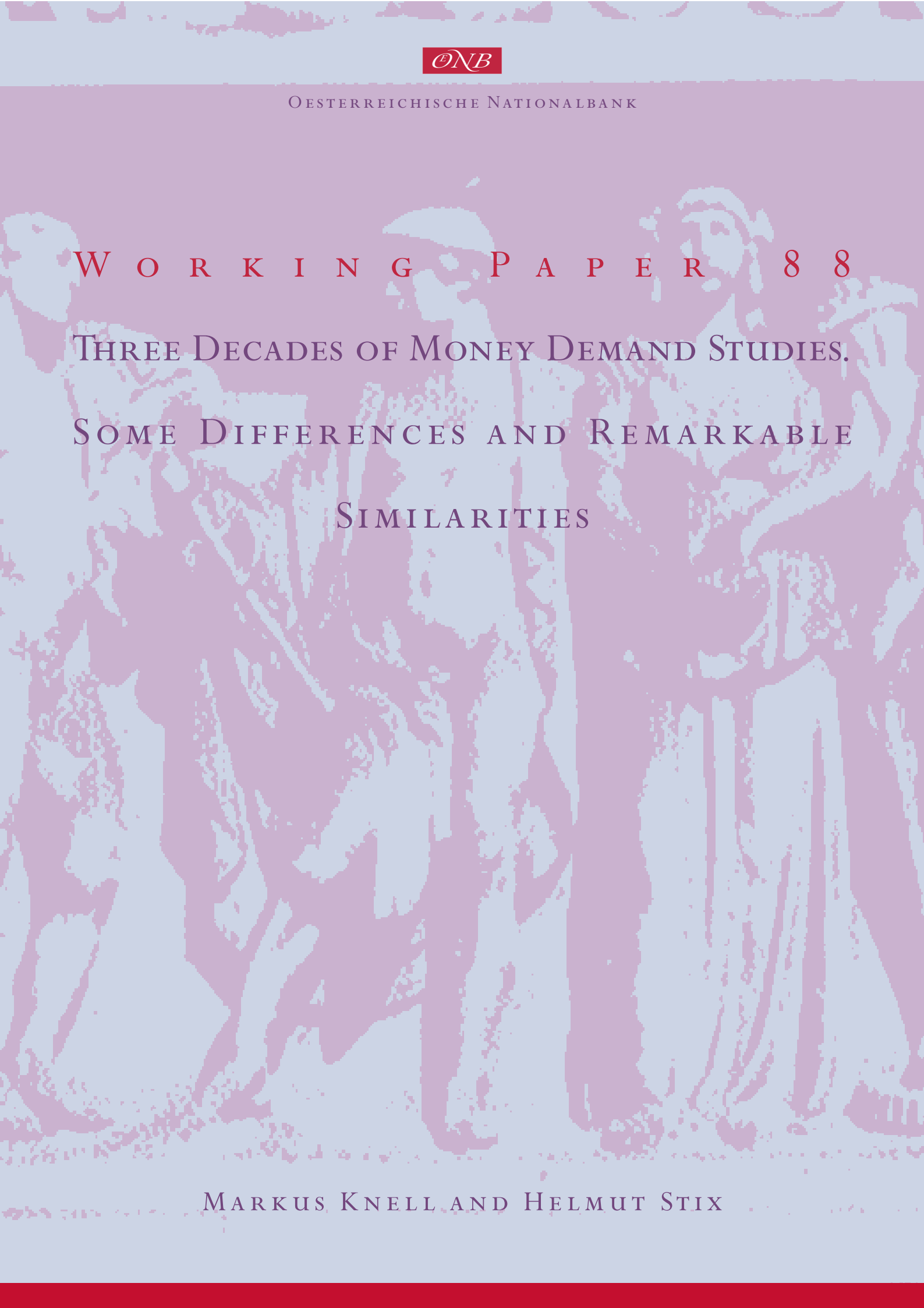

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Three Decades of Money Demand Studies. Some Differences and Remarkable Similarities

Markus Knell and Helmut Stix

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Editorial

By analyzing almost 1000 money demand estimations Markus Knell and Helmut Stix attempt to summarize the disperse findings of this literature. Using both descriptive statistics and meta-regressions they derive several stylized facts about the two most prominent determinants of money demand–income and interest rate elasticities. In particular, the authors show that the size and signs of average elasticities are systematically related to the choice of included variables (e.g., M1 or M3, short-run or long-run interest rates), the country grouping (e.g., US vs. Germany) and the empirical specification (e.g., the inclusion of one or two interest rates).

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Three Decades of Money Demand Studies. Some Differences and Remarkable Similarities

Markus Knell and Helmut Stix*

May 2004

Abstract

By analyzing almost 1000 money demand estimations this paper attempts to summarize the disperse findings of this literature. Using both descriptive statistics and meta-regressions we derive several stylized facts about the two most prominent determinants of money demand–income and interest rate elasticities. In particular, we show that the size and signs of average elasticities are systematically related to the choice of included variables (e.g., M1 or M3, short-run or long-run interest rates), the country grouping (e.g., US vs. Germany) and the empirical specification (e.g., the inclusion of one or two interest rates).

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* Oesterreichische Nationalbank, Economic Studies Division, P.O. Box 61, A-1011 Vienna. Markus Knell: markus.knell@oenb.co.at, Phone.: [+43]-1-40420-7218, Fax: [+43]-1-40420-7299. Helmut Stix: helmut.stix@oenb.co.at, Phone.: [+43]-1-40420-7211, Fax: [+43]-1-40420-7299.

1 Introduction

Although substantial scientific effort has been put into empirical money demand studies, general conclusions or unambiguous results about the underlying economic factors which determine money demand seem to be rare. Against this background, we analyze almost 1000 money demand estimations. This allows to identify stylized facts about features that are common to these studies and can be regarded as the accumulated knowledge in this field. Some of these stylized facts have been mentioned in the existing literature, others seem to be noted here for the first time.

We believe that a systematic analysis of empirical money demand estimations is interesting and important for three reasons. From a theoretical perspective one wants to know which money demand models are compatible with the available empirical evidence. For example, quantity-theory-based approaches state that the income elasticity should lie around one, whereas inventory theories suggest a significantly lower value. In contrast, approaches stressing the importance of portfolio effects often conclude that the income elasticity could be considerably larger than unity. Similar questions arise for interest rate elasticities, e.g. for determining the welfare costs of inflation. In this context, a (structured) analysis of a large number of estimates, as is done in this paper, can provide important evidence.

For an empirical economist a synopsis of observable features of existing results is useful in designing his or her research strategy. Our analysis helps to answer questions like: Which variables have a systematic influence on money demand and should therefore, if possible, be included (e.g. financial innovation)? Does the choice of a specific measurement concept (e.g., M1 or M3, short-run or long-run interest rate) systematically influence the results? What impact does the empirical specification have on point estimates (e.g. the inclusion of one or two interest rates)?

Finally an accurate knowledge about the structure of money demand is also important for the conduct of monetary policy (even though "money" might have lost some attention in this context). For example, it is necessary to employ some sort of money demand relation in order to correctly interpret movements of monetary (and credit) aggregates—the ECB's

reference value for M3 growth being perhaps the most prominent example.

Our analysis rests on estimation results collected by Fase (1993), Sriram (2001) and Knell & Stix (2003). We focus on the two most prominent determinants of money demand—income and interest rate elasticities. Our main interest is twofold: First, given the fact that money demand estimations show a large dispersion, is it possible to extract information about the underlying structure and the crucial determinants of money demand *within* each of these three collections? Second, given that the estimation results collected in Fase (1993), Sriram (2001) and Knell & Stix (2003) differ along several important dimensions (time periods, countries, estimation methods, etc.), are observable patterns comparable *across* these three collections?

For the income elasticity we find that the unconditional mean (and median) of all three samples and estimates is in fact close to one. Large difference arise, however, once one starts to disaggregate the studies according to the monetary aggregate used, and the countries that are involved. We discuss these differences and develop a set of "stylized facts" using both descriptive statistics and meta-regression analyses.

In a similar fashion we attempt to pin down properties of estimated interest elasticities. While existing surveys mostly focus on income elasticities less attention is normally paid to interest rates. Laidler (1993) finds, e.g., that "...there is an overwhelming body of evidence in favor of the proposition that the demand for money is stably and negatively related to the opportunity cost of holding it" (p.159). However, despite this unambiguous finding on the *sign* of the effect, less is known about its *size*. We try to fill this gap and present information about signs and sizes of different interest rate elasticities and how these are affected by the choice of the monetary aggregate employed in the estimation and by the number of interest rates that are included. Emphasizing only one result, we find, e.g., that in studies that include both a short and a long rate the short rate takes on the role of an own rate (positive sign) while it proxies for an opportunity rate for money holding if it is the sole asset price variable (negative sign). Thus our analysis indicates that the use of different specifications leads to—sometimes considerably—different results and that this is not a negligible issue.

The paper is structured as follows. In section 2 we present the three samples that underlie our analysis. In sections 3 and 4 we identify and discuss stylized facts about income and interest rate elasticities, respectively. Section 5 concludes.

2 Description and Summary Statistics of the Three Samples

In this paper we look at a large number of money demand estimations that were collected by different authors over the last ten years. The first sample was compiled by Fase (1993) and contains money demand estimations from 100 papers that were written from 1972 to 1992. The second sample stems from Sriram (2001) and includes estimations from 28 papers published between 1990 and 1999, while Knell & Stix (2003) comprises the results from 68 papers from 1995 to 2002.[1]

All three samples include a number of estimations that have to be regarded as outliers which are most likely associated with either particularly instable money demand relations or with econometric misspecification. In order to limit the influence of these outliers on the descriptive and summary statistics we have adjusted the samples. We use the estimated income elasticities as our "adjustment criterion" and we have discarded all estimations that involve either negative income elasticities or values larger than 2.5.[2]

Table 1 contains the main characteristics of these adjusted samples. We can observe that two samples—KS and F[3]— are rather extensive (503 and 372 observations, respectively), while the sample in S is smaller (88 observations). All samples include money demand

[1]The papers from Fase (1993) and Sriram (2001) do not contain detailed information on how the included papers were chosen from the available (extensive) literature. The selection strategy that lead to the third sample is described in Knell & Stix (2003, p.6, FN5).

[2]We use the income elasticity as selection criterion for the following reasons: (i) It is contained in basically all money demand estimations; (ii) There exists a number of theoretical models that make clear predictions about the size of the income elasticity where all predictions are included in the interval between 0 and 2.5; (iii) Income elasticities are at the center of attention in most empirical studies and extreme values are typically seen as problematic by the study authors themselves.

[3]In the rest of the paper we will use the following abbreviations: KS (Knell & Stix 2003); F (Fase 1993); S (Sriram 2001).

estimations from different countries (between 14 and 37) which include a majority of OECD countries in KS (78%) and F (100%) and a preponderance of Non-OECD countries in S (80%). Furthermore, in KS and F a larger share of estimations refer to only two countries—the US and Germany. The difference in the publication years of F, KS and S is also reflected in differences in the observation periods covered by the individual studies. While the median of the midpoints of these observation periods is 1982 and 1981 for the more recent samples by KS and S it is 1974 for the earlier collection by F. Normally, this time difference (both in publication and in median observation period) would not be regarded as a major disparity between the samples and a potential source of disagreement. However, in this special case it could make the whole difference since during the late 1980s and early 1990s the "cointegration revolution" (cf. Engle & Granger 1987, Johansen 1988) has radically changed the empirical methods that were used for money demand estimations. This paradigmatic shift is clearly reflected in our samples. While an overwhelming majority of estimations in the later samples use cointegration techniques of some kind (KS: 99.2%, S: 100%) only six (!) papers in the sample by Fase use methods which are classified as "cointegration "techniques.[4] From the outset it is not clear whether this important paradigmatic switch has had any impact on the results of money demand studies.

Broad and narrow monetary aggregates are analyzed in about an equal number of studies in F and S, while in KS there is a larger percentage of studies that employ broader monetary concepts. This might reflect the fact that KS contain primarily studies on OECD countries which refer to more recent periods during which financial development might have increased the importance of more extensive monetary aggregates. Also in the sample by KS more than 90% of the estimations have used real money $(m - p)$ rather than nominal money (m) as the dependent variable whereas in F and S the corresponding percentage is around 70%.[5]

[4]These comprise both single equation and multivariate approaches, e.g.: Engle-Granger, Phillips-Hansen FMOLS, ADL, DOLS, various variants of the Johansen technique. Cf. on this the footnote to table 1.

[5]Another interesting issue—although beyond the scope of the present paper—would be to analyze whether the price elasticity of money demand equals one. This proposition is assumed in the majority of

A majority of studies in all three samples use some national income concept (GNP, GDP, NNI and the like) as a scale variable while a much smaller percentage use consumption or personal expenditures. Despite the existence of a number of theoretical approaches that suggest the inclusion of a measure of (financial or even human capital) wealth as an additional explanatory variable for money demand only a minority of studies (between 1% and 4%) follow this suggestion.[6] A similarly small number of studies contain proxies for financial innovation which is often regarded to have a noticeable impact on individual and aggregate money demand.[7]

The second class of variables besides the scale variables that—according to most theories—should have a strong impact on money demand are asset prices, in particular interest rates. In fact, most studies in our samples include some interest rate measure. In KS around 50% of the estimations contain exactly one interest rate (70% of which short-term rates), 33% two interest rates and the rest includes either more rates or none at all. The percentages are not substantially different for the other two samples. Between 23% and 35% of the sampled estimations contain a measure of inflation either in addition to or instead of other asset price variables.

Finally we observe a slight difference in the data frequency employed in the papers. While in F almost 90% use quarterly data there is a higher percentage of estimations using monthly data in KS which might be due to improvements in data availability.

Altogether we can conclude that the three samples are fairly similar with respect to the types of explanatory variables they use. However, considerable differences are found concerning the coverage of countries, the time periods and—above all—the econometric techniques which were employed to estimate money demand functions.

In this and in the following section we will analyze the estimated coefficients of the two most crucial variables in empirical money demand studies: the income (or scale) elasticities

studies.

[6] On early papers that emphasize the role of human and non-human wealth for money demand see Friedman (1959), Laidler (1966*a*) or Meltzer (1963).

[7] Financial innovation is here understood in a fairly broad sense encompassing measures for debit-card use to stock market capitalization or the number of banks per capita.

and the interest rate elasticities. The main question we want to answer is whether they are comparable among the estimations—both within a sample and across the samples. The latter is of particular interest given the the differences in the observed time periods and empirical methodologies between F on the one side and KS and S on the other side.

3 Estimated Income Elasticities

The first panel of Table 2 contains the summary statistics of the estimated income elasticities for the three samples. The first striking result that appears in this table is that the means (and medians) of all estimated income elasticities lie around 1, the value predicted by the quantity theory of money demand. For the two large samples (KS and F) the median is in fact equal to 1 and even the mean is close to this value (0.99 and 1.04, respectively).

At the same time, however, it is also apparent from Table 2 that estimated income elasticities show a large variation within all three samples. Specifically the standard deviation of the estimates is larger than 0.3, implying that (for a mean of 1) an approximate 95% confidence interval includes values from around 0.4 to 1.6, a huge range which basically includes all theoretical predictions for income elasticities.

One explanation for this sizeable variation found in the first three rows of Table 2 is that the underlying individual estimation results are based on different countries, different monetary aggregates and the use of different empirical specifications. In order to take this into account Table 2 also contains the summary statistics for various disaggregations along these lines. First we can observe that income elasticities for broad money are larger than for narrow money, on average. In addition there seem to be considerable differences between various subgroups of countries (OECD, Non-OECD, USA and Germany). This statement, however, has to qualified to the extent that the figures for the country subgroups contain estimation results from both broad and narrow money.

A natural extension of this analysis is to analyze the results for more and more disaggregated subsamples. The disadvantage of this procedure of partitioning the sample

according to various criteria is that one soon runs to the limit of data-availability. Therefore the division of the sample into subsamples is normally only done for two (or at most three) variables at a time and it remains an open question whether the alleged impact of certain characteristics on the estimated coefficients also holds true if one corrects for a larger number of potentially important variables. There exists, however, an additional approach to investigate the influence of certain study characteristics on the diversity of results in a multivariate framework. In a meta-regression various specificities of the individual estimation can be used as possible explanatory variables for the size of the individual estimates for the income elasticity that appear as dependent variables. We will use both approaches in the following analyses.

In a first step in Table 3 we report the average income elasticities for various country subsamples separately for narrow and for broad money. In the last column of the table we indicate the statistical significance (from two-sided t-tests) of the difference between the two values.[8] One can observe that in all 8 subsamples except one (Germany in KS) the estimated income elasticities are larger for broader monetary concepts and in many cases the difference is also statistically significant (in particular for sub-categories with a large number of observations). Furthermore, it seems to be the case that for estimations that employ narrow monetary aggregates the income elasticity is smaller for OECD than for Non-OECD countries (0.79 vs. 0.89 in KS and 0.93 vs. 1.08 in S).[9] This pattern might be explained by the fact that payment systems are more developed in OECD countries allowing individuals to better economize on their transaction balances (which arguably account for a large share of narrow money) than is the case in less developed countries. For broad money, however, this impact is less important since broader aggregates are dominated by interest-bearing forms of money. Here one could speculate that income elasticities could be even higher in OECD than in Non-OECD countries since for these, aggregates portfolio decisions might influence money demand behavior and it is often maintained that this "investment

[8] Table 3 leaves out all cases where we do not have enough observations (<10) to make reasonable comparisons.

[9] The differences are, however, not statistically significant at an usual level.

driven" demand for money is associated with an income elasticity that is larger than 1. In fact this can be seen in the data for KS (1.12 [OECD] vs. 0.96 [Non-OECD])[10].

Finally we can look at the two countries for which we have most observations: the US and Germany. For both narrow and broad money the average estimated income elasticities are significantly larger for German than for US data. This is an observation commonly made in the money demand literature (Fase 1993, 434f.), although one can only speculate about the cause of this pattern. Some have argued, e.g., that this is due to the particularly strong growth of financial intermediaries in the US that has lead to considerable and increasing economies of scale since World War II (Laidler 1993, 182).

Can this pattern also be observed for the Euro-zone? By averaging all broad money income elasticity estimates for individual Euro-zone countries and weighting these *per country* means according to their Euro-zone weight one obtains an hypothetical Euro-zone income elasticity of about 1.28.[11] Studies that estimate a joint money demand relation for (several) European countries find, on average, an income elasticity of 1.42.[12] Thus, similar to the results for Germany, it seems that the income elasticity is found to be larger for the whole Euro-zone than for the US.[13]

We want to turn now to the alternative strategy that can be used to control for a number of different variables at the same time. A (multiple) meta-regression analysis allows an examination of the joint impact of various study characteristics on the point estimates and might be suited to find out whether the observed variation in the data could be due to these factors and whether empirical money demand estimations share common features and a comparable underlying structure.[14]

[10]The difference is statistically significant.

[11]We do not have observations on *per country* means for Finland, Austria and Greece. These countries are therefore omitted.

[12]These studies aggregate the country specific time series before estimation. It should be noted that these multi-country studies are difficult to compare with respect to the choice of countries included to form an "European" aggregate (some studies analyze only four European countries, some include the UK, others comprise all Euro-zone countries).

[13]Although beyond the scope of this paper, it would be interesting to analyze why multi-country studies find a higher income elasticity than is obtained by weighting individual country averages.

[14]Meta-analyses are a common tool in medical and social sciences. On various applications in the field of economics see: Stanley (2001).

In Knell & Stix (2003) we have performed an extensive meta-analysis of the income elasticity estimates in the KS sample that includes as explanatory variables besides a large number of study characteristics also specificities of the econometric technique and of the macroeconomic environment. Here we want to conduct a similar meta-regression exercise that has, however, a different focus—we want to find out whether we can detect a similar pattern underlying all three samples. To this end we concentrate on a small number of explanatory variables that are available for and comparable across all samples.

In the first three columns of Table 4 we report the meta-regression results for the three samples when a small set of explanatory variables is used. We can observe that in all samples the estimated income elasticity is higher when a broad monetary concept (M2 or higher) rather than a narrow concept (M1 or lower) is used.[15] For the samples of KS and F the effect is quite large (0.355 and 0.251, respectively) and highly significant. The meta-regression results thus confirm — in a multivariate setting — the conclusions drawn from the descriptive statistics analysis of Table 3. The result itself is reasonable, since narrow money is primarily held for transaction purposes where economies of scale will play a larger role than for broad money, for which portfolio motives might be responsible for an income elasticity that is significantly larger than one. On the other hand it does not seem to play a role whether nominal or real money is used as the dependent variable in the individual studies since the coefficient of the dummy variable "Real Money" is never significant. Furthermore the inclusion of a variable measuring wealth is associated with a significant decrease in the estimated income elasticities in all three samples (where the effect ranges from -0.522 to -0.321). This is the expected result since wealth is likely to be an important determinant of the demand for financial assets (including broad money). Considering the fact that income and wealth are typically highly correlated the omission of wealth from the money demand estimation will give rise to the observable overestimation of the income elasticity.[16]

[15]For a precise definition of the variables see the appendix.

[16]We want to note, however, that in F a number of studies that include a measure for wealth have restricted the sum of the income and the wealth elasticity to be equal to 1. In these cases it follows

The inclusion of proxies for financial innovations leads to lower income elasticity estimations in two of the three samples (only for KS it is also statistically significant). This suggests that improvements in the transaction and payment system might be important for money demand behavior although in consideration of the small number of papers using such variables we do not want to overemphasize this result. Finally there is some evidence that the later the observation period to which an individual estimation refers (proxied by the midpoint of the respective period) the lower the income elasticities. The statistically significant negative sign in all three samples suggests that this observation period variable might also capture effects like innovations in transaction technologies and financial systems.

All three meta-regressions include country dummies (coefficients not reported) that are jointly highly significant. In fact we have experimented with various combinations of country and country group dummies with and without interaction effects. In general they lead to a pattern that is very similar to the results in Table 3 while at the same time they have almost no impact on the size and significance of the other explanatory variables.[17] Altogether the three samples lead to fairly similar results that suggest that a number of study characteristics have a systematic impact on the estimated income elasticities.

The meta-regressions in the first 3 columns of Table 4 contain, however, only a small number of explanatory variables and it could be that other study characteristics also influence the income elasticity estimates. In columns (4) to (6) of Table 4 we have added a number of additional variables that could be important in this respect. First, we distinguish between papers that use consumption (or related concepts) as their measure of the scale variable (*Scale Consumption*), papers that use national income concepts (GDP, GNP, Net National Income etc., the base category) and papers that use other concepts

immediately that the income elasticities are lower. The results of Table 4, however, do not depend on the inclusion of these observations.

[17] In Table 4 we have included country-group dummies, i.e. dummies for Germany, the United States, United Kingdom, for other OECD countries (base category) and for Non-OECD countries. The results reported in Table 3 suggest that one should use interaction variables since the country effects seem to differ with respect to the monetary aggregates. The results in Table 4 refer to a specification without interaction effects but this has no influence on our general results.

(like production indices etc., denoted by *Scale Other*). For interpreting the results of these meta-regression one should note, however, that the size of the coefficients is not very homogeneous across the three regressions and that the samples F and S contain only a small number of studies that actually use consumption measures. Nevertheless the positive sign of the variable *Scale Consumption* could be attributed to the fact that the "money-intensities" of consumption and GDP and their development over time are different. Alternatively one could argue that consumption is a better proxy for permanent income and less prone to error-in-variables effects that could cause a downward bias for elasticity estimates when a traditional income concept is used. The result suggests that it is not irrelevant which scale measure is used in a money demand estimation and consequently that data availability alone should not guide this choice.

The frequency of the data used does not seem to play a significant and consistent role: only for the sample of S we find a significantly negative impact of *Monthly Data* (i.e., of studies that use data in monthly frequency as compared to quarterly frequency, the base category).

Interestingly, it seems to matter for the estimated income elasticities whether an estimation includes two interest rates (*Two IR*) or just one rate (the base category).[18] In particular, for the two large samples we can observe that studies that include two interest rates are associated with lower estimated income elasticities, where for F the coefficient is also statistically significant. Although it is not straightforward to interpret this result without further inspection of the underlying data we presume that the omission of a second interest rate causes in most cases a (positive) omitted variable bias of the income elasticity estimates (cf. section 4.2). The last result in this second set of meta-regressions is that it does not seem to play a role whether a money demand estimation contains inflation or not since the coefficient of *Inflation* is insignificant in all three regressions.

Apart from these additional variables, there are other theoretically informed variables

[18]Studies that contain either more than two interest rates or none at all were excluded from the meta-regressions. This explains the lower number of observations in the regressions of columns (4) to (6) of Table 4 as compared to columns (1) to (3).

that could have an impact on estimated income elasticities. For example, the value of time, possibly proxied by real wages, could affect the demand for money in a Baumol type model (agents with a high value of time ceteris paribus withdraw higher amounts). Since the value of time is likely to be positively correlated with income its omission could result in an upwardly biased estimate of the scale elasticity. Also, if the estimated scale elasticity is smaller than one then results could be affected by the failure to account for population growth. Consequently, it could matter whether variables are expressed in per-capita terms or not. Similarly, changes in the distribution of income might affect the results.[19] However, accounting for these factor is either difficult (since we do not have enough information on the inclusion of certain variables) or impossible due to data constraints. Therefore, we have omitted these factors in the meta-regressions.

Finally we want to emphasize that the inclusion of additional variables leaves the main results of the smaller meta-regressions basically unchanged. Broad monetary concepts are still associated with significantly higher income elasticities and studies that contain proxies for wealth with significantly lower ones. Only the results for financial innovation (i.e. *Observation Time*) are now less clear-cut, since the coefficient is no longer statistically significant in the sample of F. In general the estimations contained in the samples by KS and F seem to be more similar than the ones included in S. For the latter sample one has also difficulties to detect many statistically significant variables, in particular in the large model of column (6). This might be a consequence of the fact that it contains a less homogeneous group of predominantly Non-OECD countries and that the data sample itself is much smaller. On the whole it seems to be the case that — given the large variation of income elasticity estimates — it needs a fairly large collection of individual results to carve out the common structure of money demand estimations and arrive at significant relations.

[19] We thank David Laidler for helpful comments on these issues.

Overall the results of this section can be summarized by the following "stylized facts".

Stylized Facts 1 ***Properties of Estimated Income Elasticities***

(i) The mean (and median) of all estimated income elasticities taken together lies around 1 and they are fairly similar across the three samples.

(ii) The income elasticity estimates show a large dispersion.

(iii) Income elasticities are higher when broader monetary aggregates are employed.

(iv) When narrow money is used, OECD countries have lower income elasticities than Non-OECD countries while the opposite is true for broad money (although the pattern here is less clear-cut).

(v) The income elasticity estimates for Germany are higher than the ones for the US.

(vi) Studies that include measures for wealth or financial innovation and studies that include two interest rates are associated with lower income elasticity estimates.

4 Interest Rate Elasticities

In this section we will focus on the effect of interest rates on money demand. In particular, our analysis is based on 440 and 367 individual interest rate elasticities that were collected in F and KS.[20] This required to convert all semi-elasticities into elasticities by using actual data.[21] Making use of this large set of point estimates, we deal with three issues: First, we investigate whether—and if so how—the results differ between F and KS. Second, we analyze and compare the sign and size of the elasticities. For example, we determine how the choice of a particular interest rate (a long or a short rate) affects the results and how

[20] We have to disregard the results reported in S because too little information on specification details is available.

[21] Details about data construction can be found in the Appendix.

elasticities differ across monetary aggregates. And third, we study how estimation results vary across different empirical specifications.

A first approach to analyze the data is to calculate sample statistics, as is done for example in Fase (1993). This exercise yields that both the mean and median of the elasticities for short- and long-term interest rates are negative.[22] This result holds irrespective of the source of the data (F or KS). In particular, the means of all long run elasticities are -0.34 (KS) and -0.25 (F) and the means of all short run elasticities are -0.20 (KS) and -0.13 (F). Also, quite similar to the observation made for the income elasticities, the sample standard deviations are sizeable and—interestingly—almost identical for F and KS.[23]

This approach of separating interest rate elasticities only according to whether they refer to short- or long rates, however, can not account for the various different combinations with which interest rates actually appear in empirical specifications. For example, the point estimate of a short rate elasticity may depend on whether the empirical specification includes both a short and a long rate or only one opportunity rate. Therefore, in a next step we account for these differences by disaggregating the various combinations into cases where (a) a short rate is used alone, (b) where a long rate is used alone and (c) where both rates are employed jointly.

In reporting the results of this disaggregation we will use the notation $b_j(\cdot)$ where b_j stands for the mean or median of the estimated elasticities referring to interest rate j (i.e. $j \in \{SR, LR\}$) and where the expression in parentheses comprises the interest rate specification of the model (whether a short rate, a long rate or both are contained in the empirical specification). Thus the elasticities corresponding to the cases (a) and (b) are denoted by $b_{SR}(SR)$ and $b_{LR}(LR)$. When both rates are included (case c), the elasticities are denoted $b_{SR}(LR, SR)$ and $b_{LR}(LR, SR)$.

[22]We label any interest rate with a maturity of one year or below as a short-rate. This refers to deposit rates as well as risk-free "pure" opportunity rates.

[23]The standard deviations in all four cases (broad and narrow money, F and KS) vary between 0.30 and 0.32.

4.1 Stylized Facts

The results of this disaggregation are summarized in Table 5. The sign and the size of means and medians of interest rate elasticities allow to derive several stylized facts.

Stylized Facts 2 ***Similarity of Estimated Interest Rate Elasticities***

(i) The elasticities (means and medians) for the various sub-categories are similar between F and KS.

This stylized fact refers to a comparison between the results reported in F and in KS. Here Table 5 reveals that the results of F and KS are statistically similar.[24] We think that this finding is remarkable given the aforementioned important differences between the samples of F and KS (e.g. sample periods, estimation methods, countries) and the large variation of elasticities *within* each of the two samples. Hence if the sample means and medians reveal something about the true underlying coefficients then their similarity *across* samples suggests that interest rates have a rather stable and consistent role in determining money demand.

The next stylized fact refers to the sign of the interest rate elasticities.

Stylized Facts 3 ***Sign of Estimated Interest Rate Elasticities***

(i) In specifications with only one interest rate (either short-run or long-run) the corresponding elasticity is negative.

(ii) In specifications with both a short-run and a long-run interest rate,

(a) the coefficient of the long-run elasticity is negative, irrespective of the monetary aggregate used in the estimation;

[24] For all elasticities, t-tests yield—for both broad and narrow money estimations—that the null hypothesis of equal means between the sample of F and KS cannot be rejected. The tests are based on the null hypothesis that the $b_j(\cdot)$ are (individually) equal between F and KS. In all cases, the null hypothesis is not rejected at a 5% significance level. Detailed results about this and subsequent t-tests are available from the authors upon request.

(b) the sign of the short-run elasticity is negative for narrow money and positive for broad money.

This stylized fact provides further confirmation to the notion that opportunity costs of liquidity holdings play an important role in determining money demand (e.g. see Laidler 1993). However it also reveals that the sign of estimated elasticities depend, first, on the number of interest rates employed in empirical specifications and, second, on the number of interest rates in interaction with the monetary aggregate.

This is most clearly visible for the case of broad money where the signs of the means and medians of the short-run elasticities switch depending on whether a long rate is included or not. This result implies that the short rate, if contained jointly with a long rate, acts as the own rate of those components of broad money which bear interest. However, if only a short rate is included it takes on the role of (or proxies for) the opportunity rate and is found to enter negatively. Somewhat surprisingly, this does not hold for narrow money where the average short rate enters with a negative sign. This result therefore seems to confirm evidence reported in Laidler (1993, 155f.) suggesting that returns on components on narrow money (e.g. short rates) may actually supplement the influence of other opportunity rates (e.g. long rates).

Apart from economic reasoning, the observed pattern might, under specific assumptions, also be explained econometrically. Here, the idea is that estimated parameters are biased if relevant variables are omitted whereas no bias occurs if irrelevant variables are included in an empirical model. Conditional on a hypothesized "true" economic model, we can therefore study whether the theoretical bias caused by the omission of (hypothetically) relevant variables actually can be observed in the sample statistics of Table 5.

For this analyzes we assume that the "true" money demand model contains both a short and a long rate. Given this model, the size of the parameter bias depends on the true sign of the omitted variables and partial correlations between the omitted and the included variables. Under plausible assumptions about these factors we find that all theoretical predictions about the direction of eventual biases are reflected in Table 5. In particular

this analysis can explain that for broad money, short rates change their "role" and enter with a positive sign if included in combination with a long rate.[25]

Thus, the mere fact that theoretically predicted omitted variable biases that are calculated conditional on a stipulated "true" model containing two interest rates can be observed in the data suggests that a "correct" empirical model should include both an own rate and an opportunity rate. However, as these results are based on restrictive assumptions about the true model, one should not over-stress the generality of these results. Nevertheless we think that this analysis bears some implications for empirical money demand studies: if theory does not give a clear indication about the choice of variables—and in money demand studies this is the typical situation—then our results suggest that one is well advised to analyze the existence and direction of a bias when excluding certain asset price variables. Furthermore, this analysis clearly indicates that the conclusion of Laidler (1993) that "it is possible to obtain reasonable enough results [...] by including just one representative rate in the function" (p.157) might be reasonable in some cases but not in general (as correlations between relevant variables and hence the size of the bias varies across samples). Furthermore, a relatively small bias on interest rate elasticities does not necessarily mean that other relevant variables are not biased considerably (e.g. the income elasticity).[26]

Stylized Facts 4 ***Size of Estimated Interest Rate Elasticities***

(i) The sensitivity of money demand with respect to the long-term rate is higher than with respect to the short-term rate.

(ii) The sensitivity of money demand is higher for narrow money than for broad money.

(iii) Money demand reacts less sensitive to the interest rate spread than to (corresponding) individual interest rates.

The finding that money demand reacts more strongly to changes in long rates than to changes in short rates could be related to the lower variability of longer-term rates relative

[25]Further details about this analysis are available from the authors upon request.

[26]Ball (2001) shows how a positive correlation between interest rates and income affects the results from money demand estimations.

to short-term rates.[27] For example, in the sample of KS the standard deviation is 4.5 for long rates and 2.2 for short rates. Hence, relatively smaller changes in long rates can only explain a given change in money demand if the sensitivity of money demand is higher for long rates than for short rates.[28]

The result that interest rate elasticities differ according to the monetary aggregate used could be explained by the fact that for broad money the effects of general and relative changes in interest rates are combined in the estimated interest elasticities. This was already mentioned by Allan Meltzer in 1963 who argued that substitution effects caused by a general rise in market interest rates are then "hidden by changes within the composition of money itself" (Meltzer 1963, 226). Alternatively the result could also be due to the presence of fixed costs associated with changes in the preferred portfolio, i.e. that it is relatively cheaper to switch from near money assets contained in narrow money than from assets with a long period of notice (e.g. time deposits) contained in broad money if interest rates change. Furthermore, this stylized fact can be combined with the results concerning the income elasticities: narrow money is on average associated with a low income and a high interest rate elasticity whereas for broad money we observe a high income and a low interest rate elasticity.

Finally, it also seems to be the case that the spread elasticities are relatively small in size. We do not have any clear economic explanation for this finding. However, since it rests on results from only three papers we stress that there might be other study-specific factors which affect the results and therefore regard this finding with some caution.

4.2 Results for the US and Germany

So far, we have analyzed all countries jointly. Since results for the US and, to a lesser extent, for Germany take a predominate role in the literature, we have summarized the results for

[27] Again, this finding is supported by t-tests.

[28] Cf., "Volatility of rate can be offset by a small elasticity of response and vice versa" (Friedman 1959, 346).

these two countries separately.[29] For the US, we also compare the results obtained when analyzing the average or median of results obtained in many studies with those from well-known individual studies. For example, Lucas (2000), employing a long time series of M1 for the US, finds that the elasticity is -0.5. To the contrary, Ball's (2001) analysis suggests a somewhat lower elasticity of about -0.29 for the same monetary aggregate.[30]

For *narrow money* and if only one interest rate is included in the money demand specification, then the results in Table 6 indicate that for the US the mean elasticity is around -0.31 if a short rate is used whereas it lies around -0.50 if a long rate is employed. These numbers match very well with Lucas' and Ball's results and their difference can be explained because the former uses a long-rate while the latter includes a short rate in his empirical specification.[31]

For Germany, the respective values are -0.13 and -0.60 (however, with a low number of observations). Turning to *broad money*, it is again found that the long rate elasticities (if only the long rate is included) are considerably smaller than their narrow money counterparts ($b_{LR}(LR)$=-0.19 for the US and -0.16 for Germany). Finally it is interesting to compare our mean values to the results of an older study that investigates money demand estimations for the US from around 1900 to 1960 (Laidler 1966*b*). For broad money Laidler finds interest rate elasticities for the short-run rate between -0.124 and -0.142 and for the long-run rate between -0.303 and -0.552, while for narrow money estimates the respective ranges are -0.176 to -0.206 (short-run) and -0.516 to -0.785 (long-run). Thus the pattern of the results is fairly similar to our own analysis, although the size of the elasticities has apparently decreased for all categories over the last decades.

Turning back to Table 6 our findings suggest that the elasticities are close to values predicted by transaction demand models—like the Tobin model's interest rate elasticity of

[29]In contrast to previous results, we have merged the point estimates from F and KS. Nevertheless, the number of observation is sometimes low for sub-categories in which case some caution is necessary when interpreting the results.

[30]In fact, Ball (2001) reports a semi-elasticity of -0.05.

[31]This result could potentially be affected by the fact that Ball's paper is included in the KS sample and thus also in the calculation of the sample mean. Therefore it should be noted that this result does not change if Ball's individual estimates are excluded.

-0.5. However, this only holds for long-run interest rates. When a short rate is employed the elasticity is on the lower bound of these models' theoretical predictions. More generally, the findings about the relative size of long versus short rate elasticities for narrow and broad money are again reflected in both country samples.

5 Conclusion

The results from money demand studies show a wide dispersion along many important dimensions, in particular about income and interest rate elasticities. This makes it difficult to derive underlying structural economic relationships identified by the vast amount of available empirical estimates. The paper attempts to progress in this direction.

In fact, the quantitative analysis of almost 1000 money demand estimations conducted in this paper allows for identifying several stylized facts, some of them confirming previous findings in the literature, some providing new insights.

First, the unconditional mean of the income elasticity is close to one in all three samples. This changes, however, if one takes a more disaggregative look at the data. We find that the broadness of monetary aggregates and the inclusion of wealth and financial innovation variables in empirical money demand specifications systematically affects estimated income elasticities. Furthermore, we identify notable differences between OECD and Non-OECD countries which, mostly likely, are related to financial development.

Second, it is found that in cases where only one interest rate is included it always acts as an opportunity rate and exerts a negative impact on money demand irrespective of the precise type of interest rate or the empirical specification. In cases where a short rate is included jointly with a long rate the short rate acts as an own rate (positive sign) for broad money but not for narrow money (negative sign). Concerning the size of the impact it is found that the sensitivity of money demand with respect to long rates is higher than with respect to short rates and that the demand for narrow money reacts more sensitive to changes in interest rates than the demand for broad money.

Third, despite the large variation of elasticities *within* each of the three individual

samples average point estimates have remarkable similar properties *across* samples. The stylized facts described above can be observed in all three samples. Moreover, for interest rate elasticities the average point estimates in KS and F do not only follow the same pattern but are almost identical in size. This is striking considering the fact that these samples were collected at different times, contain different groups of countries and employ different empirical methods. In particular, the overwhelming majority of estimations in KS use cointegration techniques while this is the exemption in F. In this context it is also astonishing that the stylized facts correspond well to observations made in the classic money demand studies of the 50s and 60s.

It is clear that many important factors which determine money demand are not considered in our analysis. Hence, we do not want not overstate our findings. Nevertheless we think that this paper provides an useful overview about what is known about and can be deduced from empirical money demand studies.

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A Appendix: Data Description

Data Sources The data comprise point estimates of income and interest rate elasticities of individual money demand estimations collected in Fase (1993) (F), Sriram (2001) (S) and Knell & Stix (2003) (KS). The data from F and S are directly taken from tables in the respective publications. The data from KS, described in more detail in Knell & Stix (2003), are unpublished.

Various Definitions "Narrow Money" (NM) subsumes MB, M0 and M1, "Broad Money" (BM) all other aggregates (M2, M3, M4 etc.). "Scale Income" includes scale variables like GDP, GNP, Net National Income, "Scale Consumption" concepts like consumption, personal expenditures etc. and "Scale Other" all remaining concepts (e.g. production indices). "Two IR" is a dummy variable which takes a value of one if an empirical specification contains two interest rates. "Observation Time" refers to the mid-point of the sample period of an individual estimation.

Construction of Interest Rate Elasticities The data sources contain point estimates of interest rate elasticities and semi-elasticities. In the latter case, all semi-elasticities were converted into elasticities by multiplying the semi-elasticity with the respective estimation specific sample mean of either a short or long rate. Interest rate data are obtained from three sources: (i) OECD–Main Economic Indicator database (for most OECD countries), (ii) International Financial Statistics (for Non-OECD countries and some OECD countries) and (iii) Lawrence H. Officer who provides long time series for the US and the UK (Lawrence H. Officer, "What Was the Interest Rate Then?" Economic History Services, EH.Net, 2003, http:www.eh.nethmitinterest_rate) .

For our classification in short-term and long-term rates we use the underlying time-series as a criterion and not the claim made by the authors. Short rates (SR) include deposits and other interest rates with a maturity up to a year whereas long rates (LR) are all other interest rates. Furthermore, semi-elasticities had to be converted in some cases from decimals into percentages.

Table 1: Descriptive Statistics

	KS		F		S	
	Obs.	%	Obs.	%	Obs.	%
Observations	503		372		88	
Number of Different Countries[a)]	37		14		26	
OECD	392	(77.9%)	372	(100.0%)	18	(20.5%)
USA	207		71		6	
DEU	46		46		1	
Non-OECD	111	(22.1%)	0	(0.0%)	70	(79.5%)
Narrow Money	201	(40.0%)	195	(52.4%)	45	(51.1%)
Broad Money	302	(60.0%)	177	(47.6%)	43	(48.9%)
Nominal Money	40	(8.0%)	121	(32.5%)	23	(26.1%)
One Interest Rate	250	(49.7%)	255	(68.5%)	50	(56.8%)
Short-term Rate	176		174		44	
Long-term Rate	74		81		6	
Two Interest Rates	168	(33.4%)	102	(27.4%)	11	(12.5%)
Inflation Rate	120	(23.9%)	110	(29.6%)	31	(35.2%)
Wealth	8	(1.6%)	14	(3.8%)	1	(1.1%)
Financial Innovation	15	(3.0%)	4	(1.1%)	2	(2.3%)
Observation Period (Median)	1982		1974		1981	
Monthly Data	136	(27.0%)	16	(4.3%)	5	(5.7%)
Quarterly Data	294	(58.4%)	334	(89.8%)	70	(79.5%)
Annual Data	73	(14.5%)	22	(5.9%)	13	(14.8%)
Scale: Income Concepts	351	(69.8%)	346	(93.0%)	73	(83.0%)
Scale: Consumption Concepts	56	(11.1%)	4	(1.1%)	7	(8.0%)
Scale: Other Concepts	96	(19.1%)	22	(5.9%)	8	(9.1%)
Cointegration Techniques[b)]	499	(99.2%)	6	(1.6%)	88	(100.0%)

Note: KS=Knell & Stix (2003), F=Fase (1993), S=Sriram (2001).

[a)] Knell & Stix (2003) and Fase (1993) also include some (46 and 11, respectively) multi-country studies.

[b)] For the samples by Fase and Sriram (2001) it is not in every case straightforward to determine precisely which methodology was employed without reverting to the original study. There is, e.g., a category "error correction" in Fase that is likely to include both "older error correction" models and ones that were estimated in the cointegration framework. The figure in the table refers to the cases that were classified as using a "cointegration model".

Table 2: Estimated Income Elasticities - Descriptive Statistics

		Obs.	Mean	Median	SD
All Monetary Aggregates	KS	503	0.99	1.00	0.46
	F	372	1.04	1.00	0.39
	S	88	1.08	1.10	0.35
Narrow Money	KS	201	0.83	0.87	0.44
	F	195	0.93	0.92	0.39
	S	45	1.04	0.99	0.37
Broad Money	KS	302	1.10	1.02	0.44
	F	177	1.17	1.09	0.36
	S	43	1.12	1.13	0.33
OECD	KS	392	1.01	1.00	0.44
	F	372	1.04	1.00	0.39
	S	18	0.95	0.97	0.32
Non-OECD	KS	111	0.91	0.95	0.53
	S	70	1.11	1.10	0.36
USA	KS	207	0.86	0.86	0.40
	F	71	0.95	0.97	0.36
GER	KS	46	1.19	1.18	0.25
	F	46	1.20	1.17	0.27

Note: KS=Knell & Stix (2003), F=Fase (1993), S=Sriram (2001).

Table 3: Sample Means of Income Elasticities for Subsamples

		Broad Money	Narrow Money	Stat. Signif.
OECD	KS	1.12	0.79	***
	F	1.17	0.93	***
Non-OECD	KS	0.96	0.89	
	S	1.15	1.08	
USA	KS	0.96	0.65	***
	F	1.10	0.87	**
GER	KS	1.18	1.24	
	F	1.31	1.12	**

Note: KS=Knell & Stix (2003), F=Fase (1993), S=Sriram (2001). "Stat. Signif." refers to the p-values from t-tests of equal means (broad money=narrow money). *** (**) [*] indicate significance at a 1% (5%) [10%] level.

Table 4: Meta Regression

	Dependent Variable: Estimated Income Elasticity					
	KS	F	S	KS	F	S
Constant	14.539***	12.054**	35.383***	17.978***	4.652	-29.483
	(3.294)	(5.602)	(12.411)	(4.042)	(5.891)	(26.364)
Broad Money	0.355***	0.251***	0.094	0.453***	0.265***	0.126
	(0.043)	(0.036)	(0.073)	(0.056)	(0.036)	(0.085)
Real Money	-0.014	0.024	0.004	-0.005	0.031	-0.212
	(0.070)	(0.041)	(0.074)	(0.080)	(0.042)	(0.137)
Wealth	-0.522***	-0.364**	-0.321**	-0.450***	-0.386**	
	(0.104)	(0.177)	(0.139)	(0.120)	(0.176)	
Fin. Innovation	-0.642***	0.037	-0.102	-0.740***	-0.049	-0.004
	(0.111)	(0.085)	(0.323)	(0.134)	(0.110)	(0.345)
Observation Time	-0.007***	-0.006**	-0.017***	-0.009***	-0.002	0.015
	(0.002)	(0.003)	(0.006)	(0.002)	(0.003)	(0.013)
Scale Consumption				0.285***	0.090	0.114
				(0.095)	(0.064)	(0.195)
Scale Other				-0.147**	0.112	0.219
				(0.068)	(0.113)	(0.132)
Monthly Data				0.109	-0.075	-0.481**
				(0.096)	(0.064)	(0.219)
Yearly Data				-0.044	0.077	-0.051
				(0.079)	(0.103)	(0.101)
Two IR				-0.065	-0.102***	0.242
				(0.063)	(0.037)	(0.168)
Inflation				-0.110	-0.010	0.075
				(0.076)	(0.041)	(0.130)
R^2	0.27	0.17	0.20	0.36	0.22	0.38
Obs.	503	372	88	418	357	61

Note: Standard errors in parentheses. *** (**) [*] indicate significance at a 1% (5%) [10%] level. Estimated by OLS. The sample in column four to six is restricted to only those specifications that include either one or two interest rates. The coefficients of "Scale Consumption" and "Scale Other" measure the effect relative to "Scale Income". The coefficients of "Monthly Data" and "Yearly Data" measure the effect relative to "Quarterly Data". "Two IR" is a dummy variable set to one if an empirical specification contains two interest rates. See the Appendix for a definition of variables.

Table 5: Interest Rate Elasticities by Combination

		Obs.		Mean		Median	
		KS	Fase	KS	Fase	KS	Fase
Narrow Money	$b_{SR}(SR)$	103	112	-0.31	-0.28	-0.25	-0.19
	$b_{SR}(LR, SR)$	2	41	—	-0.10	—	-0.07
	$b_{LR}(LR)$	20	26	-0.45	-0.45	-0.38	-0.36
	$b_{LR}(LR, SR)$	2	41	—	-0.17	—	-0.15
Broad Money	$b_{SR}(SR)$	29	53	-0.11	-0.09	-0.07	-0.11
	$b_{SR}(LR, SR)$	20	58	0.23	0.12	0.18	0.14
	$b_{LR}(LR)$	38	51	-0.28	-0.23	-0.21	-0.19
	$b_{LR}(LR, SR)$	20	58	-0.35	-0.25	-0.23	-0.24
	b_{SPREAD}	130	—	-0.04	—	-0.03	—

Note: "—" less than 5 observations.

Table 6: Interest Rate Elasticities: United States and Germany

			Obs.	Mean	Median
USA	Narrow Money	$b_{SR}(SR)$	78	-0.31	-0.26
		$b_{SR}(LR, SR)$	15	-0.05	-0.06
		$b_{LR}(LR)$	20	-0.50	-0.41
		$b_{LR}(LR, SR)$	15	-0.21	-0.16
	Broad Money	$b_{SR}(SR)$	34	-0.07	-0.06
		$b_{SR}(LR, SR)$	—	—	—
		$b_{LR}(LR)$	5	-0.19	-0.19
		$b_{LR}(LR, SR)$	—	—	—
			Obs.	Mean	Median
DEU	Narrow Money	$b_{SR}(SR)$	27	-0.13	-0.12
		$b_{SR}(LR, SR)$	5	-0.06	-0.10
		$b_{LR}(LR)$	6	-0.60	-0.36
		$b_{LR}(LR, SR)$	5	-0.13	-0.12
	Broad Money	$b_{SR}(SR)$	—	—	—
		$b_{SR}(LR, SR)$	14	0.16	0.12
		$b_{LR}(LR)$	19	-0.16	-0.13
		$b_{LR}(LR, SR)$	14	-0.42	-0.31

Note: "—" less than 5 observations.

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