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The Demand for International Reserves in the Eurosystem

Implications of the Changeover to the Third Stage of EMU

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The Demand for International Reserves in the Eurosystem

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Implications of the Changeover to the Third Stage of EMU

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The Demand for International Reserves in the Eurosystem

Implications of the Changeover to the Third Stage of EMU[1]

Harald Badinger

Abstract

In this paper we analyse the implications of the euro for the international reserves in the Eurosystem. Two conceptually different effects of the changeover have to be distinguished: a technical effect that largely arises as a matter of accounting, and a behavioural effect that stems from the fact that the optimal demand of the aggregate Eurosystem is not equal to the sum of the optimal country levels. The technical effect arises from two main sources: the abolishment of the ECU-creating mechanism, and the redefinition of international reserves which precludes (former) reserves that were denominated in euro-currencies. As a result the average reserves of the Eurosystem in 1999 amounted to $287 billion, considerably less than in 1998 ($345 billion). We then derive a reserve demand function for the aggregate Eurosystem using panel data estimation techniques and simulate reserve demand for the situation after the regime shift. The optimal aggregate level of reserves turns out to be some $188 billion, which implies excess reserves in the Eurosystem amounting to approximately $100 billion in the year 1999. We go on by proposing a key by which this excess could be allocated to the individual countries taking the asymmetric distribution of reserves in the Eurosystem into account. Finally we classify and enumerate the proposals for making use of the estimated reserve overhang.

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Keywords: Eurosystem, European Monetary Union, International Reserves

[1] I wish to thank Professor Fritz Breuss for his guidance and assistance. The usual disclaimer applies.

1. Introduction

The creation of a single currency in Europe (the euro) represents by far the most significant change in the international monetary system since the end of World War II. The introduction of a common European currency and the establishment of an independent European Central Bank – two steps that had been regarded as "politically very complicated, almost utopian" (Mundell (1973b, p. 157)) three decades ago – became reality on 1 January 1999. Never in the past has a group of sovereign nations voluntarily given up their national currency for a common currency. Eleven out of the 15 members of the European Union (EU) (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain) started with the Third Stage of Economic and Monetary Union (EMU) and transferred their monetary competence to the European Central Bank (ECB).

As regards the international reserves of the Eurosystem it is commonly argued that the introduction of the euro has generated a considerable amount of excess reserves. The two main arguments usually put forward are the disappearance of a large part of international trade (intra-euro area trade has become "regional" trade) and the elimination of the need to stabilise the exchange rate vis-à-vis the currencies of other euro area countries. Other arguments refer to the existence of economies of scale in the demand for international reserves. While in the economic literature on the benefits and costs of EMU the advantage of reduced reserves has hardly been discussed in detail, this point has been (and still is) subject of heated political debates. Increased budgetary constraints, enforced by the Stability and Growth Pact, can be expected to revive and intensify the debate on the available size and the „best use" of the excess reserves. These abundant reserves, however, are no „free lunch" that could be used arbitrarily. Complex economic feedbacks as well as legal restrictions aggravate the decision on how to transform a potential reserve overhang into more productive assets.

In this paper we analyse the effects of the introduction of the euro on the international reserves in the Eurosystem. In part two of the paper we give a brief history of European Monetary Unification to provide some historical perspective. In Part three we investigate the "technical effects" of the euro that arise largely as a matter of accounting and from the redefinition of the international reserves as a result of the changeover. After a review of optimal reserve theory and its empirical implementations in part four, we provide an overview of the literature on excess reserves in the Eurosystem and outline the main theoretical arguments for a reduced reserve demand after the introduction of a common currency in part five of the paper. In Part six we estimate reserve demand functions for the euro area countries' central banks and for the aggregate Eurosystem using panel data techniques and simulate the optimal level of the international reserves in the Eurosystem after the introduction of the euro in the year 1999. In Part seven we analyse the problems involved in the allocation of the resulting excess reserves and outline the basic proposals to run down the estimated reserve overhang. In the final section we summarise the results and conclusions of our analysis.

2. History of European Monetary Unification – A Brief Review

2.1 The Road to the Euro[2]

The first steps after World War II

Monetary co-operation in Western Europe began shortly after World War II with the establishment of the European Payments Union (EPU) in 1950. In 1957 the European Communities (EC) were established by signing the treaty of Rome. The two main elements of the treaty, however, were "non-monetary": the customs union and the common agricultural policy (CAP). The only "visible" achievement from a monetary perspective was the establishment of the Monetary Committee, a co-ordination group comprising both a representative of the central bank and the finance ministry as well as two representatives of the European Commission. Somewhat later, other committees dealing with policy co-ordination were established. The only important achievement from a monetary perspective was the Committee of Central Bank Governors founded in 1964.

The Werner Plan

The first ambitious step was then taken at the European Council of December 1969 in The Hague, where the EC governments reaffirmed the wish to move forward to Economic and Monetary Union (EMU) and commissioned a major study by a group of high-ranking national and EC officials. The results of this so called Werner Report – named after the head of the study group Pierre Werner, the Prime Minister and Finance Minister of Luxembourg – suggested "full" EMU to be achieved in three stages until 1980. In March 1971, the EC Council of Ministers endorsed the strategy proposed by the Werner report and took steps to implement some of its recommendations. Only three major elements, however, survived the turbulences surrounding the collapse of the Bretton Woods System.

One important element is known as the "snake in the tunnel", an agreement among the EC countries from 1972 (Basle Agreement) to reduce the fluctuations of their bilateral exchange rates to a 2¼% band. The record of the snake's history, however, was rather instable and erratic, characterised by numerous withdrawals and returns of countries as well as several realignments. A second important element was the establishment of the European Monetary Co-operation Fund (EMCF) in 1973, which should co-ordinate the central bank interventions and harmonise reserve policies. Aside with the Committee of the Central Bank Governors it developed only a shadowy existence, which was mainly due to the formal subordination to the Council of Ministers of Economics and Finance (ECOFIN Council). The third important achievement was the agreement to co-ordinate monetary and other macroeconomic policies more closely. However, the detailed plans concerning procedures for co-ordination and consultation were never implemented as the first oil price shock produced widespread disagreement about the policy measures to be taken.

A further achievement of the pre-EMS area was the creation of the European Unit of Account (EUA). It was replaced by the European Currency Unit (ECU) with the European Monetary System (EMS) agreement.

The European Monetary System (EMS)

The EMS, which came into force in 1979, can be seen as the first yardstick on the way to the euro. Its three main elements were:

- The creation of the European Currency Unit (ECU) which was defined as a basket of EC-currencies and functions as a unit of account in the EMS. Official ECUs were issued to the central banks of the EC against the contribution of 20% of their gold and US-$ reserves by the EFMC through revolving three-month swap operations. The swap operations were renewed every three months. This allowed the necessary adjustments to be made in order, first, to ensure that each central bank's contribution to the EFMC continued to repre-

[2] Based on Breuss (1998, chapter 11), Gros and Thygesen (1998, part I) and Kenen (1995, chapter 1), Oesterreichische Nationalbank (1998), ECB (1999A, 2000).

sent at least 20% of its gold and US dollar reserve holdings, and, second, to take account of changes in the price of gold and in the US dollar exchange rate vis-à-vis the official ECU.[3]

- The system of financial assistance including the Very Short-Term Financing mechanism, the Short-Term Monetary Support mechanism and the Medium-Term Financial Assistance mechanism.
- The Exchange Rate Mechanism (ERM): each country agreed on a bilateral central rate vis-à-vis all other EMS currencies (parity grid). Intervention became mandatory once a bilateral exchange rate deviated a certain percentage in either direction of the central rate (initially 2.5%, 6% for Italy and the later entrants (ES, UK, PT). In course of the EMS crisis (1992/1993) the allowed margin was widened to 15% for all countries in 1993).

The Delors Report

The next major step was taken at the Hanover Summit in June 1988 where the Council commissioned a study group, chaired by the President of the EC Commission, Jaques Delors, to propose concrete steps that would lead to EMU. Unlike the Werner Plan, the Delors Report had a strong impact and paved the way for completion of economic and monetary union (EMU) within 10 years in three stages.

The legal framework for EMU was provided by the treaty on the European Union, signed on 7 February 1992 in Maastricht. It embodied large parts of the recommendations of the Delors Report. The first stage entered into force retroactive to July 1990 and primarily contained the elimination of all restrictions on capital mobility. The Maastricht Treaty also set the time horizon for the implementation of the next stages of EMU.

[3] Beside the official ECU, there also developed a market for private ECU, that simply comprises the contracts in which the contracting parties have denominated payment obligations in ECU (with its official definition).

2.2 The Final Steps: Stage II and Stage III of EMU[4]

Stage II began on 1 January 1994 with the establishment of the European Monetary Institute (EMI). The EMI took over the tasks of the EFMC[5] related to the EMS and was furthermore charged with two main tasks. First, strengthening central bank co-operation and monetary policy co-ordination; and secondly, making the preparations required for the establishment of the European System of Central Banks (ESCB), for the conduct of the single monetary policy and for the creation of a single currency in the third stage (harmonisation of statistics, preparation of an efficient cross-border payment system, creating an infrastructure for the European System of Central Banks, etc.). So the EMI had no responsibility for the conduct of monetary policy in the European Union, which remained the preserve of the national authorities. It went into liquidation on the establishment of the European Central Bank (1 June 1998). The ECB took over the tasks of the EMI related to the administration of the mechanisms of the EMS: the Very Short-Term Financing mechanism, the Short-Term Monetary Support mechanism, the creation of ECUs and the administration of borrowing and lending operations concluded by the Community under the Medium-Term Financial Assistance mechanism. In accordance with the EMI Statute and the EMS Agreement[6], the mechanism for the creation of ECUs against gold and US dollars was unwound by the first day of the third stage of EMU. Any existing claims and liabilities arising from the Very Short Term Financing mechanism and from the Short-Term Monetary Support mechanism were settled by the first day of the third stage of EMU.

The final step to be taken before the start of stage III was the establishment of irrevocable euro exchange rates on 31 December 1998. On 1 January 1999 the long way to a common currency was completed with the introduction of the euro (although only for a part of the European Union). Eleven out of the 15 members

[4] Based on ECB (1999A, 2000), Oesterreichische Nationalbank (1998).
[5] The EFMC and the Committee of Central Bank Governors were dissolved, the EMI took over their duties.
[6] compare Art. 23 of the EMI Statute and Art. 20 of the EMS Agreement.

of the European Union (EU) (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain) started with the Third Stage of the Economic and Monetary Union (EMU) and transferred their monetary competence to the European Central Bank (ECB).[7] Greece will become the twelfth member of the euro area on 1 January 2001.[8]

For two years, the national currencies will coexist with the euro which will only be used for non-cash transactions. Euro banknotes and coins will be put into circulation on 1 January 2002. On 1 July 2002 by the latest, the national banknotes and coins will cease to exist as legal tender.

The ERM which played a key role in the progress towards EMU, was replaced by a new exchange rate mechanism (ERM II) from the start of Stage Three. This new mechanism links the currencies of Member States outside the euro area to the euro. However, participation in ERM II is voluntary for all the Member States outside the euro area.

Finally, it should be mentioned that the Economic and Financial Committee, a consultative Community body was set up at the start of Stage Three, when the Monetary Committee was dissolved. The Member States, the European Commission and the European Central Bank (ECB) each appoint no more than two members of the Committee. Article 114 (2) of the Treaty contains a list of the tasks of the Economic and Financial Committee, including the review of the economic and financial situation of the Member States and of the Community.

[7] The group of countries that adopted the euro with the beginning of Stage Three of EMU is commonly referred to as „euroland" or "euro area", whereas the "Eurosystem" comprises the ECB and the NCBs of the euro area countries. The "European System of Central Banks" (ESCB) additionally includes the NCBs of the EU members that did not adopt the euro from the start of Stage Three of EMU. By the term "euro-currencies" we will denote the (former) currencies of the countries that have introduced the euro with 1 January 1999.

[8] Based on the assessment that Greece fulfils the necessary conditions on the basis of the convergence criteria the Commission haas proposed Greece to become the twelfth member of the euro area on 3 May 2000. On 19 June 2000 Greece was accepted by the EU Council in Santa Maria da Feira (Portugal) as participant of the euro area as of 1 January 2001.

3. The ECB, the Eurosystem, its International Reserves and the Effect of the Euro

3.1 The ECB – some Illustrative Numbers

3.1.1 Capital Endowment of the ECB

The basic legal framework for the ESCB and the ECB is provided by the *Protocol (No.18) on the Statute of the European System of Central Banks and of the European Central Bank* of the Treaty of Amsterdam (formerly Protocol No. 3 of Maastricht). The capital of the ECB is €5000 million.[9] The NCBs are the sole subscribers to and holders of the capital of the ECB. The subscription of the capital is based on a key established on the basis of the 15 Member States' respective shares in the GDP and population of the Community.[10] As the NCBs of the four non-participating countries only have to pay up 5% of their respective subscriptions, the ECB is endowed with an initial capital of slightly under €4000 million[11] (ECB (1999a, p. 121f.)).

Table 3.1 gives an overview of the NCB's shares in the ECB's capital.

[9] On 8 May 2000 the ECOFIN Council adopted a regulation (No. 1009/2000) that enables the Governing Council of the ECB to increase the capital by an additional amount of up to €5,000 million. However, as no action has been taken by now, the capital of the ECB still is €5,000 million.

[10] This key was established in accordance with Article 29 of the Statute of the ESCB and laid down in Decision ECB/1998/1 of the Governing Council of 9 June 1998. On the basis of the revised GDP statistical data which became available in November 1998, the ECB revised the capital key on 1 December 1998 with retroactive effect from 1 June 1998.

[11] An initial payment was made by the NCBs on 1 June 1998 in the form of a transfer of their claims on the ECB relating to the repayment of contributions to the resources of the EMI, to the extent possible or necessary to meet the amounts falling due. Further payments in cash, in various currencies, were made by the euro area NCBs on 1 July 1998 up to the full amounts calculated on the basis of a provisional capital key. Settlement of the final payments due was effected on 4 January 1999, in euro, taking into account: (a) a revision of the capital key of the ECB, as made in accordance with Decision ECB/1998/13 of the Governing Council on 1 December 1998, following the provision of final statistical information by the European Commission; (b) the distribution of the final loss of the EMI in accordance with the key for subscription to the resources of the EMI; and (c) interest due or payable on unsettled amounts for the period from 1 June 1998 to 4 January 1999 (ECB(1998, p. 129)).

Table 3.1 Capital of ECB – Capital shares of the NCBs and capital paid up

Country	Central Bank	%-Share in ECB's capital	Subscription to the ECB's capital [mill. €]	Capital paid up [mill. €]
Austria	*Oesterreichische Nationalbank*	2.36	117.97	117.97
Belgium	*Nationale Bank van België*	2.87	143.29	143.29
Finland	*Suomen Pankki*	1.40	69.85	69.85
France	*Banque de France*	16.83	841.69	841.69
Germany	*Deutsche Bundesbank*	24.49	1224.68	1224.68
Ireland	*Central Bank of Ireland*	0.85	42.48	42.48
Italy	*Banca d'Italia*	14.90	744.75	744.75
Luxembourg	*Banque centrale du Luxembourg*	0.15	7.46	7.46
Netherlands	*De Nederlandsche Bank*	4.28	213.90	213.90
Portugal	*Banco de Portugal*	1.92	96.16	96.16
Spain	*Banco de España*	8.89	444.68	444.68
	å *Euro Area NCBs*	**78.94**	**3946.90**	**3946.90**
Denmark	*Danmarks Nationalbank*	1.67	83.55	4.18
Greece	*Bank of Greece*	2.06	102.82	5.14
Sweden	*Sveriges Riksbank*	2.65	132.69	6.63
United Kingdom	*Bank of England*	14.68	734.06	36.70
	å *Non Euro Area NCBs*	**21.06**	**1053.11**	**52.66**
	Total	**100.00**	**5000.00**	**3999.55**

Source: ECB (1999a, p. 134).

3.1.2 Transfers of International Reserves to the ECB

In accordance with Article 30 of the Statute of the ESCB, the euro area NCBs transferred foreign reserve assets of an amount equivalent to €39500 million to the ECB at the start of stage III.[12] That amount corresponds to the limit of €50 billion[13] established by the Statute of the ESCB for the initial transfer of foreign reserve assets to the ECB, reduced in accordance with the share of the non-participating Member

[12] The transfer of the €39,500 Million took place between 4 and 7 January 1999. 85% of the amount was transferred in foreign exchange (US-dollar and yen), 15% in gold.

[13] On 8 May 2000 the ECOFIN Council adopted a regulation (No 1010/2000) that enables the Governing Council of the ECB to effect further calls of foreign reserve assets from the national central banks beyond the limit set in the Statute up to an amount equivalent to additional € 50,000 million. It has to be noted that the maximum amount of €50,000 remains, so that this regulation only allows the replenishment of already depleted reserves. Up to now, no further calls have been effected.

States in the ECB's capital. The contributions of each euro area NCB were determined in proportion to its share in the subscribed capital of the ECB. In turn, the NCBs were credited with non-redeemable euro-denominated claims equivalent to their contributions. The ECB will remunerate these claims of the NCBs at a rate derived from the Eurosystem's main refinancing rate (ECB (1999a, p. 77f., p. 129 f.)).

Table 3.2 shows the amount transferred to the ECB by the central banks according to their share in the ECB's capital.

Table 3.2 Reserves transferred to the ECB by the NCBs

Country	**Central Bank**	**%-Share in ECB's capital**	**Reserves transferred** [mill. €]
Austria	*Oesterreichische Nationalbank*	2.36	1179.70
Belgium	*Nationale Bank van België*	2.87	1432.90
Finland	*Suomen Pankki*	1.40	698.50
France	*Banque de France*	16.83	8416.85
Germany	*Deutsche Bundesbank*	24.49	12246.75
Ireland	*Central Bank of Ireland*	0.85	424.80
Italy	*Banca d'Italia*	14.90	7447.50
Luxembourg	*Banque centrale du Luxembourg*	0.15	74.60
Netherlands	*De Nederlandsche Bank*	4.28	2139.00
Portugal	*Banco de Portugal*	1.92	961.60
Spain	*Banco de España*	8.89	4446.75
	å Euro Area NCBs	**78.94**	**39468.95**

Source: ECB (1999a, p. 74), own calculations.

3.2 Some Aggregate Statistics of the Eurosystem

We will now take a look at some statistics of the Eurosystem as a whole. In 1998, the average international reserves of the Eurosystem amounted to some $345386 million and made up approximately 81% of the EU's total reserves. Table 3.3 gives some impression of the composition of the international reserves held by the Eurosystem's central banks on average in 1998.

Table 3.3 Composition of the Eurosystem's international reserves

Reserve Asset	**Average 1998** [mill. US-$]	**Share** [%]
SDRs	5572.84	1.69
Reserve Position	22312.38	6.76
Foreign Exchange	302064.14	91.56
Reserves excluding gold	329915.16	100.00
Gold (official price)	15471.07	4.48
Gold (market price)	94715.59	22.31
International Reserves including gold at official price	**345386.23**	**100.00**
International Reserves including gold at market price	**424630.75**	**100.00**

1998 Averages, calculated as average between the level at the beginning and the end of the year (as the December value reflects effects of the ECU-conversion, the end of November value is used). Aggregates calculated from the statistics of the individual countries.
Source: International Financial Statistics, own calculations.

As can be seen, the foreign exchange reserves are by far the most important reserve asset, as they account for some 92% of the non-gold reserves. Special Drawing Rights (SDRs) and the Reserve Position in the Fund are negligible in their size. Gold still plays some role, although its importance has diminished sharply over time. Depending on its valuation it makes up from 4.48% (official price) to 22.31% (market price) of the total reserves.[14] Finally we shall take a brief look at the (presumable) currency composition of the foreign exchange reserves, which is shown in Table 3.4.

[14] Total gold of the Eurosystem's central banks: 323.9 mill. fine troy ounces (oz.) = 10073.3t (1oz = 31.1g). Official gold price (since July 1974): 35 SDRs/oz. Exchange rate $/SZR = 1.36 → official price $47.8. The market price of gold, however, was much higher ($292.5). Some of the central banks favoured a valuation closer to the official price but the majority valued their gold reserves close to or at market prices.
(AT: $152.3/oz, BLX: $310.3/oz, FI: $205.3/oz, FR: $301.9/oz, DE: $82.3/oz, IE $305.2/oz, IT: $310.2/oz, NL: $219.)/oz, PT: $171.5/oz, ES: $250.0/oz → (weighted) average of national valuations $219.7/oz). All data are 1998 averages.

Table 3.4 Currency composition of the Eurosystem's foreign exchange reserves

Currency	%-Share (end of 1995)
US-$	39.92
Yen	5.26
ECUs	23.59
euro-currencies	23.94
Others	7.29
Total FX Reserves	**100.00**

The term "euro-currencies" refers to the (former) currencies of the countries that introduced the euro with 1 January 1999.
Source: IMF (1996) taken from Masson and Turtelboom (1996, p.16), own calculations.

As informatin on reserve composition is not being published by central banks, we can only proxy the presumable composition of the Eurosystem's international reserves in 1998 by using shares based on aggregate EU data of the year 1995, which have been calculated by the IMF on the basis of confidentially submitted data. We use this data to calculate the shares of the different currencies in 1995 and assume for the moment that these shares, as shown in Table 3.4, have hardly changed since then.

3.3 The Changeover to the Third Stage and its Effects on International Reserves

3.3.1 Overview of the Implications of the Euro

Having described the size and the structure of the reserves in the Eurosystem, we now turn to the analysis of the effects of the introduction of the euro on the international reserves in the Eurosystem. Two fundamentally different effects have to be distinguished:

- The first largely is a matter of accounting and arises from two technical adjustments. First, official ECUs that were issued to the NCBs through revolving swaps (agianst the contribution of 20% of their gold and dollar holdings) were unwoud into gold and dollar on 31 December 1998. Second, with effect from

1 January foreign exchange reserves previously denominated in euro-currencies became domestic assets (ECB (1999b, p. 37)). These "technical effects" of the euro introduction are analysed in part 3.3.2 of the paper.

- The second effect of the euro introduction is behavioural and arises from the fact that the optimal level of the Eurosystem's international reserves is likely to be lower than the sum of the optimal individual country levels. The two main arguments usually put forward to support this view are the disappearance of a large part of international trade (intra-euro area trade became "regional" trade) and the elimination of the need to stabilise the exchange rate vis-à-vis the currencies of other euro area countries. Other arguments relate to the existence of "economies of scale" in the demand for international reserves. These effects will be analysed more in detail in the following chapters, both theoretically (part five) and empirically (part six).

3.3.2 Technical Aspects of the Euro Introduction

3.3.2.1 The ECU-Conversion

ECUs were created against the transfer of 20% of the countries' US-$ and gold reserves to the EMI. The dissolvement of this mechanism therefore implies that these ECU reserves were returned ("swapped back") by the NCBs against gold and US-$ reserves. Of course, the swap partner in this case was the ECB that had taken over the duties of the EMI.

The first aspect of the ECU conversion regards the switching of the ECU-reserves against gold. Here, one would expect a decline in the foreign exchange reserves by an amount equivalent to the market value of the gold reserves that had been transferred to the EMI and which were returned then with the dissolvement of the ECU-creating mechanism. Table 3.5 compares the gold level of the Eurosystem at

the end of November 1998 with the level at the end of December 1998.[15] One can see an increase by 80 million ounces, which is exactly equal to 20%. Simultaneously, foreign exchange reserves declined by $36777 million, which is even more than expected, as the market value of the returned gold only amounted to $23012 million. This means that at the same time (from November to December 1998) foreign exchange reserves declined by $13764.6 million for other reasons than the dissolvement of the ECU-creating mechanism.

Table 3.5 Effects of the ECU-conversion (1): ECU → gold

Date (end of Month)	**Gold** [mill. oz.]	**Gold[1)]** [mill. US-$]	**FX** [mill. US-$]
November 1998	319.83	92047.14	304014.7
December 1998	399.79	115058.98	267237.3
Change	79.96	23011.84	-36777.40
%-change	20.00	20.00	-13.76

[1)] at market prices end of December ($287.8/oz.). Aggregate Statistics calculated as sum of the individual countries' statistics.
Source: International Financial Statistics.

The second aspect of the ECU conversion regards the switching of ECU against US-$. This of course did not alter the level of the foreign exchange reserves but led to a change in the currency composition of the reserves. As information on the currency composition is not being published by the central banks, the actual effect cannot be calculated. However, knowing that the US-$ reserves transferred to the EMI comprise 20% of the EU's total $-reserves and that – according to the liquidation balance sheet of the EMI - these transferred $-reserves amounted to $44508 million at the end of May 1998, we may conclude that the total dollar reserves of the Eurosystem at this point of time were equal to 58.3% of the total foreign exchange reserves or $175626.168 million (compare Table 3.6). In comparison with the year 1995 ($-share: 40%; compare Table 3.4), there has been a strong increase in $-holdings, (probably) at the cost of reserves denominated in euro-currencies.

[15] The change must be reflected in the December value as – according to Art. 23 of the EMI Statute and Art. 20 of the EMS Agreement – the mechanism for creating ECU shall be unwound *by*

Furthermore taking into account the reduction in total foreign exchange reserves as a result of the conversion of a part of the ECU into gold, the dollar share approximately made up some 64% at the end of 1998.

Table 3.6 Effects of the ECU-conversion (2): ECU → US-$

Reserve asset	**Value** [mill. US-$]
US-$ transferred to EWI[1)]	44508.0
Total US-$ reserves of the EU[2)]	222540.1
FX-Reserves of the EU[3)]	381533.0
%-share of US-$ reserves May 98	**58.3**
%-share of US-$ reserves after ECU-conversion against gold	**63.9**

All data refer to end of May 1998.
[1)] taken from the balance sheet of the EMI end of May 1998, an converted into US-$. Source: ECB (1999a, p. 138).
[2)] US-$ transferred to EWI/0.2.
[3)] Aggregate Statistic calculated as sum of the individual countries' statistics.
Source: International Financial Statistics (WIFO-database).
The EMI`s US-$ holdings also comprised dollars transferred from (former) members of the EWS that do not belong to the euro area. Therefore we can only calculate the $-reserves of the EU and its share in the EU's total foreign exchange reserves (End of may 1998: $ 381532.993 million) which turns out to be 58.3% (This may overstate the actual share as there were also „Other holders of ECU"). Assuming the same $-share for the Eurosystem implies that its $-reserves end of May 1998 amounted to $175626.17 million.

3.3.2.2 The Redefinition of "International Reserves"

In line with the recommendations of the 5th Edition of the IMF Balance of Payments Manual, the international reserves of the Eurosystem are defined as „highly liquid, marketable and creditworthy claims held by the ECB ("pooled reserves") and the participating NCBs ("unpooled reserve assets") on non-residents of the euro area and denominated in foreign currency (i.e. in currencies other than the euro), plus gold, reserve positions in the Fund and SDR holdings."[16] Bearing in

the first day of stage three of EMU.
[16] ECB Methodological Note: Reserve Assets within the Structure of the Template on International Reserves and Foreign Currency Liquidity. Source: Website of ECB (www.ecb.int) / statistics / international reserves

mind this definition of international reserves, we can identify the reserve assets that have ceased to exist as international reserves after the introduction of the euro.

The primarily affected reserve category were the foreign exchange reserves denominated in euro-currencies. Of course these former reserves did not disappear with the changeover but they were merely transformed into euro-claims. These former reserves can now be found in the euro area statistics under the headings „euro-claims on non euro area residents" and „euro-claims on euro area residents.[17]

Not only the claims in the former „euro-currencies" are affected but also the foreign currency claims against euro area residents. These assets are now referred to as "non-euro claims on euro area residents".

The transformation of these former foreign exchange reserves into the three different non-reserve assets is summarised in Table 3.7 which compares the foreign exchange reserves of the Eurosystem at the end of 1998 with the first euro area statistic after the changeover from 1 January. This change within one day is only effected by the redefinition of the international reserves as described above. As expected, there was a substantial decrease in the foreign exchange reserves by $34121 million as a part of the international reserves were redefined as euro-claims after the changeover.

Further information can be obtained from Table 3.7. As the euro-claims (on euro areas residents as well as on the non-euro area residents) result from the transformation of the former euro-currencies reserves, we can calculate their share in the foreign exchange reserves at the end of 1998, which turns out to be 9.4%. This value is a little lower than expected, as we calculated a US-$ share of some 64% at the end of December 1998 (compare Table 3.7). This implies that of the remaining 35% of the foreign exchange reserves, only 9.4% were made up of former euro-currency reserves. This is rather low given the fact that the share of

[17] according to an information of the ECB on request.

Yen and other Non US-$ reserves (excluding the euro-currency reserves) accounted for only 12% in 1995 (compare Table 3.4).[18]

Table 3.7 Effects of the redefinition of international reserves

Date	**FX**[1)] [mill. US-$]	**Change** [mill. US-$]	**Non-euro claims on euro-area residents**[2)] [mill. US-$]	**Euro-claims on non-euro area residents**[3)] [mill. US-$]	**Euro-claims on euro area-residents**[4)] [mill. US-$]
31. December 1998	267237.3	-34120.7	-	-	-
1. January 1999	233116.6		8867.3	10429.6	14823.8

[1)] December: Aggregate Statistic calculated as sum of the individual countries' statistics, January: Aggregate Statistic of Euro Area, Source: ECB monthly bulletin (e.g. April 2000, p. 47*): Table 8.6 2.Reserves and related assets of the Eurosystem, converted into US-$ using the $/ECU rate of 31 Dec. 1998 (1.16675)
[2)] Source: ECB, monthly bulletin, Table 8.6 2.Reserves and related assets of the Eurosystem, converted into US-$.
[3)] Source: ECB, monthly bulletin (e.g. May 1999, p. 4*) Table 1.1 Consolidated financial statement of the Eurosystem, converted into US-$.
[4)] calculated as 1) - [2)+3)]
Positions [3)] and [4)] of this table comprise the euro-claims that result form the transformation of former euro-currency reserves. Together they make up 9.4% of the total foreign exchange reserves (end of 1998).

As a result of these effects described above the (actual) international reserves of the Eurosystem after the introduction of the euro in the year 1999 were made up as follows:[19]

[18] If we account for the reduction in the reserves due to the ECU conversion and assume that the share of these other reserves has been increased relatively according to US-$ share then these other reserves would make up some 20%. This share still is by 6% too low to result in a euro-currencies share that coincides with the share implied by the reduction in the foreign exchange reserves. An explanation for this difference may be that the NCBs engaged in switching reserves denominated in euro-currencies into other reserves in the last months before the changeover to avoid a reduction in the reserves that was perceived as too large.
[19] After the numerous tables that had to rely on several approximations and assumptions due to the non-availability of data it should be noted here that the numbers in Table 3.8 are actual data of the year 1999. It is this actual level of reserves we will later compare with an estimated optimal level to calculate the actual excess of reserves in the Eurosystem.

Table 3.8 Composition of the Eurosystem's international reserves

Reserve Asset	**Average 1999** [mill. US-$]	**Share** [%]	**Average 1998** [mill. US-$]
SDRs	5248.15	2.01	5572.84
Reserve Position	25773.48	9.89	22312.38
Foreign Exchange	229544.33	88.09	302064.14
Reserves excluding gold	260565.95	100.00	329915.16
Gold (official price)	19631.66	6.84	15471.07
Gold (market price)	114720.99	29.92	94715.59
International Reserves including gold at official price	**286977.08**	**100.00**	**345386.23**
International Reserves including gold at market price	**383466.21**	**100.00**	**424630.75**

1999 Average. The quantitatively negligible reserve asset "other reserves" is not shown in this Table. Therefore "Reserves excluding gold" + "gold" do not exactly sum up to the position "International reserves including gold".
Source: International Financial Statistics.

Compared to the average level of reserves in 1998 there has been a substantial reduction in reserves due to accounting effects. Of course, these former reserves still exist, but as they are not available for intervention needs, their exclusion from the (definition of) international reserves is justified. Theoretically, this former reserves could be transformed back into reserve assets (for example by gradually changing the euro claims into US-$), but if the actual reserves were already excessive, this would make no sense from an economic point of view. However, when calculating an excess of reserves by comparing the optimal and the actual level of reserves in the Eurosystem one has to bear in mind that there exists a stock of former reserves that are denominated in euro now.

Table 3.9 gives an overview of the average level of those former reserves that were precluded by the new definition of international reserves in the Eurosystem.

Table 3.9 Former reserves assets - average 1999

Asset	**Value** [mill. US-$]
non euro-claims on euro area residents[1)]	11666.77
euro-claims on non euro area residents[2)]	7636.88
euro-claims on euro area residents[3)]	14823.77
Sum	**34127.42**

1) Aggregate Statistic of Euro Area, Source: International Financial Statistics.
2) Source: ECB, monthly bulletin, Table 8.6 2.Reserves and related assets of the Eurosystem, converted into US-$.
3) as no statistic is available for this position the value from 1 Jan 1999 (compare Table 3.7) was assumed as constant in 1999.

As regards the currency composition of the reserves in 1999 Table 3.10 gives some information on the likely shares of the different currencies.

Table 3.10 Currency composition of foreign exchange reserves

Currency	**%-share**	**Value** [mill. US-$]
US-$	80.0	183635.5
Yen	8.4	19281.7
Other Currencies	11.6	26627.1
Total FX Reserves	100.00	229544.33

The calculation of these shares is based on the assumption that the Yen and Other Currency Reserves together made up 20% of the total FX reserves at the end of 1998 as suggested by the explanation provided in footnote 18. This implies the assumption that the unexplained 6% (of the implied reduction in foreign exchange) were switched to equal parts from euro-currencies to US-$ and other Reserves (Yen, reserves in other non euro-currencies) in the months before the changeover. The values in the table account for the reduction by the euro currency reserves (9.4%), so that these shares refer to 1999.
For the level of foreign exchange reserves in 1999 compare Table 3.8.

Finally, we shall take a look at the distribution of the international reserves among the euro area countries and compare their respective shares in the total international reserves with the share in the ECB‘s capital to reveal existing asymmetries with regard to the scale of the countries.

Table 3.11 Distribution of the Eurosystem's international reserves – Average 1999

Country	**International reserves incl. gold at the official price** [1)] [mill. US-$]	**Share in the Eurosystem's reserves** [%]	***„Scaled Share"* in ECB's capital** [%]	**Share in ECB's capital** [%]
Austria	17416.78	6.16	2.99	2.36
Belgium+Luxembourg	13708.45	4.85	3.82	3.02
Finland	9141.75	3.23	1.77	1.40
France	51238.17	18.13	21.33	16.83
Germany	76287.47	27.00	31.03	24.49
Ireland	6382.59	2.26	1.08	0.85
Italy	35700.46	12.63	18.87	14.90
Netherlands	14937.04	5.29	5.42	4.28
Portugal	10067.21	3.56	2.44	1.92
Spain	47718.53	16.89	11.27	8.89
Eurosystem	**282598.45**	**100.00**	**100.00**	**78.94**

[1)] As data for 1 January are only available for the aggregate, the average reserve levels for the individual countries in 1999 in this table is calculated with the end of January and the end of December values. These individual countries' reserve levels were then adjusted by adding the $-value of the capital paid up and the reserves transferred to the ECB. Due to small statistical discrepancies there is a slight difference between the aggregate level in this Table (calculated as sum of theses values) and the according value in Table 3.8.

Source: International Financial Statistics (WIFO-database).

The „Scaled shares in ECB" refer only to the part of the capital subscribed by the euro area NCBs so that they sum up to 100%, i.e. they equal the share of the single euro area NCBs in the stake of the all euro area NCBs in the ECB's capital.

A comparison of the shares in reserves with the share in the ECB's capital highlights considerable asymmetries in the reserve holdings of the Eurosystem's central banks as the share in the ECB can be regarded as scale indicator (as it is based on population size and GDP). Austria, Portugal, and Spain, for example have a very high share in the reserves of the Eurosystem compared with their share in the ECB. Quite contrary is the situation for the central banks of France and Germany. According to their size one would expect their reserves to be higher. Of course, these comparisons are subject to a number of qualifications as reserve demand does not only depend on size as we shall see in the following chapter. Furthermore, the "lower" level of bigger countries may also indicate economies of scale in reserve demand. Nevertheless, these asymmetries related to the size will become relevant after the introduction of the euro, as will be outlined more in detail later (compare chapter seven).

4. The Demand for International Reserves - A Brief Survey

4.1 Theoretical Considerations

Considerations about the „appropriate" quantity of monetary reserves can be traced back to the beginning of the 19th century where Thornton (1802) argued, that a country's gold stock should be related to the potential benefits of being able to mitigate internal fluctuations by trade deficits and to the size of the domestic money supply. Thereafter, the gold standard triumphed and directed the attention to the close tie between reserves and the stock of money until Keynes (1913, 1930) reintroduced the importance of the external factor. In the 40s there was a widespread agreement that reserves were relevant for international purposes rather than for backing the money supply. This view is also reflected in the proposal of the Keynes Plan for an International Clearing Union, that the bancor quotas (which would have been a main source of international liquidity) should be related to trade. Triffin (1947) carried this argument one stage further and argued that the demand for reserves could be expected to grow in line with trade, so that the reserves/imports ratio (R/I-ratio) could be used as a measure of reserve adequacy. This measure was subsequently used in the first attempts to estimate the demand for international reserves (Harrod (1953), IMF (1953), IMF (1958), Franks (1958), Stamp (1958), Triffin (1960)), so that by 1960 it was regarded as the standard approach to this subject (Williamson (1973, p. 688ff.)).

The theoretical foundation of the R/I-ratio is rather weak. It is based on an analogy to the quantity theory of money which postulates a stable relation between the demand for money and the volume of transactions in current prices. If the volume of international transactions is measured by imports, this approach ends by postulating a stable relation between the demand for international reserves and the value of imports (Niehans (1979, p. 58)).
There are a number of problems with the use of this measure:

- There is no generally accepted reference period. Depending on the reference period chosen, the actual level of reserves may be assessed as too low or too high (Rohwedder and Schröder (1970, p. 434)).
- A second criticism stems from the fact first mentioned by Nurkse (1944), that reserves are used to finance deficits, not trade. It is to be expected that the relationship between the "buffer stock" and the volume of transactions is much less tight than the relationship between the actual medium of exchange and the volume of transactions.
- The assumption of a constant R/I-ratio implies that there are no other relevant factors determining reserve demand. Obviously, this is an unrealistic oversimplification. The importance of the variability of a country's imbalance has already been stressed by Nurkse (1944).
- A further implication of keeping a constant R/I-ratio is that the import elasticity of reserve demand equals one. There are a number of both theoretical (e.g. Streissler (1969), Olivera (1971)) and empirical (e.g. Officer (1976), Frenkel (1978), Frenkel and Jovanovic (1981)) studies which indicate economies of scale in reserve holdings, i.e. an import elasticity of reserve demand smaller than one.

Despite its shortcomings, the R/I-ratio was the standard approach in assessing the demand for reserves up to the mid 60s. Only „... since the mid 60´s some ´aesthetic models´ have been developed replacing the journalistic style of international monetary economics by technical rigour and awarding the recent literature on this subject more credibility among professional economists" (Claassen (1976, p. 73)).

The "post R/I-ratio" theory of optimal international reserves has then been developed along two lines. The first is that of a *cost-benefit approach*, which determines the optimum level of reserves by maximising the difference between benefits and costs from holding reserves which are considered to be of comparable dimension . This approach implicitly implies identical behaviour of different countries' central banks, as individual preferences are not accounted for. The sec-

ond line is that of a *utility-maximising approach* and begins by finding a social welfare function with the reserve level among its arguments. This function then is maximised subject to all constraints of the problem. In this approach, costs and benefits of reserve holdings need not be of comparable dimension. Differences between the central banks' preferences can also be accounted for by an according specification of the utility function (Gandolfo (1995, p. 468)).

The basis contribution in the cost-benefit line is from Heller (1966). Arguing that reserves of monetary authorities are part of the total capital resources of a country, Heller interprets the cost of holding reserves as an opportunity cost, given by the difference between the social yield on capital invested and the yield on international reserves. This (marginal) yield (r_n) is assumed to be positive and constant. The benefits of holding reserves are the avoided costs of adjusting to a (temporary) balance of payments deficit. In Heller's model the only way to adjust to an external deficit is via expenditure changing policies, i.e. external equilibrium is restored by reducing national income to reduce imports sufficiently to eliminate the deficit. Under this pure Keynesian posture, the marginal cost of adjustment per unit of deficit (A) equals the reciprocal of the marginal propensity to import (m), which is assumed to be constant ($A=1/m$). To obtain the marginal benefit of holding reserves, this cost of adjustment must be multiplied with the probability (c) of having to use the marginal reserve unit. This probability is given by the probability of an occurrence of a number of consecutive deficits whose total size is such that the stock of reserves is used up. Regarding the stochastic properties of the reserve development, Heller assumed that the stock of a country's international reserves follows a symmetrical random walk: each year reserves change by an average amount (h), where the probability of a reserve growth and a reserve decline are equal (0.5). Therefore the expectation of the reserve change is zero (which corresponds to the assumption of a fundamental balance of payments equilibrium). On the basis of the model containing these key elements (optimal) national reserve demand is given by the formula $R = h \log(r_n m)/\log(0.5)$.

This formula implies that optimal reserves are an increasing function of uncertainty (average yearly imbalances (h)) and a decreasing function of the cost of holding reserves (r_n) and of the marginal propensity to import (= reciprocal of marginal cost of adjustment (A) as $A=1/m$). Heller himself pointed out the many objections to this very simplified model. However, the meaning of Heller's contribution „ lies not in its empirical results or the realism of the theoretical model but in its formulation of the basic problem of reserve demand as a cost-benefit analysis involving probabilities of future deficits and the structural characteristics of countries determining the costs of holding reserves and of income adjustments to deal with deficits" (Grubel (1971, p. 1157)). Heller's approach was subsequently extended and refined by introducing the possibility of alternative adjustment policies. Heller and Kreinin (1973) analysed the cost of adjustment via expenditure switching policies, particularly by exchange rate variations, while Sellekaerts and Sellekaerts (1973) took the possibility of interest rate changes into account. In these two studies it turned out that for most of the sample countries exchange rate variations were the cheapest adjustment policy, "followed" by interest rate changes and the most expensive alternative of income reducing. However, there are a number of arguments for using a combination of more than one instrument to restore external equilibrium (Claassen (1976, p. 98ff.)). Other refinements were made by going more deeply into the probabilistic aspect and improving the stochastic assumptions and properties of the model (Hamada and Ueda (1977), Frenkel and Jovanovic (1981)).

More recent works in the tradition of Heller are those of Ben-Bassat and Gottlieb (1992) and of Jung (1995). Ben-Bassat and Gottlieb (1992) postulate that a national central bank needs international reserves to repay maturing foreign-currency denominated debt. Therefore reserves were rather held to avoid default costs than adjustment costs. The first order condition of their optimisation problem gives no explicit solution for the optimal level of reserves but it can be used to simulate the time path of optimal reserves. Ben-Bassat's and Gottlieb's results may be especially useful in understanding reserve demand for borrowing countries.

Jung applied Miller's and Orr's (1966) model of the precautionary demand for cash balances to the problem of optimal international reserve management. This yields a discontinuous and asymmetric reserve holding behaviour in the sense that central banks only react when reserves go beyond certain limits and that they respond faster to a deficit than to a surplus.

As regards the utility maximising approach, the basic contributions are from Clark (1970) and Kelly (1970). Both of them are based on a social welfare function with the reserve level among its arguments. Social welfare is considered as increasing function of income and as decreasing function of income instability. Both arguments are related to the level of reserves (and the stochastic properties of reserve development). A higher level of reserves reduces the (expected) income fluctuations because the probability of reserve depletion (which would enforce adjustment which in turn causes instability) decreases with a rising reserve stock. On the other hand, a higher level of reserves implies higher opportunity costs and thereby a lower level of income. This trade-off has to be solved so that the level of social welfare is maximised. Again, the uncertainty is given by the stochastic properties of the reserve development. Although the modelling strategy is somewhat different compared to the cost benefit approach, the reasoning is essentially the same. Consequently, the most important determinants of the optimal reserve level also hardly change. In Hipple's model (Hipple 1974) - a synthesis and refinement of the Clark and Kelly analysis that also integrates elements of the Heller model – optimal reserves turn out to be an increasing function of aggregate national wealth, adjustment costs and uncertainty and a decreasing function of opportunity costs.

Another important contribution to the "utility maximising line" is the paper of Claassen (1975). Building up on Kelly (1970), Claassen integrates Miller's and Orr's (1966) model of the precautionary demand for cash balances into a utility maximising framework, which results in a optimal reserve management with discontinuous and asymmetric properties. A similar approach, although based on a

cost-benefit analysis, is that of Jung (1995) which has already been described above.

One of the few papers that explicitly analyse the effect of a fundamental balance of payments disequilibrium is that of Kim (1989). As expected, the size of the fundamental disequilibrium and the optimal level of reserves are positively related, whereas there is a negative relationship between the fundamental disequilibrium and the optimal speed of adjustment. Further determinants of reserve demand in Kim's model again are the opportunity cost of reserve holdings, uncertainty as well as the costs of borrowed reserves.

Finally some further studies shall only be mentioned here: Niehans (1970), Rhomberg (1970), Iyoha (1973), Levy (1983), Suss (1980). These models are less concerned with the explicit specification of a reserve demand function but rather with the determination of the level of reserves in the framework of macroeconomic models, in which reserves, adjustment policy and other economic policy key parameters are determined simultaneously.

The major theoretical contributions to the problem of optimal reserves range from the mid 60's to the mid 70's. After the collapse of Bretton Woods, the interest in this topic sharply decreased, leaving several aspects unexplained. The role of increased exchange rate flexibility, highly developed financial markets and the possibility of fundamental disequilibria still have not been satisfactorily integrated in a theory on the demand for international reserves, so that Gandolfo only recently stated: "The problem of the ´adequacy´ of international liquidity and the related problem of the demand for international reserves are moot questions, far from being solved, notwithstanding innumerable studies." (Gandolfo (1995, p. 464)).

4.2 Empirics

Beside this theoretical literature a lot of empirical work has been done. The first attempts to estimate the demand for international reserves of individual countries were mainly based on ratio comparisons (e.g. Harrod (1953), IMF (1953), IMF (1958), Triffin (1960), Brown (1964)). Typically, reserves were compared with the level of imports or with measures of past reserve variability. The first study estimating the demand for reserves by the use of regression techniques was that of Kenen and Yudin (1965), which has to be considered as a significant improvement over the earlier studies because this procedure allows for the inclusion of more independent variables (suggested by the theoretical models) in the analysis and for more sophisticated specification of relationships with the dependent variable (Cohen (1975, p. 416)).

Meanwhile, there exists a large number of empirical studies that try to explain past levels of reserves by a number of explanatory variables using regression techniques. A basic assumption of all these studies is that reserve demand equals observed reserve levels or at least – if a partial adjustment model is estimated – that reserves are partially adjusted towards a target level which is determined by a long run equilibrium demand function. To consider this demand also as optimal, the further assumption must be satisfied that central banks have some trace of economic rationality. This is a view which has been strongly opposed by Machlup (1966) who argues that reserve demand is not a function of any identifiable variable but that it is governed by the insatiable desire of central bankers to have their reserves grow.[20] Of course, one can question if central banks behave fully rational, but the assumption that scarcity of resources does not matter in any way for central bankers is very implausible. Furthermore, the satisfactory results of the large number of empirical studies give support to the thesis that reserve demand can be well described as a function of identifiable variables (which are suggested

[20] Because of Machlup's analogy to the „demand" of his wife for new clothes this criticism has become known in the literature as "Mrs. Machlup's wardrobe theory of monetary reserves."

by the "rational" models of reserve demand). We will therefore assume that central banks behave rationally, so that the quantity of reserves demanded can also be regarded as the optimal level of reserves.[21]

The large number of empirical estimations and their results shall not be reviewed in detail here, only some general aspects shall be summarised.[22] Most studies use pooled data from several countries, some of them separate data into two groups - those from developed and from developing countries. There is only a small number of single country studies. The modelling techniques exhibit different degrees of sophistication, ranging from simple OLS-estimations to seasonal error correction models (Huang and Shen 1999).

The explanatory variables used include: gross national product (GNP), imports, average propensity to import, marginal propensity to import, reserve variability, export variability, exchange rate variability, domestic interest rates, foreign interest rates, interest rate spreads, GNP growth, money supply, money supply changes, liabilities of banks, foreign assets of banks, marginal productivity of capital.

The theoretical motivations and the results for the single variables shall not be reviewed here. We shall only mention that two variables used in most studies are the scale variable (imports or GNP) and past reserve variability. A further important measure is the average propensity to import, although its sign is theoretically ambiguous.[23]

The general results of this "standard approach", however, are very satisfactory. Many of the estimations yielded highly significant coefficients with the correct sign and a high explanatory power. Therefore we will use a modified version of

[21] In the following we therefore won't distinguish between the different notions „need", „felt need", „desire", „demand" and „optimal" reserves. This semantic aspects have especially been stressed by Machlup (1966).

[22] For detailed surveys of the empirical studies see Bahmani-Oskooee (1985), Lehto (1994) and Badinger (1999).

[23] This stems from the fact that as it may not only proxy the marginal propensity to import but also the degree of openness of an economy, for which Frenkel (1974) derived a positive relation with reserves in a price adjustment model (using small country assumptions). A problem not mentioned

this standard demand function in our estimation, as will be described more in detail below.

A note regarding the justification of an isolated estimation of a reserve demand function without accounting for the supply side is also in order here. For the isolated estimation of the reserve demand function to be justified, the assumption of a perfectly elastic supply of reserves must be fulfilled, because otherwise this estimation would result in a „simultaneous equation bias“ (Bahmani-Oskooee (1987)). To avoid this assumption Bahmani-Oskooe (1985) estimated a simultaneous equation system, in which he modelled both the demand and the supply side. Comparing his results with the isolated estimation he concludes that there is support for the already earlier stated presumption of Crockett (1978, p. 14) „[that] it is not too misleading to say that the supply of reserve currencies responds to changes in the demand to hold them with something approaching perfect elasticity.“ This result is also an ex-post justification of all isolated estimations of reserve demand functions.

is that openness is usually negatively related to the size of the economy, which makes the interpretation even more difficult (especially in studies using a cross section of countries).

5. Excess Reserves in the Eurosystem: Status of Research, Theoretical Aspects and the Modelling of the Regime Shift

5.1 A Review of the Literature on Excess Reserves in the Eurosystem

There are only a few studies trying to estimate the demand for reserves in the Eurosystem and the effect of the introduction of the euro. Most of them use rules of thumb, like the R/I-ratio or similar measures.

An early estimation of the „reserve surplus“ resulting from the establishment of monetary union was carried out by the European Commission in 1990 (Commission (1990)). Based on the assumption that the required level of reserves depends on the size of the foreign exchange transactions, the Commission concluded that reserves could be reduced according to the share of the intra-EU transactions (i.e. foreign exchange transactions denominated in the currency of EU-members) in total foreign exchange transactions. According to this method, excess reserves amounted to $230 billion. As alternative measure the Commission used the ratio of reserves to imports (R/I-ratio). Reducing imports by intra-EU imports and further assuming that the R/I-ratio of the EU is brought in line with the ratio of other industrial countries, this method produced an estimated reserve reduction of $200 billion. Both methods suggest that total reserves (including gold) can be reduced by approximately 50%.

Kenen (1995, p. 115) modifies this amount by deducting the amount of reserves denominated in the currencies of EU-members ($75 billion) and the gold share of the excess reserves ($85 billion) which reduces the assumed “overhang” to a range between $40 and $70 billion.

Using an average R/I-ratio of the OECD-countries (10%) Baumgartner et al. (1997) estimate that in the case of a small EMU (Belgium, Germany, France, Netherlands, Luxembourg and Austria) $66 billion, in the case of a big EMU (all

EU-members) $116 billion of reserves would be freed. Estimates of the investment banks J.P. Morgan (1996) and Goldman Sachs (1996) range between $150 and $200 billion.

There first study using state of the art (= regression) techniques in assessing the demand for reserves in the Eurosystem is Leahy (1996), although the ultimate aim of this paper is to analyse the effect of the euro introduction on the official US-$ holdings of the European Union's central banks. Leahy's estimation is based on a pooled cross section-time series sample: the countries integrated in the analysis comprise the 12 EU-members in 1990. Quarterly data for the time period 1985-90 is used. As explanatory variables Leahy uses GNP, imports, exchange rate variability as a measure of the variability of external shocks, a trend variable and a lagged dynamic variable (partial adjustment model). Then he goes on and specifies a multiple equation model and estimates this model using a Seemingly Unrelated Regression technique. The estimated coefficient for the GNP is positive (as expected) but insignificant, the estimated coefficient of imports is insignificant and also shows the wrong (negative) sign, the exchange rate variability measure is significant and shows - if interpreted as variability measure for external shocks - the correct sign. Leahy then simulates reserve demand of the ECB by using the estimated (long run) coefficients and constructing hypothetical aggregate variables for the EMU. The EMU-GNP simply is the sum of the GNP of the 12 EU countries. The aggregate imports of the EU countries are modified by deducting intra-EU imports from the sum of the 12 countries. Furthermore, the exchange-rate variability of the individual countries' currencies against the dollar is replaced by the variability of the ECU against the dollar. Depending on the country specific coefficients (intercept, trend) used Leahy gets a range of projected reserve demands. Reserve demand is highest if the country-specific coefficients of Portugal are used: in this case there are no excess reserves but a reserve shortage which amounts to the 18-fold(!) of the pre-EMU reserves. Reserve demand is lowest if the country-specific coefficients of the Netherlands are used: in this case, reserves could decline by 90%; i.e. a tenth of pre-EMU reserves would be sufficient. This means the projected level of reserve demand depends on the idiosyncratic char-

acteristics of the ECB assumed. Of course, the range of uncertainty in the results is very large, leading Leahy to the conclusion, that „the full distribution of outcomes, wide as it is, is probably a more accurate description of what we currently know about the demand for reserves“ (Leahy (1995, p. 388f.)).

We will also use this basic methodology of Leahy (1996) (estimating the coefficients for a demand function of the ECB by estimating a multiple equation model and simulating reserve demand in the Eurosystem by using aggregate data) in our paper. By updating and refining Leahy's work regarding the choice of variables and the modelling of the regime shift, the large uncertainty of his results shall be reduced and more reliable results concerning a reserve overhang shall be achieved.

The two most recent estimates (Frenkel and Sondergaard (1999), Eichengreen and Mathieson (2000)) also use regression techniques to estimate the relation between the demand for reserves and the size of trade (imports respectively exports). The excessive reserves are then calculated by netting out intra-EMU trade and comparing the actual holdings with the predicted values.

The result of Frenkel and Sondergaard (1999) is in line with earlier estimates that postulate excess reserves of approximately half of the actual holdings. The results of Eichengreen and Mathieson (2000) point at considerably smaller effects due to the small export elasticity of reserve demand in their estimation. The implied reduction in reserve demand turns out to be even smaller than the assumed size of the reduction in reserves due to technical effects of the changeover. Thus, Greenaway and Mathieson conclude that there is actually a shortage of reserves in the eurosystem (Greenaway and Mathieson (2000, p. 11ff.)).

5.2 Reserve Demand and the Formation of a Monetary Union

Having briefly reviewed reserve demand theory and its empirical studies, we shall now take a look at the effects of monetary unification. Theoretical interest in the

topic increased as political ambitions to form a European Economic and Monetary Union were intensified and became quite concrete in the Werner Plan, yielding two volumes with contributions from well-known economists dedicated to the implications and problems of European Monetary Unification (and its Meaning for the United States) (Krause and Salant (1973)) and to the Economics of Common Currencies (Johnson and Swoboda (1973)). The central question for our analysis is why an area with a common currency should need less reserves than the sum of the reserves needed by the single countries.

Salant (1973) investigates the implications of European Monetary Unification on international reserves emphasising the process on the way to monetary union and not the situation under monetary union itself. The analysis is based on a distinction between external reserves (= reserves acceptable to non-members of the Community) and internal reserves (= the portion of the need for total reserves that can be satisfied by reserves acceptable to members but not to non-members) plus substitutes for internal reserves (intra-Community clearing arrangements and facilities for mutual expansion of credit). Balance of Payments imbalances are regarded as major determinant of reserve need. We shall briefly sum up the main arguments put forward by Salant, suggesting a reduction in the need for reserves of the Community:

- First, there may be a reduction in the total need for reserves due to a (likely) reduction of the members' balance of payments imbalances in the process of monetary unification. But even if there is no reduction in the Community's need for total reserves, there will be some economy in its need for external reserves due to the substitution of internal reserves for external reserves. This degree of substitution will largely depend on the will of the members to finance deficits of other members.
- Secondly, economies in total reserve need are also likely to result from the expansion of intra-Community official borrowing facilities and improved adjustment through the operation of market forces on trade and private capital flows, including accommodating short-term flows.

- Finally, increased competitiveness of one of the major currencies of the Community[24] with the dollar as reserve asset and increased use as a vehicle currency and as a medium for investment in funds are also mentioned as arguments for a reduced reserve need.

Although Salant makes no attempt to quantify the excess reserves, he concludes that the "present aggregate reserves of the Community members, already abundant, will become super abundant, and even more disproportionate to United States reserves as they are now." (Salant (1973, p. 234f.)).

Mundell also argues that the introduction of a common currency will result in a saving of international reserves. In a simple model he demonstrates that the ratio of (needed) reserves to money supply falls as the currency area increases (Mundell (1973a)). This decline in the reserve ratio is mainly due to the substitution of external trade by domestic trade. This ratio based approach shall not be reviewed here. We focus our attention on two important theoretical arguments for reserve saving that are directly relevant to our empirical analysis and which were also made by Mundell (1973b):

- Substitution of external trade by domestic trade: by forming a monetary union, foreign exposure is considerably reduced as a large part of international trade becomes domestic trade; i.e. the size of the foreign trade sector is decreased. Clearly, the higher the trade share of the countries with the other participants of the monetary union (intra-union trade), the larger the reduction in the international reserves needed.
- The insurance argument: simply speaking this argument is based on the assumption that not all countries will get into deficit at the same time. As the deficits are partly offset by surpluses of other countries, pooling reserves automatically permits an economising of them. The argument has later been formalised by Baker (1980a, 1980b) and Schiemann (1986) and shall be shown more in detail below.

[24] After the introduction of the common currency one should say „of the Community's single currency".

Both arguments were also emphasised by Catte (1998) and Winckler (1998) with regard to the problem of current account imbalances and the likely effects of a monetary union. Furthermore, these two arguments directly aim at determinants of reserve demand that were widely used as explanatory variables in the empirical estimations of reserve demand functions: the size of the foreign trade sector and the variability of past reserve changes. One additional point has to be made here, as the variability of external shocks may not only be reflected in the variability of the reserve changes as external shocks may also partly be offset by adjustment policies, primarily by exchange rate changes. Therefore we will add the variability of past exchange rate changes as complementary measure for the variability of external shocks to our demand function. Hence, our reserve demand function will contain three explanatory variables:

- Imports
- Variability of past reserve changes
- Variability of past exchange rate changes

5.3 Modelling the Regime Shift

We shall now analyse how the introduction of the euro affects each of these determinants of reserve demand. The rationale for the modelling strategy described below is based on the assumption that after the introduction of the euro and the transfer of monetary competence to the ECB, the Eurosystem - as regards its international monetary relations - can be considered as a single economic entity. We will now illustrate the formal implementation and the quantitative implications of the arguments outlined above. For simplicity we let the complexities of estimation aside for a while and assume a "known" reserve demand function, which is – regarding its functional form and its parameters - the same for the individual central banks and the aggregate Eurosystem. This implies that the demand function does not change with the regime shift, which makes our approach clearly

subject to the Lucas critique. With respect to that, itcan be argued that previous empirical work indicates that significant changes in the international monetary system (as the collapse of the Bretton-Woods system) did not fundamentally change the general structure of the demand for reserves (Frenkel (1978), Leahy (1995)).

While we focus on the theoretical aspects here, the empirical implementation of the modelling strategy is carried out in chapter six of the paper.

As already mentioned, reserve demand of country i (RES_i) is assumed to be a function of imports (IMP_i), past reserve variability (s_RES_i) and past exchange rate variability (s_ER_i).

$$RES_i = f(IMP_i, s\_RES_i, s\_ER_i)$$

As we assume a linear functional form with the same parameters for all countries, the sum of the individual countries' reserve demands ($\sum_i RES_i$) is:

$$\sum_i RES_i = f(\sum_i IMP_i, \sum_i s\_RES_i, \sum_i s\_ER_i)$$

Before the introduction of a common currency this sum of individual countries' reserve demands is equal to the demand of the aggregate system. After the regime shift, however, it is not the same anymore. Although we still assume the same functional form and the same parameters, the value of the explanatory variables in the demand function of the aggregate system is not simply the sum of the individual countries' values. We will now analyse the change in (the definition of) each variable of our demand function caused by the introduction of the euro. Thereby the variables for the aggregate Eurosystem are indexed with "EU-11".

5.3.1 The Effect on Imports

As already mentioned, the scale of the foreign trade sector is an important determinant of reserve demand. With the introduction of the euro, a large part of international trade disappears as intra-euro area trade has to be regarded as "re-

gional" trade (at least what regards its effect on reserve demand). More formally we can write:

$$\sum_i IMP_i \quad \rightarrow \quad IMP_{\text{EU-11}}$$

$$IMP_{\text{EU-11}} = \sum_i IMPNONEMU_i = \sum_i (1-\alpha_i) IMP_i$$

with i ..... Index of countries participating on the monetary union

IMP_i ..... imports of country i

$IMPNONEMU_i$ ..... imports of country i from outside the euro area

α_i ..... share of intra-euro area imports of country i

This means the higher the share of intra-euro area trade, the stronger the reduction in reserve demand implied by the introduction of a common currency.

5.3.2 The Effect on Past Reserve Variability

Theoretical as well as empirical work on the demand for international reserves suggests that reserve holdings may be explained by some measure of payments variability. The most common measure used was the standard deviation of the (detrended) past reserve changes, which are viewed as best predictors of the standard deviation of future reserve changes. After completion of a monetary union it is not the sum of the individual countries' standard deviations but the standard deviation of the aggregate reserve changes that matters. This means

$$\sum_i s\_RES_i \quad \rightarrow \quad s\_RES_{\text{EU-11}}$$

The aggregate change in reserves is given by the sum of the individual countries' reserve changes. Therefore the standard deviation of the aggregate can be expressed in terms of the individual variances and covariances as follows:

$$s\_RES_{\text{EU-11}} = \sqrt{\sum_i s\_RES_i^2 + \sum_i \sum_{j \neq i} s\_RES_{ij}}$$

where $s\_RES_{EU\text{-}11}$ ..... standard deviation of aggregate reserve changes

s_RES_i ..... standard deviation of country i's reserve changes

s_RES_{ij} ..... covariance between reserve changes of country i and county j

The effect on reserve demand can be seen by comparing $\sum_i s\_RES_i$ with $s\_RES_{EU\text{-}11}$. Squaring both expressions and simplifying the resulting terms we can deduce that a sufficient condition for a reduction in reserve demand is that

$$\sum_i s\_RES_i \; s\_RES_j \;\; > \;\; \sum_i s\_RES_{ij}$$

This condition can also be written as

$$\sum_i s\_RES_i \; s\_RES_j \;\; > \;\; \sum_i \rho_{ij} \cdot s\_RES_i \; s\_RES_j$$

where ρ_{ij} is the correlation coefficient between the reserve changes of country i and country j. As it can never exceed the value one, reserve demand after formation of a monetary union can at most be equal to the situation before and it will be lower if at least one of the reserve changes is not perfectly correlated with the other members' reserve changes (Baker (1980, p. 97f.), Schiemann (1986, p. 592ff.)).

5.3.3 The Effect on Past Exchange Rate Variability

We use the standard deviation of the past exchange rate changes as complementary measure for the variability of external shocks.[25] Again, the past changes are considered as best predictors for the future changes. With the introduction of the euro exchange rate fluctuations between the EU-11 countries are ruled out. To

[25] It should be noted that there is another interpretation of the exchange rate variability. It could be argued that countries with a more flexible exchange rate system need less reserves and therefore one could expect a negative sign (e.g. Bahmani-Oskooee and Malixi (1987), Bahmani-Oskooee and Niroomand (1988)). However, as it turns out in the estimation, our data rather support the interpretation as (complementary) measure for external shocks.

capture this effect, we construct the following index of nominal effective exchange rate changes for each country i:

$$WK_{it} = \sum_{j=1}^{16} (\ln w_{ij,t} - \ln w_{ij,t-1}) TS_{ij} \times 100 \; [\sim\%] \qquad i \neq j$$

The relative exchange rate changes of country i against the countries j (j = 1, ..., 16; j ≠ i) are thereby weighted with the according trade shares (TS_{ij}), measured by the share of imports from country j and exports to country j in total imports plus exports. The partner countries j included in the calculation are the other euro area countries (i = 1,...10; Belgium and Luxembourg are again treated as one country), the remaining EU countries (i =, 11, 12, 13, 14; Denmark, Greece, Sweden, United Kingdom), Japan (i = 15) and the United States (i = 16). The variability measure (σ_ER_i) is then calculated as standard deviation of this index over the last 16 periods.[26] After the introduction of the euro there are no exchange rate changes within the euro area. Therefore the aggregate measure becomes

$$\sum_{j \neq i} s\_ER_i \rightarrow \sigma\_ER_{EU\text{-}11} = \sum_{j \neq i} s\_ER_i^*$$

where the calculation of $s\_ER_i^*$ is based on the WK_{it} with the changes $[\ln(w_{ij,t}) - \ln(w_{ij,t-1})]$ set to zero for the partner countries that belong to the euro area (j = 1,....10). This accounts for the fact that exchange rate changes between the currencies of euro area countries are ruled out after the introduction of the euro. Under "normal conditions"[27] a decrease in the measure can be expected, if the exchange rate changes between euro currencies are eliminated.

[26] see Appendix A4 for a more detailed description of the variables.

[27] Theoretically it would be possible that the exchange rate changes against the other euro-currencies stabilises the index if their aggregate effect (their weighted sum) primarily „operates against" the fluctuations of the exchange rate against the other currencies so that the overall fluctuation of the index would be mitigated rather than enforced in most cases. In this unlikely case the elimination of the exchange rate changes between the euro-currencies could even increase the measure. However, in our case a normal effect occurs (compare Table 6.4).

6. Empirical Model and Estimation Results

6.1 The Reserve Demand Function(s) and Assumptions of the Model

As already mentioned in part five, our basic strategy in the empirical implementation heavily draws on Leahy (1995). Its essence is to estimate an ECB-reserve demand function by a panel estimation of the individual countries' demand functions. While this basic strategy is quite the same as in Leahy's model, there are a number of differences, especially regarding the choice of explanatory variables, the explicit modelling of the regime shift, the definition of the dependent variable, the sample of countries and the estimation period.

Our reserve demand functions are based on three variables: imports, past reserve variability and past exchange rate variability. These variables have been used in many empirical studies and are also of central importance with regard to the effects of forming a monetary union. The motivation for the choice of the variables and a detailed analysis of the effects of the regime shift on these variables have already been given above, so that we directly turn to the demand function(s) of our empirical model:

$$RES_{it} = \beta_{0i} + \beta_{1i} IMP_{it} + \beta_{2i} \sigma\_RES_{it} + \beta_{3i} \sigma\_ER_{it} + u_{it} \qquad (6.1)$$

where *RES* ..... Total Reserves inclusive gold at official price[28] [mill. US-$]

IMP ..... Imports [mill. US-$]

σ_RES ... Standard deviation of the past reserve changes [mill. US-$]

[28] The question if the gold reserves should be included has been answered differently in the literature. Landel-Mills (1989, p. 728f.) points out the two major arguments that were used to preclude gold from the endogenous variable „reserves". First, central banks consider gold as less liquid than other reserve assets, because large sales might depress the market price and because central banks view gold as reserve that is „truly" of last resort. The second reason refers to the valuation problem: valuation at the official price will underestimate the actual value, while the market price is too high. From our point of view, these two reasons are not fully convincing: the fact that gold is used only in extremities does not alter the fact that it would be available if needed. Furthermore the

σ_ER .... Standard deviation of the past nominal effective exchange rate changes [%]

i ..... country index: i = 1, ..., 10 (euro area; BE and LUX are treated as aggregate)

t ..... time index: t = 1, ..., 17 (1981 – 1997)

A detailed description of the data, the data sources and the definition of the variables is given in Appendix A4.

As regards the disturbances we assume first order serial correlation

$$u_{it} = \rho_i u_{it-1} + e_{it} \tag{6.2}$$

The disturbances e_{it} are distributed with an expectation of 0 and a country specific standard deviation σ_i. Furthermore we assume e_{it} to exhibit contemporaneous correlation, i.e. correlation between the error terms of different countries with the same observation number.

$$E[e_i] = 0, \; Var[e_i] = s_i^2 \times I_T$$

$$Cov[e_{it}e_{js}] = \sigma_{ij} \quad \text{for } t = s \tag{6.3}$$

$$Cov[e_{it}e_{js}] = 0 \quad \text{for } t \neq s$$

As regards the coefficients of the model it is assumed that country specific effects are solely reflected in a country specific intercept term, while the coefficients of the other variables are assumed (restricted) to be equal across countries.

$$\begin{aligned} &\beta_{ki} = \beta_{kj} && \text{all } k \neq 0 \\ &\beta_{ki} \neq \beta_{kj} && \text{for } k = 0 \\ &\rho_i = \rho && \text{all } i \end{aligned} \tag{6.4}$$

valuation problem is not solved by excluding the gold reserves because this only implies the „most implausible" valuation at a price of zero. As a compromise on the safe side, we therefore include the gold holdings valued at the official price in the definition of the dependent variable „reserves".

6.2 Results of the Estimation

Table 6.1 shows the estimation results of a Restricted Seemingly Unrelated Regression (RSUR) of the system of equations (6.1).[29]

Table 6.1 Estimation results

Dependent Variable: *RES* **Sample: 1981 - 1997** **Total number of observations: 170** **Method: Seemingly Unrelated Regression**					
Variable		**Estimated Coefficient**	**Std. Error**	**t-Statistic**	**Prob.-Value**
IMP_i	β_1	0.0758	0.01	6.61	0.0000
σ_RES_i	β_2	3.5611	0.33	10.80	0.0000
σ_ER_i	β_3	443.2845	150.33	2.95	0.0037
$AR(1)_i$	ρ	0.7139	0.05	13.25	0.0000

Fixed Effects					
AT	β_{01}	4594.855	IE	β_{06}	-1452.692
BE	β_{02}	-2712.286	IT	β_{07}	-505.546
FI	β_{03}	-3607.065	NL	β_{08}	2616.868
FR	β_{04}	-6604.445	PT	β_{09}	852.413
DE	β_{05}	9204.735	ES	β_{010}	9573.312

Statistics					
R^2	0.9601	$Adj.\ R^2$	0.9478	$\Sigma e^T e$	2.96E+09

The time period covered by the estimation ranges from 1981 to 1997.[30] In the equation we use absolute rather than logarithmic values.[31] Estimation is carried out by using an iterative procedure: in a first step, the variance-covariance matrix of $[e_{ij}]$ is estimated using the OLS residuals of (6.1). In the next step, a GLS esti-

[29] Estimation was carried out with the Software EViews, Version 3.1. EViews is a registered trademark of *Quantitative Micro Soft*ware, 4521 Campus Drive, Suite 336, Irvine CA, 92612.

[30] The last year before the introduction of the euro (1998) is excluded from the analysis, as the reserve level in this year reflects not only reserve demand behaviour, but also effects of preparatory work to the changeover (liquidation of the EMI, payment of subscribed capital share, ECU-conversion, compare chapter 1). As starting period, the year 1981 is chosen as this will result in an estimation using data beginning one year after the implementation of the EMS (the AR-specification implies that data of the year 1980 is also used).

mation is carried out , where the model is weighted with the (inverted) variance-covariance matrix.[32] The resulting residuals are used to calculate a new weighting matrix which is used in the next estimation round, etc. Convergence is achieved after 35 iterations (Convergence Level: 0.1%).[33]

All coefficients are significant at the 1% level and show the expected sign. The demand for reserves increases with the scale of the foreign trade sector (proxied by *IMP*) and the variability of external shocks (measured by σ_RES and σ_ER). The fixed effects, which are regarded as the only country specific elements of the reserve demand function, range from -6604.445 (FR) to 9573.312 (ES).[34] As the equation is estimated in absolute numbers rather than in logs, some additional information is necessary concerning the quantitative meaning of each variable. Looking at the year 1997, for example, the relative contributions of the variables (value of the variable multiplied by the estimated coefficient) to the predicted value ($\sum_{i=1}^{11} \hat{RES}_{it}$) are as follows: Intercept (3.6%), IMP (35.0%), σ_RES (53.7%), σ_ER (7.8%). As absolute values are used, the implied elasticities are, of course, not time invariant. In 1997 they were 0.35 (*IMP*), 0.54 (σ_RES) and 0.08 (σ_ER). As one can see, the quantitatively most important determinant of reserve demand in our model is the past reserve variability. Imports still have a large impact, while the past variability of the exchange rate is only of minor importance. The explanatory power of the model – measured by R^2 (adj. R^2) related to the aggregate reserve level – is 96% (94.7%). The coefficients of the AR-term is also

[31] The fit turns out to be better with this specification. Furthermore, in our model the choice of logarithmic values leads to convergence problems in the estimation.

[32] Eviews substitutes the AR-specification in the main equation and transforms the equation in such a way that the coefficients of the variables and the AR-term can be estimated simultaneously by applying a Marquardt non-linear least squares algorithm to the transformed equation. So the estimation technique actually used is a weighted non-linear least squares method (EViews 3 User's Guide, p. 308f., p. 619ff.).

[33] This means that iterating is stopped when the maximum of the percentage changes in the estimated parameters is smaller than the prespecified level of 0.1%.

[34] EViews calculates the fixed effects as „residuals" by first estimating the (slope coefficients) of the model with mean corrected variables. Then the country-specific fixed effects are recovered by using the relation between the overall and the country specific means of the variables (compare Eviews 3 User's Guide, p. 569).

significant at the one percent level and successfully removes most of the serial correlation.[35]

Table 6.2 gives an overview of the estimated standard deviation of the individual countries' residuals. The strong heteroscedasticity of the residuals is mainly due to the choice of absolute rather than logarithmic values in the regression and the differences in the reserve management of the countries' central banks.

Table 6.2 Standard deviation of the countries' residuals

Standard deviation of the individual countries' estimation errors [mill. US-$]									
s_{AT}	1839.43	s_{FI}	1464.31	s_{DE}	7817.96	s_{IT}	8931.11	s_{PT}	2095.22
s_{BE}	1020.25	s_{FR}	4301.58	s_{IE}	608.09	s_{NL}	3112.09	s_{ES}	8143.83
Standard deviation of the Eurosystem's estimation error[1)] [mill. US-$]									
s_{EU-11}				15109.61					

1) As the estimated demand for the aggregate Eurosystem simply is the unweighted sum of the estimated individual country demands, the estimation error of the aggregate can easily be calculated from the variances and covariances of the individual country's' error terms using the following formula:

$\sigma_{EU\text{-}11} = \sqrt{\sum_{i=1}^{10}\sigma_i^2 + \sum_{i=1}^{10}\sum_{j\neq i}^{10}\sigma_{ij}}$ The variance-covariance matrix is shown in Appendix A5. Alternatively, of course, one could also estimate $\sigma_{EU\text{-}11}$ from the aggregate residuals. It has to be noted that the standard deviations in the table refer to the residuals that result if one calculates the predicted values using the information included in the AR-term. If the predicted values using the structural forecasts (without the AR-term) are applied the resulting standard deviation amounts to $21299.79 million.

The SUR-technique was chosen as we expected the residuals to be not only heteroscedastic, but also contemporaneously correlated. It can be seen from the correlation matrix shown in Table 6.3 that contemporaneous correlation is actually prevalent. The strongest negative correlation occurs between the residuals of

[35] If the estimation is carried out without AR-term, the residuals of all countries except BE show significant serial correlation (measured by the Ljung-Box statistic, significance level: 1%). After inclusion of the AR-term, only the error terms of AT and PT still exhibit serial correlation (measured by the same criterion). The remaining correlation in two of the countries is probably due to the restriction that the coefficient of the AR-term is equal across countries.

AT and FI (respectively between ES and NL) (-0.61), the strongest positive correlation between the residuals of IT and ES (+0.69).

Table 6.3 Contemporaneous correlation

Correlation between the error terms of country i and country j $= s_{ij} / (s_i s_j)$										
	AT	**BE**	**FI**	**FR**	**DE**	**IE**	**IT**	**NL**	**PT**	**ES**
AT	1.00	0.38	-0.61	-0.39	-0.03	-0.14	-0.27	0.20	0.15	-0.10
BE	0.38	1.00	-0.37	0.23	0.36	0.04	0.04	0.14	0.39	0.28
FI	-0.61	-0.37	1.00	0.36	-0.20	0.54	0.36	0.06	-0.11	0.06
FR	-0.39	0.23	0.36	1.00	0.38	0.24	0.41	-0.35	-0.14	0.31
DE	-0.03	0.36	-0.20	0.38	1.00	0.06	-0.37	0.14	-0.18	-0.14
IE	-0.14	0.04	0.54	0.24	0.06	1.00	0.25	0.10	-0.12	0.00
IT	-0.27	0.04	0.36	0.41	-0.37	0.25	1.00	-0.60	0.22	0.69
NL	0.20	0.14	0.06	-0.35	0.14	0.10	-0.60	1.00	-0.06	-0.61
PT	0.15	0.39	-0.11	-0.14	-0.18	-0.12	0.22	-0.06	1.00	0.67
ES	-0.10	0.28	0.06	0.31	-0.14	0.00	0.69	-0.61	0.67	1.00

A crucial assumption in the regression analysis is that the slope coefficients are equal across countries, i.e. that differences in the central banks' reserve management are solely reflected in the country specific intercept term. Theoretically, one could test these assumptions using F-statistics, but these tests usually assume a homoscedastic, uncorrelated and normally distributed error term. Thereby the sum of the squared residuals of the general and the restricted model are compared. The most general model, however, cannot be estimated in our case, as the matrix of the exogenous variables cannot be inverted here. Therefore the assumption of equal cross country slope coefficients will not only facilitate the economic interpretation, but is also a „technical necessity".[36]

[36] If one is not willing to accept this equality constraint for reasons of assumed behavioural differences, the equality constraint can still be regarded as resulting in an averaging of the coefficients.

6.3 Reserve Demand Simulations with and without Regime Shift

6.3.1 Hypothetical Reserve Demand of the Eurosystem in 1999 without Regime Shift

Having estimated reserve demand functions of the Eurosystem's central banks, that only differ by the country specific intercepts we can proceed in constructing a reserve demand function for the aggregate Eurosystem, or – taking into account that the aggregate reserves of the Eurosystem are managed by the ECB – one could also say a reserve demand function of the ECB.

The intercept of the aggregate demand function is simply calculated by adding up the country specific intercepts. The estimated slope coefficients are not only regarded as representative for each of the countries but also for the Eurosystem as a whole and therefore they enter directly into the demand function. The aggregate demand of the Eurosystem before the regime shift is equal to the sum of the individual countries' reserve demands and can therefore be expressed by the following demand function:[37]

$$\sum_{i=1}^{10} \hat{RES}_{it} =$$

$$11960.1 + 0.076 \sum_{i=1}^{10} IMP_{it} + 3.56 \sum_{i=1}^{10} s\_RES_{it} + 443.28 \sum_{i=1}^{10} s\_ER_{it} \qquad (6.5)$$

We now simulate the hypothetical reserve demand for the year 1999 with this function (6.5). It is hypothetical as it assumes that no regime shift has taken place and that the definition of the explanatory variables is unaltered. Inserting the according values for 1999 (see Table 6.4) of the explanatory variables in equation (6.5) yields a hypothetical reserve demand of \$357589.3 million. If there had been no regime shift and the NCBs had continued their reserve demand policies,

Anyway, this interpretation has to be applied to the variable σ_ER as it refers to relative changes and does not account for the country size.

the level of international reserves in the Eurosystem would have amounted to this value in 1999.

6.3.2 Reserve Demand of the Eurosystem in 1999 Accounting for the Introduction of the Euro

We now simulate reserve demand of the Eurosystem, taking into account that the euro has been introduced with 1 January 1999. As already mentioned, it is assumed that the estimated coefficients remain representative under the new regime. Therefore the shift in the regime is reflected in the definition of the explanatory variables, so that the reserve demand function of the aggregate Eurosystem after the regime shift becomes:

$$\hat{RES}_{\text{EU-11,t}} =$$
$$11960.1 + 0.076\, IMP_{\text{EU-11}} + 3.56\, s\_RES_{\text{EU-11}} + 443.28\, s\_ER_{\text{EU-11}} \qquad (6.6)$$

The change in the nature of the explanatory variables due to the regime shift has already been considered in detail in chapter five. Table 6.4 summarises the qualitative as well as the quantitative implications of the changeover to the euro concerning the explanatory variables. A simulation for the year 1999 by inserting the new values of the explanatory variables in equation (6.6) yields a new, reduced reserve demand of $188187.5 million.

This means that one would expect that the ECB and the NCBs have decreased the level of international reserves to this value after the introduction of the euro in 1999. But this has not been the case as can be seen from the actual reserve level in 1999 (compare Table 3.11) and this is the reason for the generation of excess reserves as a result of the changeover.

[37] We use the structural form for the forecasts and ignore the AR-term.

Table 6.4 Definition and quantitative aspects of the explanatory variables in the aggregate Eurosystem's reserve demand function before and after the introduction of the euro

Explanatory Variable	**Definition before introduction of the euro = å single country values** **(value in 1999)**	**Definition after the introduction of the euro** **(value in 1999)**	**Relative reduction in the size of the variable** [%]	**Implied reduction in reserve demand accountable to the variable** [%]
IMP	$\sum_{i=1}^{10} IMP_{it}$ (1999: \$1666389.1 mill.)	$IMP_{\text{EU-11}} = \sum_i IMPNONEU_i = \sum_i (1-\alpha_i)\, IMP_i$ $IMPNONEMU_i$ ... imports of country i from outside EU-11 α_i .....share of intra-euro area trade of country i (1999: \$816453 mill.)	51.0	38.05
s_*RES*	$\sum_{i=1}^{10} s\_RES_{it}$ (1999: \$54787.9 mill.)	$s\_RES_{\text{EU-11}} = \sqrt{\sum_i s\_RES_i^2 + \sum_i \sum_{j \neq i} s\_RES_{ij}}$ $s\_RES_{\text{EU-11}}$ ... standard deviation of aggregate reserve changes s_RES_i ..... standard deviation of country i's reserve changes s_RES_{ij} ..... covariance between reserve changes of countries i and j (1999: \$ 26579.6 mill.)	51.5	59.3
s_*ER*	$\sum_{i=1}^{10} s\_ER_{it}$ (1999: 54.5%)	$s\_ER_{\text{EU-11}} = \sum_{j \neq i} s\_ER_i^*$ $s\_ER_i^*$ calculated with the exchange rate changes against the currencies of „euro-countries" set to zero. (1999: 44.3%)	18.6	2.7

6.4 Excess Reserves in the Eurosystem: Hypothetical and Actual Surplus

As we regard the central bank behaviour as rational in the estimation period the demand for reserves can also be interpreted as optimal level of reserves in the Eurosystem. Taking the regime shift into account this optimal level of reserves in the Eurosystem amounts to $188187.5 million in the year 1999. When we are talking about excess reserves two different concepts of calculating this excess have to be distinguished.

6.4.1 Hypothetical Excess Reserves Generated by the Introduction of the Euro

How much excess reserves has the introduction of the euro generated? If we ask for the genuine behavioural effect of the euro on the optimal level of reserves in the Eurosystem, we have to compare the demand after the regime shift ($188187.5 million) with the hypothetical reserve demand that would have occurred in the year 1999 if no regime shift had taken place ($357589.3 million). This means that the introduction of the euro has – ceteris paribus – generated excess reserves of $169401.784 million. In relative terms, this implies a reduction of reserve demand by almost half of the hypothetical level (47.4%). Table 6.4 shows that the main share in this reduction is accounted for by the variables σ_RES (59.3%) and *IMP* (38.1%), while the reduction due to the variable σ_ER is quite negligible 2.7%. This little weight of the exchange rate variable may be explained by two facts: First, the fluctuations between the exchange rate changes of the euro-countries have been considerably reduced by the EMS-system. Secondly, there existed a number of credit facilities in the framework of the EMS that allowed a relatively uncomplicated refinancing of interventions to stabilise exchange rates in the EMS-framework.

6.4.2 Actual Excess Reserves in the Eurosystem

As our study is an ex-post analysis we also have data on the actual level of reserves in the year 1999. Even if we assume that the central banks have not accommodated their reserve levels due to the regime shift, this actual level differs not only statistically (resulting from the estimation error) from the simulated demand for reserves in 1999 without regime shift but also conceptually. This is due to the technical effects of the changeover (compare chapter three) which have led to a considerable reduction of the international reserves (according to their new definition), so that the actual reserve level in 1999 was on average only $286977.08 million (compare Table 3.8). Therefore, in 1999, actual excess reserves only amounted to $98789.53 million or 34.42% of the actual reserves in the Eurosystem.

This value can be regarded as conservative estimate for the following reasons. Comparisons of the level of international reserves in the Eurosystem with other countries (like the USA) (using measures like the reserves to imports ratio) suggest that reserves were already excessive before the introduction of the euro. In this case, even the estimated level of $188187.5 million would be too high. But also if we assume rational behaviour of the NCBs in the estimation period so that the observed levels (and also the simulated level) can be regarded as optimal, two further arguments can be put forward that the actual reserve overhang is even larger than the estimated $98789.53 million. First, the comparison of the estimated demand with the actual reserve level of $286987.08 million neglects the fact that there exists a stock of former reserves which were denominated in euro-currencies and which have been transferred into euro-claims after the regime shift. As shown in part three of this paper (see Table 3.9), these assets amounted to $34127 million on average in the year 1999. A large share of these former reserves can be regarded as excessive (euro denominated) assets. Second, gold is valued at the official price which clearly understates its actual value. In the following we therefore have to keep in mind that the estimated excess can be interpreted as lower bound.

Finally we shall consider the implications of the estimated reserve demand for two familiar measures regarding the adequacy of international reserves: the reserves to imports ratio (R/I-ratio) and the probability of reserve depletion.

If we assume that the international reserves held in 1999 were equal to its estimated optimal level of $188187.5 million we get an R/I-ratio of 0.23 for the Eurosystem, which still is much higher than the comparable value for the United States (0.07). Based on the standard deviation of the past reserve changes of the Eurosystem, the estimated reserve level implies a probability of reserve depletion of less than 1.8%.[38]

[38] Calculation based on Chebyshev's inequality, which states that the probability that the value of a random variable deviates more than the k-fold from its mean is smaller than (or equal to) $1/k^2$.

7. Allocation of Excess and Alternative Uses

In chapter six, we estimated an optimal demand for reserves in the Eurosystem of $188187.5 million. Compared to the actual level of $286977.08 million, this implies an excess of $98789.532 million. The question now is, how to make use of this excess. After a brief survey of the literature on the use of excess reserves, we will discuss the problems involved in allocating this excess and summarise the basic proposals for their use.

7.1 Literature on Alternative Uses

As regards the question of the use of these excess reserves, there are a number of suggestions but hardly estimates of their effects. Kenen (1995, p. 115) states that "there is in fact no easy way for the EC countries to transform 'excess' reserves into more productive assets. Conceivably, they could engage in public capital formation (or stimulate private capital formation); aggregate demand would then rise, producing a current account deficit, and it could be financed by running down reserves [...] but the necessary increase of aggregate demand could jeopardise other basic aims, such as price stability [...] It would be even harder for the EC countries to change the composition of their currency reserves without effecting the exchange rate".

Early considerations on possible uses of excessive international reserves were made by Felderer (1968) who discusses three basic alternatives: 1) the increase of the investment-ratio via the budget by a tax cut or higher public expenditures or via credit expansion for private investments, 2) a revaluation of the currency and 3) the reduction of tariffs.

Demertzis and Hallet (1999) mention three alternatives to run down a reserve overhang and their potential negative effects: 1) to change excess reserves into euro and let them circulate in the markets (threat of inflation) 2) to sterilise those reserves through open market operations by issuing bonds (threat of rising interest

rates and possibly recession) 3) to change them into US-$ and keep them into the ECB's reserves (threat of exchange rate instability). According to Demertzis and Hallet, all three options could cause financial instabilities.

Gros and Thygesen (1998) are of the opinion that "from an economic point of view it does not matter how these former foreign exchange reserves are used. The net worth of the government (aggregating central bank and treasury) does not change, when for example, foreign exchange reserves are used to retire public debt." A similar conclusion is reached by Gros and Schobert (1999) who argue that using the reserves for debt repayment would only have a marginal effect on the budget (0.03% of GDP on average in the euro area).

Further suggestions stem from the (political) debate on the alternative uses: **f**-nancing a research support fund, funding of a tax cut for private households and the corporate sector or using the excess reserves for public infrastructure projects (Hahn (1998)).

Manzocchi and Padoan (1996) focus on two options, both related to the issue of EU enlargement to the Central and Eastern European countries (CEECs): a debt-relief operation, and the financing of a convergence fund. Their estimations point at significant positive effects on the convergence path of these economies towards higher per capita income levels.

Regarding these questions one has to bear in mind that international reserves (at least those which have not been transferred to the ECB) still are legal property of the NCB's. From this fact, another crucial issue arises: the demand for reserves – and thus the size of a possible reserve overhang – have to be calculated from the view of the aggregate Eurosystem. This excess, however, does not belong to the Eurosystem but is composed of individual countries' excess reserves (which sum up to the excess of the Eurosystem). The question now is, how to "allocate" this total excess to the individual countries.

Following a "national approach", each country could be entitled to use the same percentage share of its own reserves. Alternatively, the operation could be under-taken on a EU wide base with a so called "redistribution approach". For example,

the excess reserves (or a large part of them) could be granted to the highest indebted countries, like Belgium or Italy, which would increase the stability of the euro. This approach, however, requires a substantial redistribution of resources within the EU (euro area) which poses a political problem that can hardly be solved (Manzocchi and Padoan (1997, p. 5f.)).

According to the arguments outlined above, two approaches have to be distinguished: a national and a European approach. In this paper, we will only consider the more realisitic national approach. In the next chapter we present a key by which the excess reserves could be allocated reasonably to the single countries and give an enumeration of alternative proposals to use the excessive reserves.

7.2 Allocation of Excess Reserves and Alternative Uses

7.2.1 Allocation of Excess

Following a national approach, the available excess reserves would first have to be allocated to the countries of the Eurosystem by determining the minimum level of reserves to which the NCBs are allowed to run down their reserves. Each country could then decide itself, how to use the available excess reserves in the most favourable way (of course contingent upon approval of the ECB).

A first possibility would be to allow each country to run down their reserves by an amount equal to its (scaled) share in the ECB, multiplied by the level of excess reserves available for the Eurosystem as a whole. Alternatively, one could allow each NCB to run down its reserves by the same share (equal to the share of the excess in the total reserves of the Eurosystem (34.42%)). Both methods would not take into account that reserves of the Eurosystem are distributed rather asymmetrically with regard to the scale of the countries (compare Table 3.11). Up to the beginning of the third stage of EMU these asymmetries (reflected in the intercept

term in the estimation) may be explained by the different exchange rate regimes, different attitudes towards risk or different preferences regarding a „rapid" adjustment vs. „buying time" by intervening. As these differences are now eliminated by the transfer of the monetary competence to the ECB, there seems to be no justification for an ongoing existence of these asymmetric reserve holdings. Therefore, a probably more reasonable approach would be to allocate the excess reserves in a way that would simultaneously eliminate these asymmetries. This could be achieved as follows: first, one would have to calculate "optimal reserve levels" for the individual countries by multiplying the share of the according NCB in the ECB's capital with the optimal reserve level of the Eurosystem. This guarantees that each country is assigned an optimal reserve level according to its size and that the country levels sum up to the optimal level of the Eurosystem. The difference between the actual reserve holdings and the calculated optimal country level would then be on disposal for each country. Table 7.1 shows the result of applying such a procedure.

As one can see, countries with a relatively high level of reserves (compared to their scale, respectively their share in the ECB's capital) also "receive" a higher share from the excess reserves in the sense that they are allowed to use a bigger share of their own reserves. A comparison of the last three columns in Table 7.1 shows that there are large differences in the allocation of the excess according to the key used. For example, according to our proposal Ireland would be allowed to use the biggest share of its reserves, while Italy's reserves would be regarded as only a little in excess of its optimal level. Austria also has large excess reserves (68% of its actual level) due to its traditionally large reserve holdings which were (considered as) necessary for maintaining a fixed exchange rate with the German Mark.[39]

[39] An early estimation of excess reserves in Austria was carried out by Felderer (1968). Based on the statistical properties of the past reserve changes he determines the (minimum) level of reserves that implies that the probability of reserve depletion does not exceed 0.5%. Using this method he concludes that on average some 90% of the reserves were abundant over the period 1958-1965.

Table 7.1 Allocation of excess reserves to the individual countries

Country	**optimal reserve level**[1)] [mill. US-$] (1)	**actual reserves**[2)] [mill. US-$] (2)	**Excess reserves**[3)] [mill. US-$] (3)=1-2	**Excess in % of own reserves** [%] (4)/(2)*100	**Share in excess** [%] (5)	**„Scaled Share" in ECB** [%] (6)
Austria	5624.80	17686.64	12061.85	68.20	12.21	2.99
Belg.+Lux.	7187.74	13920.85	6733.10	48.37	6.82	3.82
Finland	3330.44	9283.39	5952.95	64.12	6.03	1.77
France	40131.45	52032.06	11900.61	22.87	12.05	21.33
Germany	58392.38	77469.48	19077.10	24.63	19.31	31.03
Ireland	2025.44	6481.48	4456.04	68.75	4.51	1.08
Italy	35509.60	36253.61	744.01	2.05	0.75	18.87
Netherlands	10198.73	15168.47	4969.74	32.76	5.03	5.42
Portugal	4584.90	10223.19	5638.30	55.15	5.71	2.44
Spain	21202.06	48457.89	27255.83	56.25	27.59	11.27
Eurosystem	**188187.55**	**286977.08**	**98789.54**	**34.42**	**100.00**	**100.00**

Reserve data all including gold at official price; all date are 1999 Averages
(1) calculated by multiplying the optimal level of the Eurosystem 1999 ($188187.55 mill.) with the scaled share in the ECB's capital of the according NCB.
(2) calculated by multiplying the average level of the Eurosystem 1999 ($286977.08 mill.) with the share of the according NCBs in the Eurosystem's reserves (compare Table 3.11). Because individual country data are not available for the 1st January, the individual levels do not exactly sum up to the aggregate ($286977.08 mill.) on which the calculation of the excess is based.
(5) share of (3) in total excess ($98789.54 mill.).
(6) The „Scaled shares in ECB" refer only to the part of the capital subscribed by the euro area NCBs so that they sum up to 100%.

7.2.2 Alternative Uses

The economic and legal aspects of the various alternatives proposed to make use of the excess reserves are not considered in detail in this paper. Here we shall only mention some of the alternatives that have been suggested in the (primarily political) discussion on how to run down the excessive reserves in the "most favourable" way.

The two most prominent proposals are to use the excessive reserves for the repayment of public debt or for financing a research-support fund. Alternative suggestions are to use the excessive reserves to finance of a tax cut for private housholds and firms or to use it for public investments (e.g. infrastructure projects).

7.2.3 Framework for the Decision on How to Use the Excess Reserves

The excess reserves in the eurosystem of some $100 billion are no "free lunch" that could be used arbitrarily. Complex economic feedbacks as well as legal restrictions aggravate the decision on how to transform a potential reserve overhang into more productive assets.

Anyway, one has to bear in mind that in general reserves are interest bearing and that a part of the central banks' gain is transferred to the countries' governments. Consequently, running down the reserves only makes sense from an aggregate view of NCB and government, if the opportunity costs of holding reserves are bigger than the yield earned on them, or to put it differently, if the net opportunity costs are greater than zero. Furthermore, any measure that could lead to inflationary pressures would endanger the overarching goal of the ECB to maintain price stability. Thus, as a precondition for a reasonable use of the excess reserves one may define the absence of inflationary consequences.

This aspect also matters from a legal point of view because according to article 31 of the Protocol (on the Statute of the European System of Central Banks and of the European Central Bank) operations in reserve assets above a certain limit are subject to approval by the ECB in order to ensure consistency with the exchange rate and monetary policies of the Community. This limit is determined in a (non-public) guideline of the ECB adopted on 3 November 1998.

The detailed legal as well as economic valuation of a concrete proposal may be difficult in the concrete case. Ultimately, the decision how to use the reserve excess is also a political one. In this paper, however, we do not further concern us with these aspects but leave the economic and legal evaluation of the alternative uses for future research.

8. Conclusions

In this paper, we analyse the implications of the introduction of the euro on the international reserves in the Eurosystem (= European Central Bank (ECB) plus the national central banks (NCBs) of the eleven countries that have introduced the euro) on 1 January, 1999. Two conceptually different effects have to be distinguished: a technical effect that arises largely as a matter of accounting and a behavioural effect that stems from the fact that the optimal demand of the aggregate Eurosystem is not equal to the sum of the NCBs' optimal demands for international reserves.

The technical effect arises from two main sources. First, in course of the abolishment of the ECU-creating mechanism (ECUs were formerly swapped by the ECB against 20% of the NCB's gold and dollar reserves) the ECUs were transformed (back) into gold and US-$ reserves, leading to a redistribution in the reserve composition from foreign exchange to gold and within the remaining foreign exchange reserves from ECU to US-$ denominated reserves. Secondy, international reserves were reduced by the fact that reserves that had been denominated in euro-currencies or which had been held as claims against euro-area residents ceased to exist as international reserves according to their new definition (= non-euro claims on non-euro area residents). As a result, the average reserves of the Eurosystem in 1999 amounted to $286977.08 million, considerably less than in 1998 ($345386.23 million).

In assessing the optimal level of reserves in the Eurosystem, we start with estimating reserve demand functions for the euro area countries using a fixed-effects panel data estimation technique. Thereby, reserve demand is explained by the scale of the foreign trade sector (proxied by imports) and the variability of external shocks which is measured by the past reserve variability (the standard deviation of the past reserve changes) and the past exchange rate variability (standard deviation of the changes of a nominal exchange rate index). From this estimation we derive a reserve demand function for the aggregate Eurosystem and

simulate reserve demand for the situation after the regime shift in the year 1999. In our model, the reduction in reserve demand as a result of the euro introduction operates via three channels and is reflected in the explanatory variables as follows:

1) After the introduction of the euro intra-euro area trade has to be regarded as domestic trade. This implies that the foreign trade sector is decreased in proportion to the share of intra-euro area imports.

2) There are also economies in reserve demand resulting from an insurance effect of the monetary union which is due to the fact that the variability of the Eurosystems's reserve changes is smaller than the sum of the individual countries' variabilities.

3) Finally, the introduction of the euro per definition rules out exchange rate changes between the euro area countries. This leads to a decrease in the exchange rate variability measure and thereby to a lower reserve demand.

As a result of the simulation, the optimal level of reserves in the Eurosystem after the regime shift turns out to be $188187.5 million in the year 1999. The introduction of the euro has therefore generated excess reserves amounting to $98789.532 million.

In the last section we propose a key by which this excess could be allocated to the different countries taking the asymmetrical distribution of reserves within the Eurosystem into account. Thereby, countries with a relatively high reserve level would be allowed to run their reserves down by a larger share. Finally, we briefly summarise the proposals to run down the estimated reserve overhang. The alternatives suggested, range from using the excess for the repayment of public debt to financing of a tax cut for private housholds and firms. However, as reserve trancactions exceeding a certain level require the approval of the ECB not only welfare considerations but also the consistency with the exchange rate and monetary policies of ECB matters for a decision on how to use the excess reserves.

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Appendices

Appendix A1: List of Tables

Appendix A2: List of Abbreviations

CAP	Common Agricultural Policy
CEECs	Central and Eastern European Countries
EC	European Community (Communities)
ECB	European Central Bank
ECOFIN	Council of Ministers of Economics and Finance
ECU	European Currency Unit
EMCF	European Monetary Co-operation Fund
EMI	European Monetary Institute
EMS	European Monetary System
EMU	Economic and Monetary Union
EPU	European Payments Union

ERM ..... Exchange Rate Mechanism
ESCB ..... European System of Central Banks
EUA ..... European Unit of Account
FX ..... Foreign Exchange
IFS ..... International Financial Statistics
IMF ..... International Monetary Fund
NCB ..... National Central Bank
OeNB ..... Österreichische Nationalbank (Austrian Central Bank)
WIFO ..... Österreichisches Institut für Wirtschaftsforschung (Austrian Institute of Economic Research)

Appendix A3: Country Codes

Country	ISO 3166-1-Alpha-2 Code [1)]	Subindex of the Variables i	IFS-Country Code
Euro Area		EU-11	163
Austria	AT	1	122
Belgium+Luxemburg	(BLX)	2	126
Belgium	BE	2a	124
Luxembourg	LU	2b	137
Finland	FI	3	172
France	FR	4	132
Germany	DE	5	134
Ireland	IE	6	178
Italy	IT	7	136
Netherlands	NL	8	138
Portugal	PT	9	182
Spain	ES	10	184
Non Euro Area EU			
Denmark	DK	11	128
Greece	GR	12	174
Sweden	SE	13	144
United Kingdom	GB	14	112
Others			
Japan	JP	15	158
United States	US	16	111

[1)] Source: Website of the ISO 3166/MA-Secretariat
http://www.din.de/gremien/nas/nabd/iso3166ma/index.html]
[4.5.2000]

Appendix A4: Data Sources and Definition of Variables

Variable		Source and Calculation
RES_i	Reserves including gold at official price [mill. US-$]	IFS: *Total Reserves minus Gold* *+ Gold [mill. Ounces]* * 35 *SDR * $/SZR-rate* *Total Reserves minus Gold* line XXX"_1L_D *Gold [mill. Ounces]* line XXX"_1AD *$/SZR-rate (End of Period)* line 111"__SA in the estimation the average reserve level was used as dependent variable and simply defined as average of the reserve levels at the beginning and the end of the year. As the reserve level at the beginning of the year is de facto identical to the reserve level at the end of the preceding year, the average level for t was calculated by ½(RES_t+RES_{t-1}). The average level was used as it can be regarded as more representative than a single value at the end of the year that may be influenced by short term developments.
IMP_i	Imports [mill. US-$]	IFS: *Imports.CIF* *Imports.CIF* line XXX"71__D
s_RES_i	Variability of past reserve changes [mill. US-$]	Standard deviation of the reserve changes over the last 16 periods*) Calculation for t = T. $\sigma_RES_{iT} = \sqrt{\frac{\sum_{t=T-16}^{T-1}\left[?\,RES_{it} - E(?\,RES_{iT})\right]^2}{15}}$ with $\Delta RES_{iT} = RES_{it} - RES_{it-1}$ $E(\Delta RES_{IT}) = 1/n \sum_{t=T-16}^{T-1} \Delta RES_{it}$
s_ER_i	Variability of past exchange rate changes [%]	Standard deviation of "nominal effective exchange rate (changes) index" Calculation for t = T. 1. Calculation of Index $WK_{it} = \sum_{j=1}^{16} (\ln w_{ij,t} - \ln w_{ij,t-1}) TS_{ij} \times 100$ [~%] i≠j w_{ij} ... annual average exchange rate of the currency of country i against the currency of country j i = 1, ...10 (see A3); j = 1, ...16 (see A3) .....

Variable		**Source and Calculation**
s_*ER*$_i$ **(continued)**	Variability of past exchange rate changes [%]	..... w_{ij} was calculated as cross rate from the exchange rate of the countries' currencies against the US-$: $w_{ij} = w_{i16}/w_{j16}$. Source IFS: w_{i16}: units of national currency per US-$: line XXX"__RF (1: Austrian Shilling, 2: Belgian/Luxembourg Francs, 3: Finish Markka, 4: French Francs, 5: Deutsche Mark, 6: Irish Pound, 7: Italian lira, 8: Dutch Gilder, 9:Portuguese Escudo, 10: Spanish Peseta, 11: Danish Krone, 12: Greek Drachma, 13: Swedish Krona, 14: Pound Sterling, 15: Japanese Yen, 16: US Dollar) TS_{ij} ... Trade share of country i with country j in total trade in 1997: $TS_{ij} = (IMP_{ij}+X_{ij})/(IMP_i+X_i)$ IMP_{ij} .... Imports of country i form country j X_{ij} ..... Imports of country i form country j IMP_i ..... Total Imports of country i X_i ..... Total Exports of country i Source: UN-World Trade Database; (imports from and Exports to j = 16 (United States) include also the trade with the rest of the world, i.e. the weight TS_{i16} was calculated as $TS_{i16} = 1 - \sum_{j=1}^{15} TS_{ij}$ 2. Calculation of the Standard deviation of the Index $\sigma\_ER_{iT} = \sqrt{\frac{\sum_{t=T-16}^{T-1}\left[WK_{it} - E(WK_{iT})\right]^2}{15}}$ with $E(WK_{iT}) = 1/n \sum_{t=T-16}^{T-1} WK_{it}$

Subindex i refers to the different countries (see A3); XXX acts as a proxy for the IFS-Country-Code (see A3). .g.: IMP_1 = Imports of Austria; Source: IFS line 122"71__D.
Due to limited data availability Belgium and Luxembourg were treated as aggregate.
Unless stated otherwise all IFS data were taken from the WIFO database.

All monetary data were used in nominal terms. In the literature, both, real as well as nominal demand functions were estimated. The arguments for using real data are rather elusive and not fully convincing (e.g. (Saidi (1981, p. 274)): "It is the demand for real rather than nominal reserves which is assumed to matter, since movements in the price level imply a one-to-one proportionate change in nominal reserves."; or (Edwards (1984, p. 497)): "[reserves] are held either to finance *real* transactions or to face *real* unexpected shocks. In that sense, the demand for reserves is a demand in real terms."). Furthermore, because reserves as well as imports are denominated in different currencies the choice of a proper deflator is very difficult, if not impossible. Therefore, we follow the numerous studies that estimate nominal rather than real demand for reserves (e.g. Frenkel (1978) or more recently Landel-Mills (1989)).

*) In the literature most studies followed Frenkel (1978) and used the standard deviation of the *detrended* reserve changes. For the calculation of σ_T* (* denotes the detrended measure), first, the trend was estimated from the equation $R_t = \alpha+\beta t+\varepsilon_t$ (t = T–17, ..., T–1), then the standard devia-

tion σ_T* of the detrended reserve changes over the last 16 periods [(ΔR_t* = ΔR_t – b), t=T–16, ..., T–1] was calculated. De facto, the detrending hardly matters as deducing the (same) trend (b) from the reserve changes $\Delta R_t = R_t - R_{t-1}$ (t=T–16, ..., T–1) only leads to a shift in the level of the variable, not to a change in its (theoretical) standard deviation.
This can be seen by comparing the formulas for the theoretical variances. For the detrended reserve changes we have $E[(\Delta R_t^* - E(\Delta R_t^*))^2]$. For the changes without trend adjustment we have $E[(\Delta R_t - E(\Delta R_t))^2]$. It is easy to show that these two expression coincide as $E(\Delta R_t^*) = 0$ and $E(\Delta R_t) = \beta$.
However, a slight (negligible) difference arises from the fact that – in the calculation of the standard deviation of the reserve changes ΔR_t – we do not use the theoretical expectation but the sample estimator for $E(\Delta R_t)$ which equals $1/N \sum (R_t - R_{t-1}) = 1/N \sum (R_t - R_{t-N})$. This can also be written as $1/N\{[a+bt+e_t - (a + b(t-N) + e_{t-N})]\} = 1/N[Nb + e_t - e_{t-N}] = b + (e_t - e_{t-N})/N$. Therefore a slight (negligible) difference arises, compared to the detrended version which was usually calculated in the literature (using the known expectation of ΔR_t*) as $1/(N-1)\sum[\Delta R_t - b]^2$.
So the choice between the detrended or absolute reserve changes turns out to be a rather academic question. We regard the standard deviation of the reserve change as an appropriate measure. However, if someone is keen on adjusting for the linear trend, he may interpret our measure as very good approximation for the detrended version.

Appendix A5: Residual Covariances

s_{ij} [1)]	AT	BE	FI	FR	DE	IE	IT	NL	PT	ES
AT	2388359.5	504110.9	-1152326.8	-2150577.3	-302597.0	-113444.0	-3138504.4	826044.5	420540.1	-1031250.6
BE	504110.9	734765.1	-394455.4	715574.0	2029597.3	18392.2	268593.0	303524.4	583412.0	1624653.7
FI	-1152326.8	-394455.4	1513551.4	1605862.2	-1586925.2	339829.2	3348726.5	207097.9	-244985.6	493838.1
FR	-2150577.3	715574.0	1605862.2	13061351.1	8922544.8	442083.2	11212390.7	-3298114.4	-916709.4	7677497.4
DE	-302597.0	2029597.3	-1586925.2	8922544.8	43143827.7	195625.2	-18280863.2	2462577.3	-2089764.5	-6513128.7
IE	-113444.0	18392.2	339829.2	442083.2	195625.2	261016.1	954341.5	132371.8	-111603.1	3027.0
IT	-3138504.4	268593.0	3348726.5	11212390.7	-18280863.2	954341.5	56304508.9	-11852543.5	2844082.0	35183211.4
NL	826044.5	303524.4	207097.9	-3298114.4	2462577.3	132371.8	-11852543.5	6836559.9	-291424.5	-10886802.0
PT	420540.1	583412.0	-244985.6	-916709.4	-2089764.5	-111603.1	2844082.0	-291424.5	3098792.0	8107529.8
ES	-1031250.6	1624653.7	493838.1	7677497.4	-6513128.7	3027.0	35183211.4	-10886802.0	8107529.8	46815461.0

[1)] asymptotically consistent estimates using the formula $\sigma_{ij} = n^{-1}E^TE$; n .. number of observations, E ... matrix with residual series $[e_{AT}\, e_{BE}\, ...\, e_{ES}]$.

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