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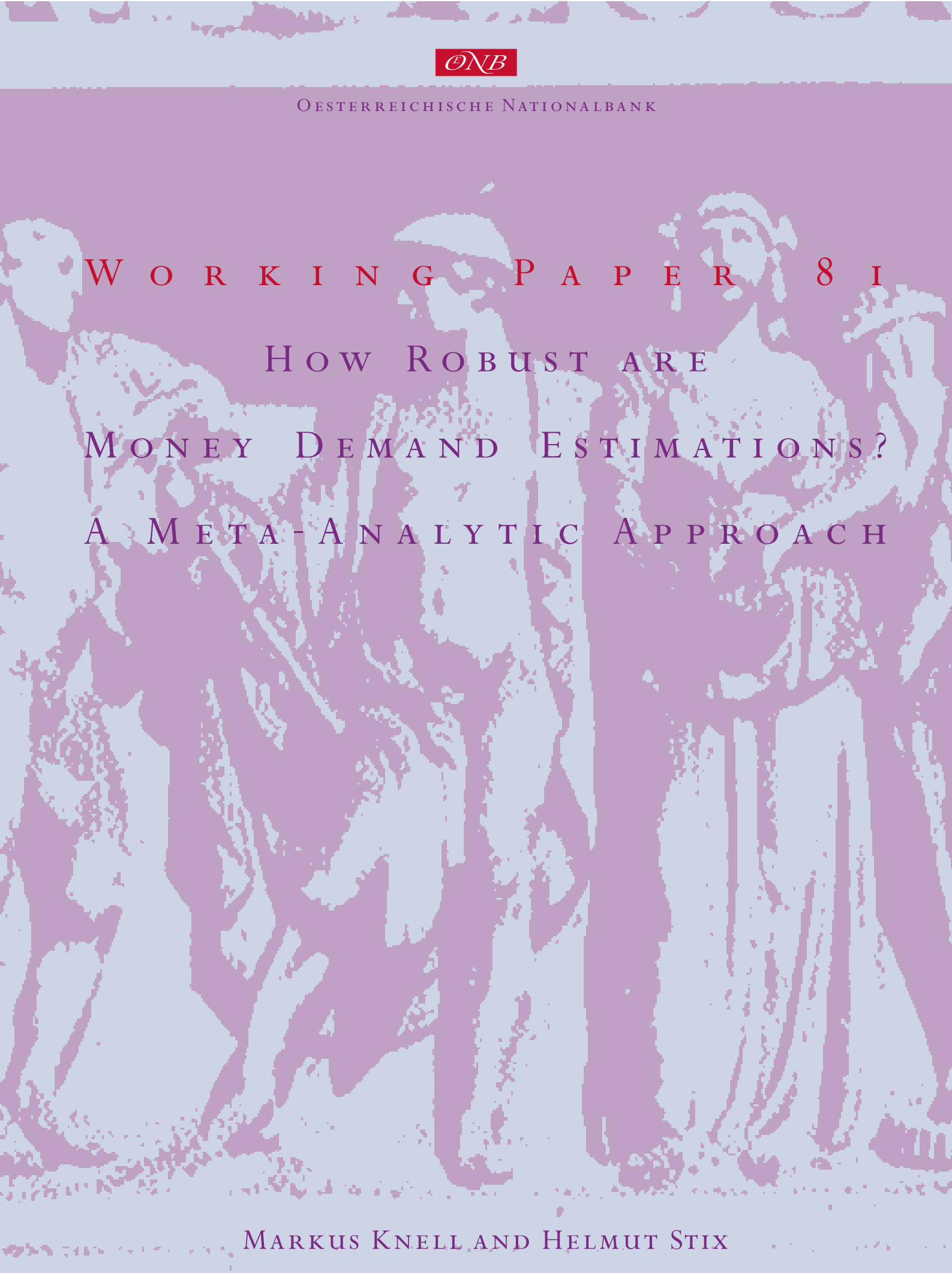

WORKING PAPER 81

HOW ROBUST ARE MONEY DEMAND ESTIMATIONS?

A META-ANALYTIC APPROACH

MARKUS KNELL AND HELMUT STIX

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Editorial

In this paper, Markus Knell and Helmut Stix perform a meta-analysis of empirical money demand studies involving almost 500 individual money demand estimations. They analyze whether the wide variety of results can be explained by characteristics of the studies, different macroeconomic environments or the imprecision of individual estimates. The authors find that estimates for the income elasticity of money are systematically related to various study characteristics (e.g., broadness of the monetary aggregate, inclusion of financial innovation and wealth, etc). Also, the macroeconomic environment (inflation, nominal and real uncertainties) seems to play a role. Nevertheless, a substantial part of the variability remains unexplained. Their findings thus raise some doubts about the robustness and reliability of money demand estimations.

June 30, 2003

How Robust are Money Demand Estimations?

A Meta-Analytic Approach

Markus Knell and Helmut Stix*

Oesterreichische Nationalbank

Abstract

In this paper we perform a meta-analysis of empirical money demand studies involving almost 500 individual money demand estimations. We analyze whether the wide variety of results can be explained by characteristics of the studies, different macroeconomic environments or the imprecision of individual estimates. We find that estimates for the income elasticity of money are systematically related to various study characteristics (e.g., broadness of the monetary aggregate, inclusion of financial innovation and wealth, etc). Also, the macroeconomic environment (inflation, nominal and real uncertainties) seems to play a role. Nevertheless, a substantial part of the variability remains unexplained. Our findings thus raise some doubts about the robustness and reliability of money demand estimations.

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Keywords: Money Demand, Meta Analysis, Empirical Methods

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1 Introduction

Money demand is certainly one of the best researched fields in economics. Literally thousands of articles have been published over the last decades that contain empirical money demand estimations for numerous countries and time periods. However, despite these considerable efforts the results of this huge literature are quite diverse. The range of the estimated income and interest-rate elasticities is wide and while some papers maintain that money demand is stable others come to the converse conclusion. In an international sample of studies analyzed in later parts of this paper, income elasticities between -14.11 and 44.79 (or—corrected for outliers—between 0.01 and 2.46) are observed and even for the same country and time period sometimes substantial differences can be found. Most surveys of money demand studies find a similar diversity: "The present survey hardly shows any convergence of empirical findings, with clear outliers for certain coefficient values. This leads to the conclusion that the theoretical simplicity of the demand for money fades away in an empirical approach" (Fase 1994, 433).

Existing surveys on this topic, however, have more or less confined themselves to investigate the point estimates of crucial parameters. In our view, an extension of these analyses seems worthwhile since a number of factors could be responsible for the variation of estimates. The variation might, e.g., be due to the fact that studies differ from each other in various important dimensions, including the definition of monetary aggregates, scale variables, deflators, the inclusion or exclusion of specific interest rate and asset price variables and of proxies for wealth or financial innovation. Money demand theories suggest that a number of these factors should have an impact on the estimations (e.g. that the income elasticity should be higher for broader monetary aggregates) which could explain the diverse results. Furthermore, studies also differ with respect to the estimation methods used which could—in principle—also have a systematic influence on the estimations. An analysis of the implications of the different study characteristics should be based on comparable models, which requires to control for all of these factors. This is barely possible in qualitative surveys.

In this paper we undertake a meta-analysis of money demand studies involving almost 500 individual estimations in order to analyze whether and to what extent different characteristics of the individual studies can explain the wide-spread results. Meta-analytic methods allow to summarize these estimations in a systematic, quantifiable and multivariate manner and to detect similarities across studies—similarities that hold irrespective of the country, the time period, the estimation method or the money demand specification.

Our results show that the meta-regressions are able to explain about half of the variation in estimated income elasticities. In particular, the findings of the meta-regressions reveal that—in line with theoretical conjectures—broader monetary aggregates lead to consistently higher point estimates of the income elasticities while the inclusion of variables that stand for wealth tend to decrease them. Other variables, like the choice of scale variables and some details of the estimation method are also found to exert a significant influence on income elasticity estimates. However, still about half of the variation remains unexplained by individual study characteristics.

It could be argued that the variation is not only caused by differences in individual study characteristics but also by the fact that the studies refer to periods that were characterized by different macroeconomic situations. For example, a highly volatile economic environment (e.g. strongly fluctuating inflation and interest rates) might be associated with a systematically different money demand structure than a more stable economic environment and this difference is reflected in point estimates. Thus, in a further step we investigate whether the variation between and within countries observed in our sample can be explained by different macroeconomic situations that prevailed during the observation periods of the individual studies. It is found that inflation, inflation uncertainty and real growth uncertainty are correlated with the size of income elasticities. However, despite the fact that the estimated coefficients of these variables are significant in a statistical sense their impact is rather moderate and altogether differences in the macroeconomic environment are also not able to explain much of the variation.

Finally, we deal with the argument that the distribution of point estimates reveals nothing about the precision of estimates. For example, a particularly high or low point

estimate does not necessarily imply that a particular value, like the unitary income elasticity associated with the quantity theory, is not contained in the respective confidence interval. Therefore we conduct an analysis of the frequency distribution of the confidence intervals associated with the point estimates. We find that individual confidence intervals are typically rather narrow and do not have large overlaps. Therefore we conclude that imprecision is also not able to explain the wide diversity in point estimates.

The paper is structured as follows. In the next section, a brief overview of existing money demand theories is given. In section 3 the principles of meta-analyses are described, our data presented and hypotheses about the possible influences on the income elasticity of money demand are developed. In section 4 we test these hypotheses by undertaking a meta-regression analysis and we discuss our results. In section 5 we deal with the influence of certain macroeconomic variables on the income elasticity estimates and with the role of the precision of point estimates. Section 6 concludes.

2 Theoretical Background

The starting point in most of the empirical literature on money demand is a specification of the form:

$$m_t - p_t = \gamma_0 + \gamma_1 y_t + \gamma_2 i_t^{own} + \gamma_3 i_t^{out} + \gamma_4 \pi_t + \gamma_5 w_t + \gamma_6 X_t + \varepsilon_t, \tag{1}$$

where $(m_t - p_t)$ is the logarithm of real money demand[1], y_t is the logarithm of the scale variable, i_t^{own} stands for the nominal rates of return on financial assets included in the definition of the monetary aggregate, i_t^{out} for the one exclude from the definition, π_t for the rate of inflation, w_t for wealth and X_t for a vector of other variables that—according to specific theories or to the conjecture of the respective author—might have a systematic impact on aggregate money demand. Virtually all money demand theories expect a positive sign for

[1]Some papers estimate nominal instead of real money, implying that the LHS of (1) is m_t while the RHS contains as an additional regressor $\gamma_7 p_t$.

γ_1 while there exists less agreement about its size. According to quantity-theory-based approaches it should equal unity whereas inventory theories, e.g., suggest that it should be significantly lower.[2] In general equilibrium approaches (as propagated, for example, by Milton Friedman) the demand for money of an individual depends on all (intratemporal and intertemporal) prices and on his or her wealth, including money, bonds, shares, real assets and human capital. An implication of this theory is that the income elasticity of (broad) money can be different from 1. A growth in income might well lead to an excessive increase in the demand for financial assets, including holdings of money. In this view (broad) monetary assets are, so to say, a luxury good with an income elasticity of $\gamma_1 > 1$. A further implication is that wealth should be an important additional determinant of money demand, thus suggesting that $\gamma_5 > 0$.[3] With the notable exception of the quantity theory in its most basic form almost all theories of money demand (e.g. the liquidity preference theory, the portfolio approach, etc.) allow for a sometimes crucial role of asset prices, in particular of interest, inflation and exchange rates. The expected signs for the various asset price coefficients in (1) are $\gamma_2 > 0$, $\gamma_3 < 0$, $\gamma_4 < 0$ and possibly $\gamma_2 = -\gamma_3$.

As this brief discussion shows, money demand theories arrive at quite different conclusions and testable hypotheses when it comes to the importance and predicted effects of various explanatory variables. In the next section we will discuss some of these implications and hypotheses more extensively and we will subsequently test them in the framework of a meta-regression analysis.

[2] In the seminal papers by Tobin (1956) and Baumol (1952) the income elasticity is 0.5, in other variants of the inventory model (e.g. Miller & Orr 1966) it ranges from 1/3 to 2/3.

[3] The Keynesian money-demand model also predicts a dependence on wealth since the latter determines an economy's total demand for financial assets (cf. Laidler 1993, 54f.).

3 Empirical Methodology, Data Description and Some Hypotheses

In the following we briefly describe the principles of meta-analyses and we outline our procedure for paper selection, study retrieval, coding and estimation. Subsequently we present descriptive statistics of the studies and their characteristics and we develop some hypotheses how the latter could be expected to influence the results.

3.1 The Concept of Meta-Analysis

"Meta-analysis" is the collective name for quantitative methods of combining the results of previous separate but related studies on a specific topic to synthesize summaries and conclusions. "Meta-analysis can be understood as a form of survey research in which research reports, rather than people, are surveyed" (Lipsey & Wilson 2001, 1). The "surveyed papers" can then be statistically examined in order to investigate whether variations in the results can be explained by the specific characteristics of the individual studies. A special form of a meta-analysis is a meta-regression analysis, where "the dependent variable is a summary-statistic, perhaps a regression parameter, drawn from each study, while the independent variables may include characteristics of the method, design and data used in these studies" (Stanley 2001, 131f.). Thus, the difference to the more traditional surveys on a specific topic ("narrative literature reviews") is that the meta-analysis involves less subjective reasoning and judgmental arguments about what represents an acceptable empirical method, a "state-of-the-art" treatment of the question at hand, etc.[4] In our context, e.g., surveys of the empirical money demand literature normally stop after having presented descriptive statistics and histograms of the point estimates, typically separated according to one single dimension (like broad and narrow money). A (multiple) meta-regression analysis, however, allows an analysis of the joint impact of various study characteristics on

[4]This is concisely summarized in the title of a recent book by Morton Hunt on the history of this method: "How Science Takes Stock".

the point estimates, to compare and quantify these effects and to use statistical tools to test for their significance, etc. This multivariate framework should thus be better suited to find out whether empirical money demand estimations share common features and a comparable underlying structure which can shed light on open theoretical questions and pave the way towards a unified, commonsensical empirical money demand specification.

Over the past years a huge number of meta-analyses was conducted in medical and social sciences (e.g. involving analyses of clinical trials of new drugs and medications). In economics, however, only a handful of studies that rely on meta-analytic methods exist up to now (cf. Stanley 2001, 134). Most of them are in the field of labor economics, others deal with the returns to education or tests of Ricardian equivalence. The meta-regression analysis on money demand studies conducted in this paper is—according to our knowledge—the first meta-analysis in the field of monetary economics.

3.2 Data

The first step in undertaking a meta-analysis involves the retrieval of relevant studies. Here it is important to use a search and selection method that is as objective as possible in order to avoid possible selection and availability biases. We have searched in July 2002 in the EconLit Database for articles that met certain criteria. In the end we arrived at a sample of 79 papers published in academic journals after 1994 that form our basic sample.[5] Most of these studies contain more than one money demand estimation yielding a total sample of 559 estimations.[6] For each of these estimations we extracted and coded information

[5]First we looked for entries that contained the words "money demand" and one of the following word parts: "empiric*", "estimat*", "stab*" or "instab*". In addition to this we required that studies were published in one of 232 leading economic journals and that they included an abstract (in order to check whether they contain empirical estimates). This left us with a total of 386 papers. This number was further narrowed down by considering only papers published after 1994 that had either "mon* demand" or "mon* stability" in the title. After reading the abstracts of all remaining entries and excluding all papers that were not appropriate for our purpose (since they contained only theoretical models, cross-section analyses, purely econometric analyses, etc.) we arrived at a sample of 94 articles. During the process of coding another 15 papers were excluded (e.g. for missing empirical results) leaving us finally with 79 papers. A complete list of these papers is available from us upon request.

[6]We did not distinguish between the different estimations within a paper following the suggestion that in a meta-regression analysis the differences in the results should (at least partly) be explained by the

about the estimated coefficients and about a number of potential explanatory variables (see Table 1).

Our sample again shows the typical wide variability of money demand estimations. This variability is again a multi-dimensional issue that is reflected, e.g., in differences in the estimates for the income elasticities, the interest rate (semi-)elasticities and other coefficients, the number of cointegrating vectors found, the lag structure employed, etc. In this paper we focus on the most common and arguably the single most important parameter of money demand estimations, the income elasticity γ_1.[7]

A wide variety of estimates for the income elasticity of money demand is reported in our sample. This is summarized in Table 2. Although these figures refer only to unconditional means they already contain some interesting results. First, the average estimated income elasticity over all 559 usable models is 1.06 which is surprisingly close to the unitary prediction of the basic quantity theory specification. Second, however, there exists substantial variation both within the total sample and across various subsamples. For the total sample, e.g., the standard deviation is 2.1 and the estimates range from -14.11 to 44.79.[8] In order not to have our own results be dominated by implausible point estimates we discarded outliers.[9] This leaves us with an adjusted sample of 491 observations for which the summary statistics are shown in the lower part of Table 2. The average income elasticity for this adjusted sample is now even closer to the focal point of 1 while the minimum and maximum values are reduced to 0.16 and 2.10, respectively, and the standard deviation is 0.40. This implies that an approximate 95% confidence interval ranges from around 0.2 to 1.8, a massive range including basically all values for income elasticities

particularities of the specifications. We come back to this issue, however, when we turn to the question of weighting.

[7]Existing surveys and our own data show that the variability of the interest rate (semi-)elasticities is even larger than the one for the income elasticity. In a follow-up study, however, we plan to turn to other aspects of the estimations including the information about stability tests that are conducted in a number of papers.

[8]Cf. on this FN 6.

[9]We discarded the estimates in the lower and upper five percentiles of our data. More elaborated techniques result in quite similar adjusted samples. Furthermore we eliminated models where the income elasticity was restricted to be one without proper statistical testing.

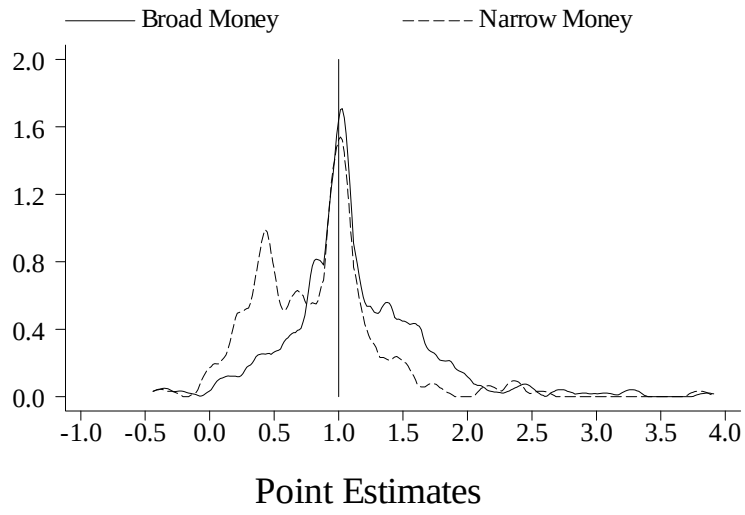

Figure 1: Smoothed Histogram of Point Estimates

implied by theoretical models.

In traditional money demand surveys (cf. Fase 1994, Sriram 2001) the variety of estimates is usually illustrated in histograms. We perform a similar exercise for our sample in Figure 1 where we have used kernel density estimations to "smooth" the histograms (separately for broad and narrow monetary aggregates). We see the expected peak at 1 and for narrow money estimations also a second peak around 0.5. In addition, it is again clearly visible how strongly the point estimates of the income elasticities differ across studies. Looking at the summary statistics of specific subsamples of countries one can observe that there also seems to be a high degree of between-country diversity. For OECD countries the average point estimate of the income elasticity is exactly unity, while Non-OECD countries have a significantly lower value (0.89). The average estimates for the US are considerably lower (0.84) than for Germany (1.16) or for multi-country studies of European economies (1.34).[10]

[10]The subsample "EU Multicountry" refers to studies that combine the data on various European countries to derive some aggregate money demand estimation. Thereby special emphasis has to be laid on the question how the data are aggregated (fixed exchange rate, flexible exchange rate or PPP method) and how cross-border holdings are treated (Wesche 1997). In our sample we have 44 EU Multicountry estimations, ranging from an EC-3 (Germany, France, the Netherlands) to an EU 15 sample. Many of them were done in the run-up to the formation of EMU.

The discussion thus far, however, did not take the differences between studies explicitly and systematically into consideration. As the variation across subsamples and the different pictures for broad and narrow monetary aggregates indicate, it could well be that the point estimates of the income elasticities are influenced by certain specific characteristics of the individual studies and that correcting for these particularities leads to a more coherent picture. This is the issue to which we want to turn next.

3.3 Basic Hypotheses

One can think of various characteristics that might be responsible for different estimated income elasticities γ_1 across studies. First and foremost different studies might use different concepts for the dependent variable—money. Second they might also refer to different measures of certain independent variables (e.g. the scale variable, asset price variables) or they might include or exclude certain variables altogether (e.g. wealth). Finally they might be estimated by different econometric methods and techniques. All of these factors might (in general or under specific circumstances) have an impact on the point estimates of the income elasticity. In many cases, however, the direction of the impact is not a priori clear. In the following we want to derive three basic hypotheses where theoretical considerations lead to unambiguous predictions of the possible effects. In section 4 we will then use meta-regression techniques to investigate whether these hypotheses are confirmed by the data. In subsequent sections, however, we will also include additional study characteristics as potential explanatory variables into the meta-regressions.

Typically money demand equations use quite different definitions of the monetary aggregate (MA), ranging from rather narrow concepts like the monetary base and currency in circulation up to the broadest concepts like $M3$ and $M4$. The distribution of monetary aggregates employed in our sample is shown in Table 3. About 40% of all models use narrow concepts of money (MB, $M0$ or $M1$) while the rest takes broader aggregates. In studies which analyze Non-OECD countries narrow money concepts are used more often than broader concepts.

As discussed above the choice of the MA is not innocuous for the size of the income elasticity. Various theories of money demand imply that the holding of money for transaction purposes involves considerable economies of scale. Inventory approaches, e.g., derive income elasticities between 1/3 and 2/3 thus implying that the income elasticity γ_1 estimated in models that use a narrow concept of money should be lower than where a broader MA is employed. For broader aggregates the inventory approach models are not directly applicable and economies of scale are less likely to be present. On the contrary, following the argumentation by Milton Friedman and others, the income elasticity for these MAs might well be larger than one. We can summarize these arguments in our first hypothesis.

Hypothesis 1 *Empirical money demand studies that use narrow concepts of money should lead to systematically lower estimates for the income elasticity than studies that use broad concepts.*

Some support for this hypothesis can already be found in Figure 1 where the distribution of income elasticities for narrow money is more skewed to the right than the one for broad money. This, however, is only a "univariate" comparison and it is not clear whether it still holds if one corrects for other potential explanatory variables.

Various theories of money demand assume that wealth plays an important role for the desire to hold monetary assets. Most studies, however, do not include measures for wealth (in our sample only 2% do, see Table 3). Noting that (at least in the aggregate) current income and total wealth are very likely to be positively correlated the neglect of wealth would cause an omitted variable bias and lead to an overestimation of the income elasticity.[11] This can be expressed in the following hypothesis.

[11] In the context of OLS this is straightforward to show. Assume that the true model is given by: $Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + u_t$, while the following model is estimated: $Y_t = \beta_0 + \beta_1 X_{1t} + v_t$. In our case X_{1t} represents income and X_{2t} wealth. It can be shown that OLS estimation of the second ("wrong") model leads to a biased estimate of the coefficient: $E(\hat{\beta}_1) = \beta_1 + \beta_2 \frac{Cov(X_{1t,}, X_{2t})}{Var(X_{1t,})}$. Because $\beta_2 \neq 0$ (according to theory) $\hat{\beta}_1$ will be biased unless X_1 and X_2 are uncorrelated. The direction of the bias thus depends on the sign of β_2 and on whether X_1 and X_2 are positively or negatively correlated.

Hypothesis 2 *Money demand estimations that include a measure for wealth should—ceteris paribus—lead to lower estimated income elasticities than studies that exclude such a measure.*

A minority of studies contains measures for financial innovations reflecting the view that changes in a nation's payment system and payment habits should alter the income velocity. Financial innovation is thereby proxied by a wide variety of variables including the number of ATMs, the dissemination of electronic payment cards, the ratio of currency to the total money stock, the ratio of population to bank offices, the degrees of monetizations and financial development in general, etc. Taking the dissemination of electronic payment cards as an example one would suspect that this innovation should tend to lower the demand for currency and other narrow concepts of money. Since on the other hand the distribution of electronic payment systems is likely to be positively correlated with national income the exclusion of proxies for these financial innovations will lead to an underestimation of the income elasticity. Other financial innovations, however, like bank concentration and the degree of financial development are probably better thought of as being proxies for the sophistication of available financial products which could well go hand in hand with a *larger* demand for (broad) money. In this case the exclusion of the respective financial innovation variables would cause an upward bias in the estimation of the income elasticity.

Hypothesis 3 *The exclusion of variables proxying for financial innovation could lead to an omitted variable bias in the estimation of the income elasticity. The direction of the bias depends on the exact nature of the financial innovation variables used in the respective studies.*

4 Meta-Results

4.1 Basic Meta-Regression

In the meta-regressions the income elasticities estimated in the individual studies are regressed on the set of our basic explanatory ("meta-independent") variables that were dis-

cussed in the previous section. The results are summarized in Table 4 for five different specifications: columns 1 to 4 report the results of specifications without individual country dummies, while country dummies are included in the specification of column 5.[12] In addition to the OLS estimations in column 1 and 5, the results in columns 2 to 4 are based on specifications which are estimated by weighted least squares.

The question of whether meta-regressions should be weighted is controversial (Weichselbaumer & Winter-Ebmer 2001; Wolf 1986, 39; Krueger, 2003). Econometrically, weighted least squares should correct for heteroscedasticity in the error term. If the source of heteroscedasticity is known or if there are strong theoretical reasons for assuming such a relation this is straightforward. In many situations, however, as in our framework, weighting expresses a priori beliefs about the "quality" of studies with certain characteristics (like the rank of the publishing journal, reputation of the authors, comprehensiveness of the study etc.). Thus the weighting scheme reflects to a lesser degree theoretical presumptions and remains to some extent arbitrary. In Table 4 we experiment with three different weighting schemes. In column 2 the weights are based on the sample size of the individual studies reflecting the idea that the "quality" of the point estimates should increase with the number of observations. In the context of studies on long-run money demand one could also argue that the estimates of the *long-run* income elasticity are the more accurate the longer the time span a study covers.[13] Following this line of reasoning we use the number of years a study covers as a weighting scheme in column 3. In column 4 we finally employ the precision of the income elasticity estimations (given by the square root of the t-value) as our weight.[14] This follows the suggestions, often found in the meta-analytic literature, that higher weight should be given to more precise estimates.

Altogether the results of the meta-regressions in columns 1 to 4 suggest that different

[12]The coefficients for the country dummies are not shown in Table 4.

[13]In the unit root literature some evidence suggests that the power of unit root tests depend on the span of the data rather than on the number of observations (cf. Maddala & Kim 1998, 129f.).

[14]Using instead the inverse of the standard deviation of the estimations as a measure for precision leads to similar results. Not all estimates of our basic sample include a measure for the precision of estimation (a standard error, a t-value or a p-value) and thus we lose almost a third of our observations when using this weighting scheme.

weighting schemes do not cause fundamental changes in the results. The signs of all estimated coefficients are consistent across the four specifications and also their sizes and levels of significance are quite similar.[15] In light of these results and of the above discussion about the appropriateness of weighting in our framework we use the unweighted scheme of column 1 as our benchmark specification on which we will base subsequent meta-regressions.

Turning to column 5 we observe that the inclusion of country dummies seems to make a non-negligible difference. Some explanatory variables change their level of significance once country dummies are considered, while at the same time the explanatory power of the regression (as measured by $\bar{R}^2$) increases considerably (from 0.22 to 0.4). The significance of many of the individual country dummies thus implies that there are important differences between countries even if individual study characteristics are controlled for. Given this evidence, we include country dummies in all subsequent specifications. In section 4.3 we will discuss the issue of between-country and within-country variation more extensively.

The results of our basic meta-regression in column 5 of Table 4 lend support to hypothesis 1 that the income elasticity increases with the "broadness" of the used MA. We find that income elasticities are significantly higher when a broader MA—a variant of $M2$, $M3$ or $M4$— is used. In particular, the results show that the income elasticity of $M1$ does not differ significantly from $M0$ (the base category), whereas $M4$, $M3$, $M2$ and MZM[16] are not only different from $M0$ but also from $M1$.[17] For example, the estimated coefficients imply that in studies using $M3$ income elasticities are on average 0.17 higher than if $M0$ is used. These results suggest that the studies sort themselves neatly into ones that use narrow concepts ($M0$ or $M1$) and such that use broader concepts of money. Finally, our results suggest that the use of *nominal* money as the dependent variable is associated with

[15] As far as the size is concerned column 4 is an exception stemming from the fact that—due to data availability—it uses a different sample of observations.

[16] The monetary aggregates MZM and $M2M$ are similar to $M2$ but exclude small time deposits. Carlson, Hoffman, Keen & Rasche (2000) argue that these small time deposits are responsible for the instability of $M2$. Since this paper contains a considerable number of estimations we have kept $M2M$ and MZM as separate categories.

[17] Within the group of broad MAs, the income elasticity of $M4$ is significantly larger than those of $M2$ and $M3$, where the latter two concepts yield the same income elasticities, statistically. This is not surprising as the definitions of $M2$ and $M3$, depending on the country, often comprise similar assets.

slightly lower income elasticities although the coefficient is not statistically significant.

Studies that include a variable for wealth have a significantly lower estimated income elasticity. This is again the expected result that confirms hypothesis 2. Wealth plays a role for people's demand for financial assets (including broad money) and since income and wealth are typically highly correlated the omission of wealth from the money demand estimation leads to a considerable overestimation (by 0.48) of the income elasticity.

The inclusion of variables that proxy for financial innovations do not seem to influence the estimated income elasticities in a systematic manner. In column 5 the impact is negative but not statistically significant.[18] As expressed in hypothesis 3 this would mean that the proxies are related to innovations in the payment system etc., rather than to innovations that facilitate the investment in financial assets.

4.2 Extended Models and Robustness Tests

Thus far we have focused on a set of explanatory variables for which we had clear hypotheses about the direction of their likely effect on the estimated income elasticity. Individual money demand estimations differ, however, in a number of additional dimensions for which it is less clear whether one should expect an impact on the estimated income elasticities or in which direction such an impact could work. Despite these theoretical ambiguities it is interesting to investigate whether the diversity of estimates can be explained by some of these additional variables and, furthermore, whether the results of the previous section are robust to these extensions. We focus mainly on two sets of additional explanatory variables that are contained in almost all money demand estimations and capture central aspects: the measurement of the scale variable and details of the estimation method. In column 1 of Table 5 we have amended the basic regression of Table 4, col. 5 with measures for these two sets of variables.

The quantity theory of money is normally formulated with regard to total transactions

[18] In the models of columns 1 to 4 (without country dummies) financial innovation is significant. We suspect that this variable captures a country effect in these specifications and is therefore significant.

rather than to total income. Since the total volume of transactions is difficult to measure most studies resort to some proxy for the scale variable, mostly GDP or national income (62% in our sample, see Table 3), but sometimes also even smaller subsets like consumption or industrial production.

The results in column 1 indicate that the choice of the scale variable significantly affects income elasticities. Studies that use consumption as a scale measure seem to produce significantly higher estimates of the income elasticity than studies that use national income (our base category, measured by GNP, GDP or NNI). In order to interpret these results one should note that the use of measures like GNP, NNI or consumption etc. assumes that the total volume of transactions that give rise to the transaction demand for money and the employed scale variable move in lock steps over time. Usually this sounds like a reasonable assumption to make but there might be periods where it is likely to be violated: "For example, one might posit that consumption is more money intensive than other components of GNP, a hypothesis supported by some evidence." (Goldfeld & Sichel 1990, 320). If some period of time is characterized by a shift in the composition of GNP towards less money intensive sectors then money demand estimations that use GNP as their scale variables will find a smaller income elasticity than ones that use consumption. Under this interpretation the positive sign of consumption indicates that such changes in the composition of GDP were in fact present in the corresponding observation periods.

Next we want to look at the second set of additional explanatory variables: the estimation method used in the empirical analysis. In Table 3 the use of the different estimation methods is summarized.[19] This table reflects the fundamental changes that took place in empirical money demand estimations. While a decade ago most estimations involved partial adjustment or buffer stock models[20] today a majority of the papers employs the Johansen method to estimate long-run money demand functions. In principle, if the econo-

[19]For an overview of the different models, the reader is referred to Maddala & Kim (1998) or Patterson (2000).

[20]In Fase (1994), e.g., the majority of empirical papers surveyed employs partial adjustment models and only 1.5% of all studies use cointegration techniques. In our sample of papers the partial adjustment models have almost disappeared.

metric model is correctly specified, the method used for estimation should not have any systematic influence on the results asymptotically. In practice, however, taking small sample properties into account, the estimated income elasticities are likely to vary across estimators. Some papers which apply different methods suggest that this may indeed be the case. For example, Ball (2001) and Wolters, Teräsvirta & Lütkepohl (1998) provide evidence that the estimation method might influence the results.[21]

In Table 5, col. 1 we have added variables that capture the specificities of the econometric method to our basic meta-regression. This involves, first, a set of dummy variables that stand for the estimation method used in the paper. Furthermore, however, since the finding of differences in estimated income elasticities may reflect peculiarities of the sample and not differences in the estimators, it might also be important to control for sample effects. Therefore we include a number of additional variables that capture the observation time, the data frequency and the potential inclusion of dummies in the underlying regressions.

The results indicate that the estimation method does not seem to matter for the methods that are most frequently employed (ADL, Johansen, EG, DOLS and FMOLS). Two other methods, in particular the random coefficient method, and to a lesser extent the Cooley-Prescott method, generate lower point estimates than the other methods. However, since only a small number of studies in our sample use these methods, the corresponding negative coefficients might also capture some other (omitted) characteristic(s) from these studies. The insignificant coefficients of the most frequently used econometric techniques, however, indicate only the absence of any *systematic* relations (from a meta-analytic perspective) between the methods and the income elasticity estimates. As the above mentioned studies about certain countries and periods show, different estimation methods might lead to considerably different results, where the precise form of the differences apparently varies across studies and seems to depend on the details of the econometric specification, on the

[21]Ball (2001) compares the income and interest rate elasticities obtained from various methods for two samples of U.S. data. For the first sample ranging from 1946 to 1987, he finds point estimates for the income and interest rate elasticity which vary widely across estimators. However, when the sample is extended to 1996, the point estimates are much more clustered. Wolters et al. (1998) compare various methods using German data and obtain income elasticities ranging from 0.94 to 1.44.

properties of the sample, etc. In any case we think that our results as well as a reading of the literature suggest that it is highly advisable not to rely too much on a single method but to apply several methods. Interestingly, this "robustness check" is done in only 30% of all papers in our sample.[22]

The use of monthly and of annual data results in lower estimates for the income elasticity than studies that employ quarterly data (the base category). We have no good explanation why this might be the case and we can only speculate that probably the frequency of the data determines the degree to which the results on long-run money demand are disturbed by short-run influences. There is also some evidence that the inclusion of dummy variables in the money demand specification increases the estimated income elasticity.

The significance of the negative coefficient for the time period over which money demand was estimated (*Time*)—the earlier a sample starts, the higher the income elasticity—could reflect the steady increase in financial innovations over time.

The inclusion of variables for the different scale measures and for the econometric details does not change the main results from Table 4 concerning the use of monetary aggregates, wealth and financial innovation. As further robustness tests we analyze different subsamples based on this specification of the meta-regression. In column 2 of Table 5 we use a "coarser" classification of the monetary aggregates that consists of only three groups: currency ($M0$, the base category), narrow money ($M1$) and broad money ($M2$, $M3$, $M4$).[23] This classification is in fact suggested by the pattern of significant coefficients of the "finer" categorization of MAs in column 1. In column 3 of Table 5 we take only models that are estimated with the Johansen cointegration technique, arguably yielding a more homogeneous and comparable sample. In column 4 of Table 5 we have excluded estimations that cover pre-World War II observations since money demand is likely to have changed fundamentally since these early days. The next robustness test deals with the potential problem that papers which contain a large number of estimations might dominate the results. In fact, four of our 79 papers—each containing more than 23 individual estimations—cover

[22]Out of these 30%, two thirds apply two and one third more than two methods.
[23]In column 2 the category "broad money" is denoted as $M4$.

30% of our total sample. In Table 5, col. 5 these papers are excluded. Finally, an alternative approach towards this issue is provided in column 6 where individual money demand estimations from the same country are given a lower weight.

Altogether the results of the robustness tests support the main findings of the benchmark regression in the first column of Table 5. The income elasticity is significantly higher for broader monetary aggregates and the inclusion of variables for wealth lead to significantly lower estimates. Taking account of financial innovations also causes lower estimates, although this effect is not always statistically significant. Some part of the influence of financial innovations might, however, be captured by the variable *Time* which is also significantly negative in most of the regressions (with the exception of column 4).[24] Independent of the subsample, the use of monthly data results in lower point estimates while for annual data the results are more ambiguous. The effect of the various estimation methods differs across subsamples and only the use of random coefficients and of the Cooley-Prescott method seems to be correlated with lower estimates (although the small number of studies using this method raises some doubts about this result). As far as the scale variables are concerned we can also uphold our conclusion that the use of consumption is associated with higher estimates of the income elasticity.

4.3 Predicted Income Elasticities

Table 6 summarizes the means of the predicted income elasticities for some subsamples. In contrast to narrative surveys, meta-analysis allows for a comparison of the predicted values across countries by using a common benchmark specification to calculate the predicted values. In particular, the reported numbers represent the average income elasticities one obtains if a model were estimated in real terms, with GDP as the scale variable, without wealth, financial innovation and dummies, with quarterly data and with Johansen's method. Furthermore, since the country specific effects are likely to be different for broad

[24]The fact that *Time* is not significant in the specification using only post-World War II data is compatible with the interpretation that this variable might implicitly control for the effects of financial innovation, where the most fundamental changes in payment systems took place over long periods of time.

and narrow money, the predicted values are based on separate regressions for narrow and broad money (not reported).

For the total sample, the average predicted value for the income elasticity for narrow money is 0.90. For broad money, the average income elasticity is considerably larger (1.33). This holds for all subsamples and country groups analyzed. Thus, there is supportive evidence that broader monetary aggregates might be a "luxury good" implying an income elasticity > 1. For narrow money the income elasticities for almost all subgroups are smaller than one, which might be explained by the presence of economies of scale for narrow money. Notable exceptions are found for EU Multicountry studies and, due to the low number of observations with some caution, for Germany. This result thus confirms statements that can be found in qualitative surveys of the literature.[25]

As these results concerning the predicted values of the income elasticities indicate, there exists a considerable amount of between-country variation even after correcting for various study characteristics. Also, this can be seen by the fact that the country dummies remain statistically significant even in the regressions of Table 5 where the larger set of explanatory variables was included. At the same time, however, one can also observe substantial within-country variation that cannot be reduced to international differences. One way to see this is to note that although the variation of income elasticity estimates (as measured by the standard deviation) is reduced from 0.4 (raw data, Table 2) to 0.294 (basic set of explanatory variables including country dummies, Table 4, col. 5) and to 0.260 (extended set of regressors, Table 5, col. 1) almost 50% of the variation in the income elasticities remains unexplained. Information about the explanatory power of various models, including the ones just mentioned, is summarized in the first two columns of Table 9. Alternatively one can also look at meta-regressions that include only estimates for a single country. The US, Germany and the United Kingdom are the only countries for which we have enough data to run such regressions. Similarly to the case of the total sample the inclusion of

[25]For example: "[B]roader definitions of money on the whole produce higher estimates of the income or wealth elasticity of the demand for money than narrower ones. [...] Studies using a narrow definition of money are more prone to yield income or wealth elasticities of demand below unity." (Laidler 1993, 169).

meta-independent variables helps to explain some of the diversity in the "raw data" but again a large part of the variation remains unexplained (not shown). Taking the evidence together we can thus conclude that the variety of the estimated income elasticities is due to both between-country and within-country differences.

5 Further Discussion

Thus far we have established that the estimated income elasticities vary widely even after individual study characteristics have been controlled for. This finding, however, does not necessarily imply that money demand estimations are genuinely unreliable and unrobust as there are still some possible explanations for the observed diversity. For example, it could be the case that the individual estimates refer to periods of considerably different macroeconomic environments that could correspond to systematically different structures of money demand. Also, the fact that the individual studies are not necessarily from an identical quality could explain the wide dispersion. Finally, it could well be possible that the point estimates are very imprecisely estimated and that most individual confidence intervals include plausible values of income elasticities. In this section we will discuss each of these points.

5.1 The Role of Macroeconomic Variables

The country dummies which are found to be significant reflect, in a pure statistical sense, average differences between countries. From an economic point of view, these differences might be correlated with national differences in preferences, institutions, etc., which in principle can be proxied by macroeconomic variables. Furthermore, if a country experienced significant changes in its economic conditions over time and money demand estimations for that country were conducted in different time periods, then macroeconomic variables may also affect the variation of point estimates within a country.

It is interesting to test whether this conjecture is in fact confirmed by the data. Thus, we

have constructed several variables which summarize the macroeconomic condition that prevailed during the sample period of each individual estimation. In particular, the variables are the average level and standard deviation of inflation, the average level and standard deviation of the short term nominal interest rate, the standard deviation of real growth rates (as a proxy for economic stability), the average level of GDP per capita (at PPP) and the number of payment cards per inhabitant.[26].

The choice of the variables follows economic reasoning. For example, it is often argued that during periods of high inflation the velocity of money increases and the income elasticity decreases since people economize on their money holdings. Similarly it was argued that considerable uncertainties about asset returns (interest rates, inflation rates) will also tend to lower money demand of risk-averse consumers. These arguments imply that the level of inflation or nominal interest rates as well as their standard deviation (which is highly correlated with the level) are negatively correlated with the size of the income elasticity. In Friedman's restatement of the quantity theory, tastes for liquidity are likely to affect money demand. For example, wealth holders preferences shift towards more liquidity if unstable economic conditions, like economic downturns, are expected. This argument would suggest that the degree of real economic uncertainty should be positively correlated with the size of the income elasticity. Furthermore, the development of a countries' payment system might affect the demand for money. More payment cards allow to economize on (narrow) money holdings, thus also a negative impact is expected.

To allow for variation between and within countries each macroeconomic variable v is decomposed into two (uncorrelated) parts. Given this decomposition we then run the following regression,

$$\hat{\gamma}_{1i}^{c} = \alpha \cdot x_i + \beta_1 \cdot \bar{v}^c + \beta_2 \cdot (v_i^c - \bar{v}^c) + \epsilon_i \ , \tag{2}$$

$$\bar{v}^c = \frac{1}{j} \sum_{i}^{j} v_i^c$$

[26]See the appendix for the construction and the sources of these variables

where $\hat{\gamma}_{1i}$ is the estimated income elasticity obtained in estimation i for country c and x_i is a vector of study specific characteristics as used previously.[27] v_i^c measures the average value of the macroeconomic variable that prevailed in study i's sample period and $\bar{v}^c$ is the average value of the macroeconomic variable that prevailed in country c. Thus, variation in $\bar{v}^c$, which fluctuates across countries, represents the between country effect and variation in $(v_i^c - \bar{v}^c)$ represents the within country effect of the macroeconomic variable on the point estimate $\hat{\gamma}_{1i}^c$.

The results from including the macroeconomic variables are summarized in Table 7. Due to data limitations the results are based on a sample of OECD countries only (about 300 observations). Indeed, the results reveal that—within our relatively homogenous sample of countries—the between country differences are significantly correlated with the economic environment. Also the coefficients' signs are in accordance with intuition. All variables that measure inflation or "nominal" uncertainty (the level and standard deviation of inflation and the nominal interest rate) have a negative impact, supporting the notion that individuals economize on their money holdings if inflation is high. At the same time we find some support for the argument that growth fluctuations induce individuals to increase their money holdings thus providing some support for Friedman's argument. Furthermore the number of payment cards is negatively correlated with the average country effect. However, as data for payment cards are only available cross-sectionally for nine countries, this latter result must be treated with some caution. For the within country variation, we find just one significant effect (which might reflect the fact that the variation within a country is smaller than between countries): inflation uncertainty enters significantly negative.

The magnitudes of the estimated parameters are also meaningful from an economic perspective. For example, a one standard deviation increase in inflation uncertainty (as measured by the standard deviation of inflation) reduces the estimated income elasticity by 0.081 between countries.[28] An increase by one standard deviation of the within country

[27] See Table 7 for a detailed description.

[28] The mean of the between country standard deviation of inflation is 3.1%. The standard deviation of this variable is 1.3%. This implies that a country with a mean inflation SD of 4.4% has, on average, an

effect of the same variable reduces income elasticities by 0.097. The between country impact of a one standard deviation increase in real growth uncertainty (as measured by the standard deviation of real growth rates) is 0.118.

To check for the robustness of these results we have also run regressions with two macroeconomic variables added simultaneously.[29] In Table 8 we present three regressions that combine the variable for real economic uncertainty (standard deviation of real growth) and a nominal variable (inflation, inflation SD or interest rate SD) and one regression including the payment cards variable. The results remain basically unaffected and seem to be robust.

As mentioned above, these estimations are restricted to a subset of our previous sample. To compare the remaining variation in the residuals after controlling for macroeconomic variables with the variation found in earlier models we re-ran all previous regressions with the sample restricted to the one used in Table 8. This is summarized in the last two columns of Table 9. As shown, the model including macroeconomic variables can explain about as much of the variation in income elasticities as the model with country dummies and the residual standard deviation is still sizeable. Therefore we conclude that, despite their statistical significance, the inclusion of macroeconomic variables does not contribute substantially to the explanation of the wide dispersion.

5.2 Study Quality

It might be argued that the meta-analysis mixes studies with very different characteristics and qualities. Not every paper proceeds with the same diligence and the sometimes inconclusive results might be due to such qualitative differences. In a related context this opinion is lucidly expressed by Alan Krueger: "Research is not democratic. In any field, one good study can be more informative than the rest of the literature. There is no substitute for understanding the specifications underlying the literature." (Krueger 2003, F35).

income elasticity that is lower by 0.081 than a country with a mean inflation SD of 3.1%.

[29] As the macroeconomic variables are typically highly correlated, we are limted to adding not more than two variables jointly.

Undoubtedly, there is something to this view. At the same time, however, it must be emphasized that the "elitist" approach of focusing on the "chosen few" is again dependent on subjective judgments and that in this respect the more objective, "democratic" meta-analytic approach can be regarded as a valuable complement. This is in particular true for the field of money demand studies where fairly sophisticated econometric techniques are employed that differ in sometimes subtle details of the empirical procedure (e.g. data adjustments, the procedures of lag-length selection, the determination of the cointegrating vector, the inclusion of dummies, etc.) making it particularly difficult to decide what constitutes a high-quality study. Here Meta-regressions are a useful tool since the explanatory meta-independent variables are precisely included to (partly) capture and control for differences in the empirical design.

Also, we have employed various weighting schemes to take the potential problem of qualitative differences into consideration, as shown in Table 4. We have discussed there that one could argue that the quality of an estimation (and therefore the weight given to it) should increase with the number of observations, the number of years a study covers, the precision of the income elasticity estimations. The outcome of these comparisons, however, was that the use of the weighting schemes leads to similar results as the unweighted meta-regression. Similar conclusions arise if we apply the different weighting schemes on the extended model in Table 5 or if we use additional weighting procedures (e.g. according to the quality of the publishing journal).[30] Finally, we want to note that sometimes highly different estimates are reported in one and the same paper (thus holding most quality-related factors constant) without the authors choosing one as their most preferred model. All in all we think that the unprejudiced meta-analytic method has clear merits in summarizing scientific results, in detecting patterns in the data and in deriving and testing hypotheses, if used cautiously and with full awareness of its limits.

[30]More specifically, we employed three distinct weighting schemes for journal quality: one from the Free University Amsterdam (4 categories), one from Kalaitzidakis, Mamuneas & Stengos (2001) (ranking from 1 to 159) and an impact factor based on data from the "Journal Citation Reports" database. In all three cases, the results do not change qualitatively.

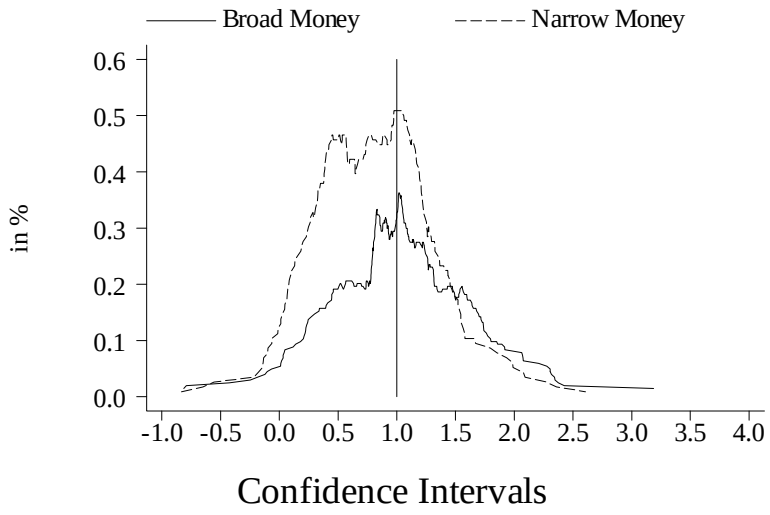

Figure 2: Frequency Plot of Confidence Intervals

5.3 Precision of Estimation

The last point discussed in this section refers to the possibility that the diversity of income elasticity estimates reflects only the imprecision of the underlying estimations. In order to illustrate this argument we can again look at the variability of the point estimates of the income elasticities visible in the "smoothed histograms" in Figure 1. Interestingly, it is rarely asked in traditional money demand surveys whether this variation in point estimates is due to imprecise estimation or whether it is "genuine", i.e. reflecting differences in the underlying economic structure. This can be analyzed only if also the stochastic distribution of the point estimates is taken into account. For example, a peak at 0.5 does not a priori imply that a unitary income elasticity is rejected by the data since the value of 1 could still be included in most confidence intervals of the respective point estimates. To account for this possibility we have constructed frequency plots of confidence intervals (shown in Figure 2) for which we have used the information of all studies that report some measure for the precision of estimation (standard errors, t-statistics or p-values).[31] The height of the curve indicates the sample frequency with which a certain income elasticity is contained

[31]Unfortunately, this is not the case for all studies and thus the number of observations decreases in this case to 323.

in the respective 95% confidence interval of the 323 individual point estimates.[32] Quite surprisingly, this analysis shows that for broad money the value 1 is included in only 32% of these confidence intervals implying that for a majority of empirical money demand estimations the prediction of the quantity theory is clearly rejected.[33] In contrast, the value of 0.5 is contained only in 18% of all confidence intervals for broad money. For narrow money the values of 0.5 and 1 are included in 44% and 50% of all confidence intervals, respectively.

Although these frequency plots of the confidence intervals do not control for the study characteristics (as was done in the meta-regressions) we still regard the results as sufficiently strong to conclude that imprecision alone is not able to explain the wide diversity of point estimates.

6 Conclusion

When summarizing the results from the huge literature on empirical money demand estimations, one typically encounters coefficient values that vary substantially. In this paper we analyzed whether and how this wide diversity of results can be explained.

We extended the existing literature in various dimensions. First, we performed a meta-analysis of almost 500 empirical money demand studies to investigate whether different study characteristics might play a role for the variation. In particular we showed that the estimations for the income elasticity of money demand are systematically and significantly higher if broader definitions for the monetary aggregate are used. The inclusion of variables like wealth and financial innovation on the other hand tend to be associated with lower estimates. The results for the use of different scale variables, the use of different econometric methods and various additional details of the specification are less clear-cut. It is noteworthy that some of these results are similar to observations made in previous

[32] A value 0.32 for an income elasticity of 1 means, e.g., that 1 is contained in 32% of the confidence intervals of all studies.

[33] The peak of the curve is reached at an income elasticity of 1.02 which is contained in 36% of all studies.

surveys—despite the fact that we use a completely different sample of papers and despite the fact that in our sample most studies use modern cointegration techniques while older surveys (e.g. Fase 1994, Laidler 1993) were dominated by partial adjustment models, etc.

The meta-analyses reveal that while specific features of the individual studies help to explain a substantial part of the differences in the empirical results the unexplained variation still remains large. Therefore we analyzed in a next step whether the remaining variation is related to different economic situations that prevailed during the sample periods of the individual studies by conducting meta-regressions with macroeconomic variables as additional explanatory variables. Interestingly the results obtained from a relatively homogenous sample of OECD countries suggest the existence of a significant link between money demand and the state of the economy. In particular we found that estimated income elasticities are significantly lower in samples with higher average inflation and "nominal" uncertainty supporting the notion that individuals economize on their money holdings if inflation is high. Also the extent of uncertainty about the real economy affects income elasticities. Finally, there is some evidence that the distribution of cashless payment means, approximated by the number of payment cards, has a negative impact on income elasticities. However, despite the fact that the estimated coefficients of these variables are statistically significant, a sizeable part of the variability remains unexplained even if one controls for the macroeconomic environment.

Finally, we analyzed the precision of the point estimates since the large variability of estimates over studies could be related to uncertainty of estimation—e.g. wide confidence intervals for individual point estimates. However, we showed that this issue does not seem to be at the root of the problem since point estimates are in general rather precise and therefore confidence intervals do not overlap to a large extent.

Given the evidence presented in this paper, our overall conclusion is that a substantial part of the variation in point estimates cannot be explained by differences in the study characteristics, different macroeconomic environments and imprecision of estimation. Thus, our findings raise some doubts about the robustness and reliability of money demand estimations, implying that it does not seem to be very likely that open questions in the field of

theoretical money demand studies (concerning, e.g., the size and long-term constancy of the income elasticity) are resolved by turning to empirical estimations. From a practical point of view, however, it does not matter whether the unreliable estimations are due to an inherently unstable money demand relation or whether they are due to shortcomings in the empirical methodology.

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Appendix

Data Sources: The data for GDP per capita are obtained from the PENN World table. The number of payment cards (the sum of credit and debit cards) is taken from the BIS for the year 1991. Since no historical time series are available for payment card data, we are restricted to nine cross-sectional observations only. All other macroeconomic time series are from the OECD Economic Outlook or from the IFS database.

Construction of Macroeconomic Variables: For each individual money demand estimation in our sample we downloaded several annual macroeconomic time series. Then we calculate the mean level, the standard deviation and the coefficient of variation for each macroeconomic series for each period. The country average of a specific macroeconomic variable is obtained by taking the mean over all observations for the macroeconomic variable for a given country. In turn, the within country effect is obtained by subtracting this country specific mean from the individual macroeconomic variables.

Estimation of the Effect of Macroeconomic Variables: The results in Table 7 and Table 8 are based on weighted LS. For some country specific sample periods we have many observations (e.g. for the US we have more than 50 observations for an identical sample) while for some other sample-country combinations we have only one observation. This implies that for some country-sample combinations, the value of the independent variable does not change while the value of the dependent variable, the estimated income elasticities, varies. Obviously, we do not want this to influence the results. Therefore, all observations are weighted by the inverse of the square root of the number of observation for each country-sample combination. Alternatively, one could also weigh by the inverse of the number of observations. This does not change the results qualitatively.

Table 1: Meta-Independent Variables

Income Elasticity	= the point estimates of the income elasticities
Monetary Aggregates	
M0	= 1 ... if a study uses M0 or MB
M1	= 1 ... if a study uses M1
M2	= 1 ... if a study uses M2
M2M	= 1 ... if a study uses M2M (broader concept than M2 for the US)
MZM	= 1 ... if a study uses MZM (broader concept than M2 for the US)
M3	= 1 ... if a study uses M3
M4	= 1 ... if a study uses M4
Money Broad	= 1 ... if a study uses either M2, MZM, M2M, M3 or M4
Money Narrow	= 1 ... if a study uses M1
Money Currency	= 1 ... if a study uses M0
Nom. Money	= 1 ... if a study uses nominal money as the dep. variable
Scale Variables	
GDP	= 1 ... if a study uses either GDP, GNP or Net National Income as a scale variable
Consumption	= 1 ... if a study uses either consumption, personal income or private GDP (GDP less government component) as a scale variable
Indices	= 1 ... if a study uses either an index of industrial production or of coincident indicators as a scale variable
Expenditure	= 1 ... if a study uses a measure of expenditures (real total transactions, total final expenditures, etc.) as a scale variable
Data Frequencies	
Monthly Data	= 1 ... if a study uses monthly data
Quarterly Data	= 1 ... if a study uses quarterly data
Annual Data	= 1 ... if a study uses annual data
Estimation Method	
ADL	= 1 ... if a study uses a distributed lag estimation method
EG	= 1 ... if a study uses the Engle-Granger estimation method
DOLS	= 1 ... if a study uses the dynamic OLS or GLS estimation method
FMOLS	= 1 ... if a study uses the fully modified OLS estimation method
CP	= 1 ... if a study uses the Cooley-Prescott estimation method
Random Coeff.	= 1 ... if a study uses the random coefficients estimation method
Spectral	= 1 ... if a study uses the spectral regression method
Johansen	= 1 ... if a study uses the Johansen system estimation method
CCR	= 1 ... if a study uses the canonical correlation estimation method

Note: See continuation on next page.

Table 1: Meta-Independent Variables

Other Variables	
Dummies	= 1 ... if a study included at least one dummy variable as an explanatory variable
Wealth	= 1 ... if a study included a measure of wealth
Fin. Innov.	= 1 ... if a study included a measure of financial innovations
Time	= the sample mid-point year of a study
Precision	= the t-value of the estimated income elasticity (calculated under the null of a unitary income elasticity)
No. of Obs.	= the number of observations uses for estimating income elasticities
No. of Years	= the number of years in the sample uses for estimating income elasticities

Table 2: Descriptive Statistics for Income Elasticities

	Mean	Std. Dev.	Min.	Max.	Obs.
All Observations					
Total	1.06	2.10	-14.11	44.79	559
OECD Countries	1.09	2.32	-14.11	44.79	435
Non-OECD Countries	0.95	0.96	-2.98	5.55	124
USA	0.83	1.23	-14.11	5.81	227
GBR	0.97	0.39	0.04	2.03	33
DEU	1.19	0.24	0.60	2.17	47
EU Multicountry	1.42	0.64	0.86	5.04	45
Adjusted Sample					
Total	0.98	0.40	0.16	2.10	491
OECD Countries	1.01	0.40	0.16	2.10	392
Non-OECD Countries	0.89	0.39	0.19	2.05	99
USA	0.85	0.33	0.18	1.97	206
GBR	0.99	0.41	0.22	2.03	25
DEU	1.17	0.20	0.60	1.52	45
EU Multicountry	1.34	0.32	0.86	1.96	44

Note: The table summarizes descriptive statistics for the estimated income elasticities. "Adjusted Sample" denotes the sample obtained after eliminating the 5% highest and lowest income elasticities as well as all income elasticities that were constrained to be one (without statistical testing). "EU Multicountry" denotes a sample consisting of studies about European countries where the individual countries were aggregated. For a definition of the variables see the Appendix.

Table 3: Characteristics of the Studies by Sub-Groups

	Total	OECD	Non-OECD	USA
MB	1	1		1
M0	6	2	22	1
M1	32	29	45	30
M2	29	31	20	48
M2M	2	3		6
MZM	6	8		15
M3	21	24	12	
M4	3	4		
Sum	100	100	100	100
GDP, GNP, NNI	62	60	69	29
Consumption	16	18	10	33
Indices	19	19	19	35
Expenditure	3	4	2	4
Sum	100	100	100	100
Monthly Data	26	30	11	57
Quarterly Data	57	54	72	21
Annual Data	16	16	17	22
Sum	100	100	100	100
ADL	16	15	21	5
EG	10	5	30	3
DOLS	8	10	1	10
FMOLS	7	9		2
CP	1		7	
Random Coeff.	2	2		3
Spectral	1	1		2
Johansen	54	57	40	73
CCR	1	1		2
Sum	100	100	100	100
Nom. Money	7	9		1
Wealth	2	2		
Fin. Innov.	3		12	
Dummies	21	23	13	4
Obs.	491	392	99	206

Note: The table shows the frequencies (in percent) of the various characteristics of the studies. For a definition of the variables, see the Appendix.

Table 4: Meta-Regression – Simple Specification

	Dependent Variable: Income Elasticity				
	(1)	(2) (1) + number of obs.	(3) (1) + number of years	(4) (1) + precision	(5)
Country Dummies	No	No	No	No	Yes
M1	-0.120*	-0.072	-0.169**	-0.137	-0.063
	(0.068)	(0.081)	(0.084)	(0.153)	(0.077)
M2	0.083	0.039	0.226***	0.116	0.225***
	(0.069)	(0.077)	(0.083)	(0.152)	(0.078)
M2M	-0.059	-0.009	-0.061	-0.022	0.167
	(0.119)	(0.098)	(0.147)	(0.189)	(0.118)
MZM	0.126	0.176**	0.124	0.309*	0.353***
	(0.089)	(0.082)	(0.104)	(0.175)	(0.096)
M3	0.322***	0.330***	0.210**	0.516***	0.171**
	(0.073)	(0.087)	(0.091)	(0.158)	(0.087)
M4	0.519***	0.529***	0.479***	0.415**	0.385**
	(0.110)	(0.133)	(0.145)	(0.173)	(0.157)
Nom. Money	0.034	0.108	0.109	0.079	0.055
	(0.066)	(0.085)	(0.088)	(0.120)	(0.076)
Wealth	-0.396***	-0.356**	-0.378**	-0.406***	-0.480***
	(0.126)	(0.149)	(0.165)	(0.140)	(0.159)
Fin. Innov.	-0.548***	-0.488***	-0.455***	-0.816***	-0.149
	(0.102)	(0.115)	(0.127)	(0.143)	(0.157)
C	0.925***	0.875***	0.926***	0.846***	0.155
	(0.062)	(0.074)	(0.078)	(0.147)	(0.359)
R^2	0.23	0.17	0.21	0.30	0.45
$\bar{R}^2$	0.22	0.16	0.20	0.28	0.40
Obs.	491	491	491	319	491

Note: Standard errors in parentheses. *** (**) [*] indicate significance at a 1% (5%) [10%] level. Column (1) and (5) estimated by OLS, columns (2)-(4) by weighted LS. See the Appendix for a definition of variables.

Table 5: Meta-Regression – Extended Specification

	Dependent Variable: Income Elasticity					
	(1) Total	(2) BM/NM	(3) Johansen	(4) Post WW-II	(5) <23 models	(6) Weighted
Monetary Aggregates						
M1	-0.021	-0.033	-0.037	0.012	0.016	-0.064
	(0.073)	(0.074)	(0.095)	(0.073)	(0.080)	(0.057)
M2	0.390***		0.342***	0.340***	0.340***	0.192***
	(0.077)		(0.097)	(0.078)	(0.083)	(0.059)
M2M	0.508***		0.468***	0.408***	—	0.457
	(0.115)		(0.127)	(0.118)		(0.289)
MZM	0.648***		0.594***	0.584***	—	0.601***
	(0.097)		(0.112)	(0.098)		(0.200)
M3	0.294***		0.343***	0.294***	0.296***	0.140**
	(0.082)		(0.113)	(0.082)	(0.088)	(0.071)
M4	0.521***	0.356***	0.895***	0.480***	0.484***	0.282*
	(0.148)	(0.073)	(0.215)	(0.150)	(0.160)	(0.145)
Nom. Money	0.111	0.062	0.043	0.088	0.031	0.205***
	(0.075)	(0.074)	(0.107)	(0.078)	(0.084)	(0.075)
Wealth	-0.502***	-0.480***	—	-0.492***	-0.451***	-0.617***
	(0.146)	(0.148)		(0.145)	(0.156)	(0.105)
Fin. Innov.	-0.251*	-0.252*	-0.697*	-0.234	-0.118	-0.236**
	(0.149)	(0.151)	(0.358)	(0.149)	(0.192)	(0.120)
Time	-0.013***	-0.013***	-0.017***	-0.003	-0.010***	-0.011***
	(0.002)	(0.002)	(0.003)	(0.004)	(0.003)	(0.003)
Scale Variables						
Consumption	0.193***	0.182**	0.165*	0.157**	0.132	0.140*
	(0.070)	(0.071)	(0.093)	(0.072)	(0.091)	(0.074)
Indices	0.126	0.131	0.093	0.081	0.129	0.022
	(0.082)	(0.084)	(0.106)	(0.084)	(0.162)	(0.105)
Expenditure	-0.131	-0.147*	0.094	-0.193**	-0.121	-0.264**
	(0.087)	(0.088)	(0.161)	(0.089)	(0.100)	(0.122)

Note: All models include country dummies. Standard errors in parentheses. *** (**) [*] indicate significance at a 1% (5%) [10%] level. See continuation on next page.

Table 5: (Continued)

	Dependent Variable: Income Elasticity					
	(1) Total	(2) BM/NM	(3) Johansen	(4) Post WW-II	(5) <23 models	(6) Weighted
Monthly Data	-0.381***	-0.300***	-0.265***	-0.351***	-0.424***	-0.432***
	(0.072)	(0.070)	(0.084)	(0.073)	(0.148)	(0.110)
Annual Data	-0.181**	-0.192**	-0.202	-0.172**	0.168	0.053
	(0.078)	(0.079)	(0.142)	(0.079)	(0.124)	(0.111)
Dummies	0.059	0.058	0.086	0.022	0.053	0.066
	(0.044)	(0.045)	(0.068)	(0.046)	(0.048)	(0.049)
Estimation Method						
ADL	-0.082	-0.073	—	-0.088*	-0.082	-0.155***
	(0.051)	(0.051)		(0.051)	(0.057)	(0.050)
EG	-0.034	-0.029	—	-0.034	-0.144	-0.090
	(0.076)	(0.077)		(0.076)	(0.102)	(0.064)
DOLS	-0.057	-0.050	—	-0.076	-0.052	-0.052
	(0.057)	(0.057)		(0.061)	(0.070)	(0.066)
FMOLS	-0.005	-0.008	—	-0.025	0.046	-0.013
	(0.061)	(0.063)		(0.063)	(0.070)	(0.072)
CP	-0.317**	-0.285**	—	-0.320**	—	-0.428***
	(0.135)	(0.138)		(0.135)		(0.087)
Random Coeff.	-0.591***	-0.610***	—	—	-0.793***	-0.869***
	(0.126)	(0.128)			(0.149)	(0.212)
Spectral	-0.253*	-0.261*	—	-0.219	—	-0.606
	(0.152)	(0.155)		(0.152)		(0.479)
C	25.646***	25.580***	33.430***	6.180	19.889***	22.775***
	(4.357)	(4.262)	(6.307)	(8.057)	(6.331)	(5.693)
R^2	0.57	0.55	0.55	0.56	0.56	0.74
$\bar{R}^2$	0.51	0.49	0.47	0.49	0.48	0.71
Obs.	491	491	268	467	319	491

Note: All models include country dummies. Standard errors in parentheses. *** (**) [*] indicate significance at a 1% (5%) [10%] level. The models in column (1)-(5) are estimated by OLS, the model in column (6) is estimated by weighted LS. The weight is the inverse of the number of observations per country. See the Appendix for a definition of variables.

Table 6: Predicted Income Elasticities

	Narrow Money	Broad Money
Total	0.90	1.33
OECD	0.92	1.32
Non-OECD	0.84	1.34
US	0.78	1.15
GBR[1]	0.74	1.10
DEU	1.03	1.25
EU Multicountry	1.17	1.46

Note: The table shows the means of the predicted values for individual countries or country groups. The predicted values are calculated under the assumption that the model is estimated in real terms, with GDP as the scale variable, without wealth, financial innovation and dummies, with quarterly data and with Johansen's method.

[1] For narrow money 4 observations only.

Table 7: Individual Effects of Macroeconomic Variables

	Dependent Variable: Income Elasticity		
	Between Countries	Within Countries	
Inflation	-2.661***	-2.065	R^2=0.35, Obs.=309
	(0.798)	(4.040)	
Inflation SD	-6.074***	-29.327***	R^2=0.41, Obs.=307
	(1.524)	(7.207)	
Int. Rate	-0.022***	0.039	R^2=0.36, Obs.=307
	(0.008)	(0.044)	
Int. Rate SD	-0.388***	-0.075	R^2=0.43, Obs.=307
	(0.059)	(0.089)	
Real Growth SD	18.713***	-2.854	R^2=0.36, Obs.=309
	(4.885)	(5.816)	
GDP Real	-0.121	-0.047	R^2=0.38, Obs.=317
	(0.087)	(0.144)	
Cards	-2.489***		R^2=0.45, Obs.=330
	(0.383)		

Note: The table shows the coefficients of macroeconomic variables on the income elasticities obtained by adding the macroeconomic variables individually to the model shown in column (1) of Table 5 (excluding country dummies and $Time$ and restricting the sample to OECD countries). When estimating the model, the observations are weighted according to the inverse of the number of observations for a given country and sample period (e.g. if there are 50 observation for the same country and time period, then each of these observation is weighted by 1/50). The effect of macroeconomic variables is decomposed into the effect between countries and within countries. "SD" and "CV" denote the standard deviation and the coefficient of variation, respectively. Standard errors in parentheses. *** (**) [*] indicate significance at a 1% (5%) [10%] level.

Table 8: Joint Effects of Macroeconomic Variables

	Dependent Variable: Income Elasticity		
	Between Countries	Within Countries	
Inflation	-1.913**	-3.868	R^2=0.37, Obs.=309
	(0.813)	(4.083)	
Real Growth SD	16.661***	-1.477	
	(5.112)	(5.881)	
Inflation SD	-4.546***	-35.269***	R^2=0.45, Obs.=307
	(1.521)	(7.178)	
Real Growth SD	18.993***	-4.441	
	(4.699)	(5.548)	
Int. Rate SD	-0.350***	-0.021	R^2=0.43, Obs.=303
	(0.061)	(0.091)	
Real Growth SD	14.779***	1.972	
	(5.061)	(5.769)	
Inflation SD	-9.516***	-36.944***	R^2=0.49, Obs.=289
	(1.477)	(6.885)	
Cards	-1.853***		
	(0.454)		

Note: See Table 7. Standard errors in parentheses. *** (**) [*] indicate significance at a 1% (5%) [10%] level.

Table 9: Model Comparison

		Total Sample (491 obs.)		OECD Countries (307 obs.)	
		Std. Dev. Residuals	$\bar{R}^2$	Std. Dev. Residuals	$\bar{R}^2$
(1)	No Explanatory Variables	0.40	–	0.36	–
(2)	Standard Set of Explanatory Variables	0.34	0.22	0.30	0.28
(3)	(2) + Country Dummies	0.29	0.40	0.27	0.37
(4)	(2) + Scale + Econometric	0.31	0.35	0.28	0.37
(5)	(2) + Scale + Econometric + Country Dummies	0.26	0.51	0.26	0.42
(6)	(2) + Scale + Econometric + Macroeconomic	–	–	0.27	0.39

Note: "Total Sample" refers to the sample used in Table 4 and 5, "OECD Countries" refers to a sample for which macroeconomic variables were available (Table 7 and 8). The table summarizes the standard deviations of the residuals and the adjusted R^2 for various estimated models which are in detail reported in the above mentioned tables (the model with macroeconomic variables is the model with inflation SD and real growth SD).

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1) vergriffen (out of print)
2) In abgeänderter Form erschienen in Berichte und Studien Nr. 4/1990, S 74 ff
3) In abgeänderter Form erschienen in Berichte und Studien Nr. 4/1991, S 44 ff
4) In abgeänderter Form erschienen in Berichte und Studien Nr. 3/1991, S 39 ff
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