:	304		
Variable	M_0 d-o-d changes	M_0 splines	M_0 ARIMA
$\Delta(\text{Libor})_{t-1}$	0.411***	0.402***	0.407***
	(5.590)	(5.761)	(5.626)
$\Delta(\text{Libor})_{t-2}$	0.175	0.176	0.170
	(1.584)	(1.675)	(1.623)
$\Delta(\text{Libor})_{t-3}$	-0.019	-0.027	-0.030
	(-0.223)	(-0.302)	(-0.335)
$\Delta(\text{Libor})_{t-4}$	-0.151*	-0.157*	-0.156*
	(-1.810)	(-1.850)	(-1.812)
$\Delta(\text{Libor})_{t-5}$	0.097**	0.088*	0.098**
	(1.973)	(1.920)	(2.206)
$\Delta(\text{Libor})_{t-21}$	0.047***	0.045***	0.043***
	(4.489)	(4.517)	(4.686)
$\Delta(\text{Libor}_{\text{US}})_{t-1}$	0.002	-0.001	-0.008
	(0.089)	(-0.020)	(-0.347)
$\Delta(\text{Libor}_{\text{US}})_{t-2}$	0.045	0.042	0.041
	(1.373)	(1.284)	(1.217)
$\Delta(\text{Libor}_{\text{US}})_{t-3}$	0.008	0.009	0.009
	(0.189)	(0.214)	(0.211)
$\Delta(\text{Libor}_{\text{US}})_{t-4}$	-0.079***	-0.083***	-0.088***
	(-2.801)	(-2.972)	(-3.050)
$\Delta\text{ARPI}_{\text{t}}$	-0.002*	-0.002**	-0.002**
	(-1.927)	(-2.235)	(-2.219)
$\Delta\text{ARPI}_{\text{t}-1}$	-0.002	-0.002	-0.002
	(-1.438)	(-1.619)	(-1.611)
$\Delta\text{ARPI}_{\text{t}-2}$	-0.001	-0.001	-0.001
	(-0.785)	(-0.971)	(-1.019)
$\Delta\text{ARPI}_{\text{t}-3}$	-0.001	-0.001	-0.001
	(-0.064)	(-0.024)	(-0.133)
$\Delta\text{ARPI}_{\text{t}-4}$	-0.002*	-0.002**	-0.002**
	(-1.927)	(-2.151)	(-2.153)

ΔCDS_{t-1}	0.012***	0.013***	0.013***
	(2.591)	(2.684)	(2.587)
ΔCDS_{t-2}	0.002	0.004	0.004
	(0.452)	(0.650)	(0.723)
ΔCDS_{t-3}	-0.008	-0.007	-0.006
	(-1.434)	(-1.339)	(-1.214)
ΔCDS_{t-4}	-0.003	-0.002	-0.001
	(-0.769)	(-0.467)	(-0.333)
$(M_0)_t - (M_0)_{t-21}$		-0.007*	-0.007**
		(-1.733)	(-2.127)
$\Delta(M_0)_t$	-0.089*		
	(-1.783)		
R^2	0.435	0.441	0.4447

Ehrenwörtliche Erklärung

Ich habe die vorgelegte Dissertation selbst verfasst und dabei nur die von mir angegebenen Quellen und Hilfsmittel benutzt. Alle Textstellen, die wörtlich oder sinngemäß aus veröffentlichten oder nicht veröffentlichten Schriften entnommen sind sowie alle Angaben, die auf mündlichen Auskünften beruhen, sind als solche kenntlich gemacht.

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