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U.S. MONEY DEMAND: SURPRISING CROSS-SECTIONAL ESTIMATES

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Abstract

We estimate money demand functions using cross-sections of U.S. states over the period 1929-1990. We arrive at a number of interesting conclusions: First, our estimates of the income elasticity lie between 1.3 and 1.5, significantly above one. Second, money demand is a **stable** function over an impressive sample period, 1929-1990. Third, income per capita is a better scale variable than consumption. And finally, after having been fairly constant between 1950 and 1980, the rate of technological progress (which determines the amount of money demanded for given incomes, price levels and interest rates) accelerated substantially over the 1980s.

KEY WORDS: Money Demand

The specification of the money demand function has important implications for a number of macroeconomic issues. First, if policymakers are responsible for the achievement of price stability,[2] reliable quantitative estimates of money demand are needed. In particular, the income elasticity yields the rate of money growth that is consistent with long-run price stability, at least for a given long-run growth rate of income and technology.

Second, macroeconomic theorists need quantitative estimates of the money demand function in order to determine what the exact predictions of their models are. In Keynesian models, for instance, the relative ability of monetary and fiscal policy to affect the real economy depends on the elasticities of the demand for money: for a given interest elasticity, a larger income elasticity implies a more vertical LM and, as a result, monetary policy is relatively more potent than fiscal policy. In fact, part of the debates between monetarists and fiscalists in the 1950s and 1960s was over the 'slope' of the LM curve. In the general equilibrium Real Business Cycles models (which have recently started to emphasize monetary aspects of the economy), money demand elasticities are among those numbers which need to be replicated by the equilibrium conditions of the model. Furthermore, in such models, the money demand elasticities matter for the determination of the aggregate price level and the inflation rate, given the rate of money growth. Classical economists may also argue that the elasticities are important in determining the optimal seigniorage policy.

Finally, both Classicals and Keynesians need to worry about the reasons

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2 That economic research promotes "prosperity and price stability" has always been a primary goal of the *Brookings Papers on Economic Activity*. Readers of the BPEA find a formal statement of the goal on the first page of every issue.

why people hold money. Hence, the size and the stability[3] of the money demand elasticities can be seen as 'tests' of the implications of different theories. Only after the predictions of a model are consistent with the data we will be confident about the stories which underpin different theories of money demand.

Economists disagree on the size of the income elasticity of money demand. At the theoretical level, the predicted elasticities range between one third and one: a strict interpretation of the Baumol (1952)-Tobin (1956) model of the transactions demand for money predicts an income elasticity of one half.[4] The stochastic version of the model (developed by Miller and Orr (1966)) reduces the prediction to about one third. The elasticity predicted by the popular "cash-in-advance" model is unity.[5]

At the empirical level, the elasticity estimates are even more erratic.[6] They seem sensitive to the choice of sample period, to the exact functional form and number of lags, to the inclusion of an interest rate variable and to the precise choice of that variable. Typical problems arise with the potential simultaneity bias of money supply and demand, with the correlation of income and technology over time,[7] with the unit roots of

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3 Some models predict that the elasticities are structural and, therefore, stable. Such stability over time is therefore a testable implication of such models.

4 This is true if transaction costs are thought to be independent of income. This assumption, however, is not completely realistic. For instance, if one thinks that transaction costs are related to time needed to go to the bank, then the cost is related to the wage rate which, in turn will be positively correlated with income. The overall income elasticity would in this case be one (Karni (1973)).

5 See Barro and Fischer (1976) for a survey of theories of money demand.

6 The estimates reported in the literature are too many and too variable for us to report in this paper. Without trying to be exhaustive, some of the contributions include Friedman (1959), Metzler (1963), Laidler (1977), Goldfeld (1973) and (1976), Judd and Scadding (1982), Lucas (1988), and Braun and Christiano (1992).

7 Because of its unobservable nature, technology is commonly thrown into

money and income variables (and therefore, on whether regressions should be run in first differences, or in levels with time trends, or with trends with a number of breaks, etc) and with the stability of the coefficients over time. That the money demand function is stable over time is a standard identifying assumption, yet there is no shortage of evidence to the contrary. Friedman and Kuttner (1992) say that for the period 1970-1990, time series data reveal no "close or reliable relationship between money and nonfinancial economic activity."

In this paper we argue that these and other problems are solved when money demand is estimated cross-sectionally. We estimate money demand functions using cross-sections of U.S. states over the period 1929-1990 and we arrive at a number of interesting conclusions: First, our estimates of the income elasticity lie between 1.3 and 1.5, significantly above one. Second, money demand is a **stable** function over an impressive sample period, 1929-1990. Third, income per capita is a better scale variable than consumption although the empirical estimates do not depend significantly on the choice of the scale variable. And finally, after having been fairly constant between 1950 and 1980, the rate of technological progress (which determines the amount of money demanded for given incomes, price levels and interest rates)[8] accelerated substantially over the 1980s.

The rest of the paper is organized as follows. Section I describes our data set which measures various bank deposits for 48 U.S. states over the period 1929-1990. The deposit data are used to construct a narrow measure

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the error term, which biases the estimated income elasticities downward.

In the Baumol-Tobin model, for instance, technology enters into the analysis through the 'transaction cost' variable. Presumably, a better financial technology allows people to economize on transaction costs, which decreases the demand for money.

of money (which we call MX1) as well as a broader measure (MX2). The second section shows that there is considerable cross-sectional variation in both money per capita and velocity. This allows us to proceed with the estimation of cross-state money demand functions. In section III, we argue that time-series estimation of money demand encounters a number of problems that can be successfully solved using cross-sectional analysis. In section IV we present the empirical estimates. Section V studies the shifts in the money demand function over time. The final section concludes.

I. Data: Sources & Definitions

We have compiled data on two concepts of money - which we call MX1 and MX2 - for 48 states. Our sample period is 1929-1990. Subsection A reviews conventional definitions of money for the U.S. as a whole. Our state money data are explained in subsection B. Other variables included in the empirical analysis are described in the final subsection.

A. U.S. Money Aggregates

For the U.S., four aggregate definitions of money are common: M0 (the monetary base), M1, M2, and M3. Currency together with reserves constitute the monetary base. M1 is the sum of currency, traveler's checks, demand deposits and, after the 1980s, other checkable deposits.[9] M1 together with savings deposits, small time deposits, overnight repurchase agreements, overnight Eurodollars and money market mutual funds (excluding institution only) constitute M2. M3 adds other "less liquid" financial assets.

9 Barro (1990), 427-8.

B. State Money Aggregates

Because currency data is not available by state, it is very difficult to measure the monetary base at the state level. However, aggregate U.S. data suggest that broader aggregates can be approximated by deposit data: in 1987, for instance, currency constituted only 26% of M1.[10] Hence, we decided to collect and analyze deposit data by state.

In each year since 1950, the FDIC surveyed all banks.[11] Each bank reported the composition of its deposits as well as a profile of its depositors. Thus, a bank's "call report" revealed amounts owed in the form of demand deposits, savings deposits and time deposits. The reports also showed the importance of various depositor groups: individuals, partnerships and corporations; federal government agencies; state and local governments; and other banking institutions. Before 1950, similar surveys were conducted by state governments or by the Federal Reserve.

The FDIC summed various subsets of banks and reported state aggregates for various types of deposits. In the years 1950-57, all operating banks were included in the aggregates. After 1957, only FDIC insured commercial banks were included; mutual savings banks or uninsured banks were excluded.[12] Demand deposit measures by state were compiled by the Federal Reserve for the years 1929-1949, often using individual state government sources.[13] The Federal Reserve totals included all banks.

Today, a deposit is considered to be in a state if the *banking branch*

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[10] Barro (1990) 439, 428.

[11] Most of the surveys were taken on the last working day in December. Sometimes the survey was on the last day of June or both in June and December.

[12] In 1973, 99.1% of demand deposits in the U.S. were liabilities of FDIC insured commercial banks. In 1983, the fraction was 98.6%.

[13] Most of the 1929-1949 surveys were taken in June.

at which the deposit is made is located in that state, regardless of the location of the main office.[14] Before 1981, it was the main office location that mattered.

For 1929-87 our narrow measure of money, MX1, is demand deposits held at banks by individuals, partnerships and corporations.[15] After 1987, we use "non-interest bearing deposits," regardless of the depositor. Our broad measure, MX2, includes *all* deposits held at insured commercial banks. MX2 includes savings and time deposits and includes those held by public entities. Inconsistencies in the types of banks surveyed are shared with MX1.

Above we have reported some minor inconsistencies of the definitions of MX1 and MX2 over time. Mutual savings banks may or may not be counted, government bank deposits are sometimes counted, and surveys vary between June and December. In every instance of a definition change, we had overlapping data.[16] Levels of four series were adjusted accordingly. Most importantly, *definitions were consistent cross-sectionally.*

Appendix Figure A1 sums our measures of money, MX1 and MX2, for all 48 states and compares them to two popular U.S. concepts M1 and M2. We deflate the four series and divide by the U.S. population in order to remove the

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[14] According to the FDIC, a branch is "any office or facility of a bank, including its main office, at which deposits are received, checks paid, or money lent even though some of these may not be defined as branches by state laws. A branch includes, but is not limited to all of the following: drive in facilities, seasonal offices...." (*Banks and Branches Data Book, 6/30/84*) Branches do not include electronic fund transfer units and customer bank communication terminals.

[15] Not included as individuals, partnership or corporations (IPC's) are federal government agencies and other banks. Nor are state and local governments included, except in the 1929-49 period. Deposits held **by** mutual savings banks **at** FDIC insured commercial banks are sometimes included in the IPC total during the 1958-1987 period.

As noted above, state aggregates include deposits owed by all banks for 1929-57 but only those owed by FDIC insured commercial banks for 1958-1990.

[16] The definition changes were in 1950, 1958, 1984 and 1988.

common trend.[17] Of course, since M1 and M2 include currency the levels of M1 and M2 are greater than the levels of MX1 and MX2, respectively. What we learn from the figure is that year-to-year variations are fairly similar. The main exception is the early 1980's when demand deposits dropped more sharply than did M1. MX1 and M1 have a correlation of .80 for the full sample and one of .97 when the 80's are excluded.[18] MX2 and M2 have a full sample correlation of .99.

C. Other Variables

Our primary scale or transactions concept will be personal income, although, in part of the analysis, we will also consider 'consumption' as measured by retail sales. The data set includes annual observations for 48 states compiled by the BEA.[19] Retail sales differ from a broad measure of consumption in that it excludes services. It includes consumer durables and other forms of non-food consumption that are excluded at the PSID level.

Population density and agriculture's share of personal income are used in order to capture other state-specific determinants of money demand. We include an agricultural variable as an attempt to capture regional differences in prices or transactions technologies. In particular, we would like to allow for the possibility that new transactions technologies may slowly diffuse from urban to more rural areas. Hence, at a given point in time, different states may be undergoing different degrees of technological

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17 For U.S. population, we use the sum over the 48 states. M1 and M2 for 1959-1990 are from the *Economic Report of the President* and from Friedman and Schwartz (1963) for 1929-1958.

18 The main difference between M1 and MX1 during the 1980s is probably due to the introduction of NOW accounts and other checkable deposits which are part of M1 but not of MX1.

19 For retail sales the available years are: 1929, 1935, 1939, 1948, 1954, 1958, 1963, 1967, 1972, 1977, 1982, 1984, 1987, and 1989. A *Census of Retail Trade* was not conducted every year.

progress. Our annual agricultural income series, however, has too much high frequency variation to capture our notion of technological diffusion. We therefore compute five year averages of agriculture's share of personal income. Population and area are from the Bureau of the Census' *Current Population Report* and the *Statistical Abstract of the United States* respectively.

For our time series analysis, each of MX1, MX2, personal income and retail sales are expressed in constant prices. We deflated using the U.S. implicit price deflator for personal consumption expenditure from the *Economic Report of the President*.

II. Dispersion of Velocity and Money per Capita

For both our measures, velocity and money per capita differ substantially across states: states are not simply miniature replicas of the U.S. We therefore think that we can learn something about U.S. money demand by exploiting this cross-sectional variation.

To get a feeling for the size of this cross-sectional variation, Figure 1 graphs with a solid line $\sigma_{v,t}$, the unweighted, cross-sectional standard deviation for the log MX1 **velocity** for every year between 1929 and 1990, for the 48 states. We note that this simple measure of dispersion is very high during the Depression and World War Two period, peaking at nearly .40 in 1933. After the Second World War dispersion diminishes steadily until the early 1970s, whilet the period 1973-1980 is one of steadily increasing $\sigma_{v,t}$. Note that dispersion is never below .20

Dispersion of log MX1 **per capita**, $\sigma_{m,t}$ is shown as a dashed line in

Figure 1.[20] The pattern is quite similar to that of MX1 velocity: the highest dispersion is in the Depression and War period. The postwar period exhibits a steady decline for $\sigma_{m,t}$ of demand deposits until the early 1970s. Again, note that dispersion never falls below .23.

Figure 2 studies the cross-sectional dispersion of our broader measure of money, MX2.[21] Velocity, shown as a solid line, is always above .21. MX2 dispersion is greatest during the Depression as we found for MX1. However, we do not find the steady decline in dispersion of MX2 velocity during 1947-1973 that we found for MX1 in Figure 1. MX2 dispersion increased during the 1970s, leaving it at .30 for the 1980s. The dashed line in Figure 2 is the cross-sectional dispersion of MX2 per capita - a series which closely parallels its MX1 counterpart.

A dispersion of .2 to .4 is large. The U.S. aggregate time series for (log, at constant prices) MX1 per capita, for instance, has standard deviation .26 for the 1929-90 period. When the Depression-War period is excluded, the figure is .215.[22] Hence, the cross-sectional variation of log MX1 is quite comparable to the U.S. time series variation.[23] The time series dispersion of aggregate U.S. (log) MX2 velocity is a mere .14 for 1929-1990 and .08 for 1947-1990.[24]

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[20] Similarly, $\sigma_{m,t}$ is the unweighted cross-sectional standard deviation of the log MX1 per capita, again for the 48 states.

[21] There is one notable outlier in our MX2 data - Delaware experiences a unusually rapid expansion of MX2 during the 1980's.

[22] The corresponding figures for U.S. log MX1 velocity are .49 (1929-1990) and .48 (1947-1990).

[23] Time-series variation for individual states is similar to that for the U.S. as a whole. Standard deviations of (log, at constant prices) MX1 per capita range from .18 for New Jersey to .60 for Arizona and North Dakota. They are .38 on average. The corresponding figures for MX1 velocity average .45 and range from .36 for Florida, Vermont and West Virginia to .59 for Delaware.

[24] Like the U.S. aggregate, time series variation for individual states of

III. Time Series Problems & Cross-Sectional Solutions

A. Time Series Problems.

Traditionally, money demand equations have been estimated with time-series data.[25] The constant elasticity money demand equation below is a typical one used in these analyses,

$$\log m_t = a + \beta \log y_t - \delta \log R_t + \varepsilon_t \tag{1}$$

where y_t is real per-capita output, R_t is an interest rate and m_t is real money balances per capita. Several difficult issues arise in examining this specification.

First, what is the relevant interest rate? One's choice of an interest rate depends on the monetary model that one has in mind and on the concept of money employed. For example, inventory models of money demand such as Baumol (1952) and Tobin (1956) predict that the interest rate relevant for money demand is the return on an alternative, less liquid asset. For demand deposits, the appropriate asset might be treasury bills. For a broader concept, corporate bonds or equities might be appropriate.

Time-series estimates are somewhat sensitive to the choice of an interest rate. In Table Ia, we display some time-series regressions of

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MX2 is low. Excluding Delaware .40, standard deviations of (log) MX2 velocity range from .09 for Indiana, Louisiana and Tennessee to .28 for Maryland and South Dakota. They are .16 on average. The corresponding figures for (log, constant prices) MX2 per capita average .47 and range from .16 for California to .78 for South Dakota.

[25] See for instance Friedman (1959), Meltzer (1963), Laidler (1977), Goldfeld (1973) and (1976), Judd and Scadding (1982), Mankiw and Summers (1986), Lucas (1988) and Braun and Christiano (1992).

money demand using U.S. aggregates for the period 1932-1990. When the Treasure Bill rate is used and the equation is differenced, the estimated income elasticity is 1.32. Estimates change when the Treasury bill rate is replaced by Moody's AAA corporate bond rate - the elasticity falls to .94.[26]

Second, it is difficult to measure "money" consistently over time. It can be persuasively argued that 50 years ago, M1 was a good definition of money, but with technological advances and financial deregulation, a broader concept of money is more appropriate today. Although there have been some attempts to construct a consistent time series for the U.S., we believe that cross-sectional analysis can make use of a consistent definition for money.[27]

Third, how does one deal with both serial correlation of the error term and with nonstationarity? Time series estimates of (1) yield serially correlated errors. According to Lucas (1988), various correction procedures obtain "wildly erratic elasticity estimates." A related problem is the potential nonstationarity of various series.

Our Table Ia illustrates some of the problems. When a differenced money demand equation is estimated in a time series with U.S. aggregates, the income elasticity is fairly near unity.[28] Elasticities fall to less than

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[26] Sections a,b and c of Table 1 use the sum of all states' MX1 for every year. As a comparison, Table 1d runs the same regressions over the same time period as 1a using M1 (for 1959-1990 M1 is taken from the *Economic Report of the President* and from Friedman and Schwartz (1963) for 1929-1958). We note that the estimated elasticities for M1 and MX1 are similar. In particular, note that the point estimates seem quite sensitive to the choice of interest rate.

In all sections of Table 1, substituting the level of interest rates for the log does not seem to have much impact on the estimated income elasticity.

[27] As we argued in Section I, our data set contains measures of money that are consistent across states for every year. Hence, a single cross-section will not suffer, even if the definitions of money change over time.

[28] In Table 1, no attempt has been made to replicate any of the previous time series studies of money demand. In particular, we did not correct for serial correlation, we did not include lagged money has been always excluded

one half when the differenced specification is replaced by a level specification. Adding a time trend to the level specification (ie, a time trend variable is added to the RHS of (1)) delivers estimated elasticities of nearly three!

Fourth, is the money demand function stable? Many econometricians have argued that U.S. money demand is not stable, meaning that both the intercept and slope coefficients in the money demand equation are functions of time.[29] Our Tables Ib and Ic do suggest some instability. When the 1980s are dropped from the 1932-1990 sample period (Table 1b), income elasticity estimates drop from about 2.7 (in Table 1a) to about 2 when the trend specification is used. Dropping the Depression/WWII period (Table 1c) tends to increase income elasticity estimates under a differenced specification; the income elasticities here are about 1.5.

Of course, time series estimates of money demand presume that the money demand coefficients are constant. A cross-section approach would instead presume geographic similarities in money demand, at least once certain conditioning variables were held constant. The individual cross-sectional estimates can be used to test the stability of the coefficients over time.

Fifth, if the level of technology is increasing with the level of income, how do we deal with the bias that the omission of technology introduces in the estimated income elasticities? As a matter of fact, this could very well be the reason behind the apparent unstability of the time-series estimates of the income elasticity: the correlation between financial innovation and income growth may vary over time; this will

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(except for the case when we used first differences) and we did not perform any of the fancy econometric techniques usually used in this literature.

29 See Friedman and Kuttner (1992) and Braun and Christiano (1992).

introduce different degrees of bias in different time periods. Observing the unstability of the estimated elasticities, the time-series researcher may be lead to think that the true elasticities are unstable.

Finally, are there demand/supply simultaneity problems we need to worry about?

B. Three Plausible Assumptions.

If we make three plausible assumptions about regions of the U.S., we can - without having to answer these difficult questions - estimate the income elasticity of money demand using cross-sectional data.[30]

Assumption 1: the interest rate relevant for money demand - whether it is the Treasury Bill rate, AAA corporate bond rate or the return on some other asset - is the same for every state. Hence, for every cross section, the interest rate effect is subsumed in the constant term. This assumption is plausible if we think that everybody in the U.S. has access to the same capital market.

An interest rate may enter a cross-sectional money demand equation if some 'local' investment project is the relevant alternative to money. Students of regional growth have argued that there are important regional differences in rates of return to some types of capital, so that relatively poorer regions have the higher rates of return.[31]

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30 Some of the problems are solved by the mere use of state data. For instance, since states do not print their own money, the demand/supply simultaneity problem disappears. As we argued in above, our data set contains measures of money that are consistent across states for every year. Finally, in a cross section we do not need to worry about the stationarity, integration and cointegration properties of our series.

31 See Barro and Sala-i-Martin (1991) for a discussion of regions of the United States and Western Europe. Barro, Mankiw and Sala-i-Martin (1992) argue that perfect capital mobility is consistent with regional differences in income if some of the assets cannot be used as collateral. In particular, they identify human capital as a possible non-collateralizable

The omission of a regional interest rate variable, which should enter a money demand equation with a negative sign, may bias elasticity estimates upward. Econometric theory allows us to compute an upper bound on the bias. First, we suppose that a state's income y_i is a Cobb-Douglas function of its capital stock k_i and a productivity parameter A_i:[32]

$$y_i = A_i k_i^{\alpha}$$

We interpret capital k_i broadly to include not only physical capital but human capital. We apply standard analysis of omitted variable bias to compute an estimate of the bias.[33] Our estimate, .125, is an upper bound because we choose parameters so as to maximize the bias while remaining plausible.[34]

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asset.

If following Barro, Mankiw and Sala-i-Martin (1992), we think that this is the reason why we should not assume a constant interest rate across states, then we should keep in mind that the underlying theory of money demand may look like this: "people make trips to the bank and exchange human capital (which, admittedly, is not a very liquid asset) for money so they can purchase cookies and Rice Roni".

32 In principle, the capital stock determines output, not income. Barro and Sala-i-Martin (1991) have argued that the concepts are very similar at the state level.

33 Bias is defined to be the probability limit of the estimated coefficient minus the true coefficient.

34 The formula for the bias is $\delta \frac{1 - \alpha}{\alpha}$ when the productivity parameter is cross-sectionally uncorrelated with income. If productivities and incomes are positively correlated, $\delta \frac{1 - \alpha}{\alpha}$ is an upper bound. Using a cross section of the 48 states, Barro and Sala-i-Martin (1991) argue that in order to explain the slow speed of convergence across states, the capital share cannot be smaller than .8 (this would of course include human capital and other kinds of inputs that can be purposefully accumulated). If we take into account open economy considerations, the capital share needs to be closer to .9 (see Barro, Mankiw and Sala-i-Martin (1992)).

If we choose an interest rate elasticity of $\delta = .5$ and a capital share of $\alpha = .8$, the implied bias is .125. Lower interest rate elasticities or higher capital shares reduce the bias (a higher capital share allows for less cross-sectional variation of interest rates). Finally, an offsetting

Summarizing, the income elasticity of money demand can be consistently estimated without the inclusion of an interest rate variable in the quite plausible case that the interest rate relevant for money demand does not vary cross-sectionally. Even when we entertained the possibility that the relevant interest rate can have substantial cross-sectional differences, we concluded that cross-sectional estimates of the income elasticity cannot be biased by more than .125.

Assumption 2: the price level is the same in every state, or at least, it is uncorrelated with the level of income. Again, a U.S.-wide price level is subsumed in the constant term for every cross-section.

The only reason why this assumption is made is that state price level data are not available. One reasonable conjecture is that richer states tend to have gigher price levels. If this is the case, our assumption of constant regional prices would introduce a term $(1-\beta)p_i$ in the error term (where β is the true income elasticity of money demand and p_i is the price level of state i). The correlation between the explanatory variable and the error term would intoruce a bias in our estimates. If we denote the coefficient of a regression of state prices on state real income by d, the **estimated** income elasticity of money demand would be $\hat{\beta} = \beta + (1-\beta)d/(1+d)$. Note that the bias introduced by the omission is positive when $\beta<1$ and negative when $\beta>1$. Furthermore, if the true β is less than one, then the estimated β cannot be larger than one. In other words, the omission of state price levels biases the estimates of the income elasticity of money demand towards one but it never biases it by so much as to overshoot one.[35]

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effect that tends to reduce the bias includes the productivity "level" A_i.

We know of no empirical evidence which suggests that poor states tend to have higher interest rates.

[35] We will show in the empirical section that our estimated elasticities are larger than one. The above reasoning suggests that the omission of a

Assumption 3: at every point in time, the money demand functions are the same in every state. In the empirical section, we allow for the possibility of different states having different levels of technology (and, therefore, different constant terms) at a given moment in time. We impose, however, the same income elasticity for all states at a point in time.[36] In some specifications, we try to capture the differing degrees of financial sophistication by introducing the shares of income originating in the agricultural sector (this is meant to capture the possibility that technology diffuses slowly from urban to rural areas).[37] In some other specifications, we also allow for state fixed-effects.

Under our assumptions, a constant elasticity money demand equation for period t is,

$$\log M_{it} = \alpha_t + \beta_t \log Y_{it} + \phi_t z_{it} + \varepsilon_{it} \qquad i = AL, AZ, \ldots \qquad (2)$$

M_{it} is money per capita, Y_{it} is per capita income and z_{it} is a vector of state variables such as population,[38] population density, agricultural sector's share of income, or regional dummies. Nominal money is appropriate

state price variable is NOT inducing this result.

[36] We allow for these income elasticities to be different over time. In fact, we will be testing the hypothesis that these elasticities are constant over time.

[37] Agricultural areas may tend to hold more money if they tend to have lower price levels and the true income elasticity is not one. Hence, these agricultural variables may tend to hold constant the omitted state price level. We will go back to this point in section IV,B.

[38] Population is also included as an attempt to correct for any aggregation bias. The Appendix, which presumes that an equation like (2) holds for every household, shows that aggregation can result in a positive (partial) correlation of population with per capita money balances once per capita income is held constant.

if all states have the same price level since, as we already argued, the price level is subsumed by the constant term α_t.

C. Conclusions

It may be preferable to estimate money demand functions in a cross-section rather than a time series. Interest rates do not appear in a cross-sectional regression, so the econometrician can estimate the income elasticity without settling on a particular interest rate series. Money can be consistently defined in a cross-section. Our cross-section approach conveniently sidesteps some difficult time series questions, like: "Is money stable?" or "What are the time series properties of the money demand errors?" In fact, a cross-sectional analysis permits us to test the stability hypothesis.

Our cross-section approach, however, is not strictly dominant. A drawback is that currency is excluded. Another is that we are limited to an annual frequency. Our series are based on census rather than survey data, but sometimes the census counts only a subpopulation, such as FDIC-insured commercial banks. We rely on the geographical similarity of money demand functions, although we permit money demand to change over time. Finally, to the extent that state income differentials vanish slowly over time (as Barro and Sala-i-Martin (1991) show they do), then our estimates are closer to what time-series analysts call 'long-run elasticities'. Hence, our analysis is silent as far as the short-run elasticities is concerned.

Finally, there are some criteria for which time series and cross-section cannot be ranked a priori. For instance, income can have transitory components both in a time series and a cross-sectional sense. If permanent income determines money demand, then the income elasticity will be biased downwards - actual income is a noisy proxy for permanent income.[39] An opposing upwards bias would result if money is a store of value during periods of high transitory income. In light of some of our results, we will conclude that transitory components of income are not quantitatively problematic for our cross-sectional estimates of money demand.

IV. Regression Results

Our cross-sectional money demand estimates are presented in this section. We begin by showing that the income elasticity from cross-sectional univariate regressions of MX1 per capita on income per capita is stable over time and is significantly larger than one. Subsection B adds conditioning variables and finds even sharper results; our stability conclusion for the income elasticity is even stronger. Consumption elasticities are remarkably similar, although it is personal income that has the most explanatory power for money demand. Conclusions for MX1 carry over to our broader money concept MX2, at least when conditioning variables are included.

A. Cross-Sectional Estimates of Univariate Regressions.

Table II shows regression estimates of the money demand elasticity for different time periods. The dependent variable in all regressions is the log of the stock of demand deposits (MX1) per capita in year t. Column 1 includes the log of per capita income as the only regressor in each of the years. To economize on space, we plot the annual income elasticities

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[39] See Friedman (1959).

corresponding to column 1 as the solid line in Figure 3. Table 2 only reports the regressions at five years intervals. The cross sectional money demand elasticity for 1930 was 1.26 (s.e.=.10). Hence, not only is the coefficient significantly positive but it is also significantly larger than one. The number in the upper right corner of each box corresponds to the adjusted-R^2, which in this case is .78. This good fit can also be appreciated in Figure 4a. The standard error of the regression is .26.

Figures 4b, 4c, and 4d show the univariate relation between the log of MX1 per capita and the log of personal income per capita. As we can see from the adjusted R^2 reported in column 1 in Table II, the fit is not as good in 1990 as it was in 1930, but it is better than in 1970.[40] Figure 5 is a scatter plot of the log of MX1 per capita and the log of income per capita in all 62 cross-sections (1929-1990) at the same time. Time and state fixed-effects are extracted from each data point to yield an impressive picture that allows us to visualize the goodness of fit of these state money demand equations.

We note that, for all the years before 1963, the point estimates are above 1. For the period between 1963 to 1980, the point estimate falls below one but the standard error of these estimates increases substantially. In the last row of column one we report the income elasticity when we constrain it to be equal across all 62 years. The result is β=1.25 (s.e.=.02).

One of the key questions asked in the money demand literature is whether the elasticity of money demand is stable over time. We find that

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[40] Although the R-squared statistics of the cross-sectional regressions change dramatically with time, the standard errors of the regressions do not change as much. Hence, we do not report weighted least squares estimates; the WLS elasticities are very close to the OLS estimates. For example the restricted WLS income elasticity estimate for Table 2, column 2 is 1.30 (compared to 1.31 with OLS).

the F-statistic based on the null hypothesis that the β coefficients are constant across the 62 subperiods reported in Table 1 is 1.17. Such a statistic follows an F-distribution with 61 degrees of freedom for the numerator, 2852 for the denominator. The critical value at the 5% significance level is 1.32. Thus, *we cannot reject the hypothesis that the income elasticity has been stable over the long (1929-1990) sample period.*[41]

B. Adding Some Conditioning Variables

One possible reason why the coefficients of the 1960s and 1980s appear to be smaller than those of the rest of the sample (even though we just showed that we cannot reject the hypothesis that they are equal in a statistical sense) could be that the introduction of financial technologies follows a slow process of regional diffusion. Hence, at a given year, different states may enjoy different degrees of financial sophistication. To the extent that the 'high income' states tend to implement those technologies faster (maybe because they are urban states where it pays banks to introduce the technological innovations more quickly or maybe because when wages are higher, it is more costly for people to go to the bank), the coefficients on income would tend to be biased downwards. To assess this possibility, we introduce the (log of the) share of income originating in the agricultural sector as an additional regressor. We believe that the process of diffusion of financial technologies is likely to start in urban areas and slowly expand to rural areas. We expect to find, therefore, a positive association between the agricultural shares (called AGRY in Table II) and demand deposits.

Column 2 in Table II reports these results. The dashed line in Figure

41 The 10% critical value is 1.24; the null hypothesis cannot be rejected even at this level significance level.

3 plots the corresponding annual income elasticities. We find that ONLY ONE (1934) of 62 point estimates of the income elasticity is now below one while only three fall below 1.1. We also find that the agricultural share is statistically insignificant between 1929 and 1950. In 1950 it starts having a significantly positive effect on the demand for money. The positive association between AGRY and MX1 disappears in the 1980s. Under the 'slow technological diffusion hypothesis', this would suggest that between 1950 and 1980, there is a process of financial innovation that moved slowly from urban to rural areas. Hence, other things being equal, rural states tended to demand relatively more money over this period.

The interesting point, however, is that the introduction of AGRY increases the point estimate of the income elasticity for the periods when the elasticity was previously below one (column 1). This, again, is consistent with the concept of slow regional diffusion of technology being a source of bias in the univariate regressions: once we correct for it, the estimates of the income elasticity move up to their unbiased values. An alternative interpretation of the positive signs of the agricultural shares is that, because β is larger than one, the log of the 'state price level' should enter the regression with a negative coefficient. If agricultural regions tend to have lower prices levels than urban regions, we would expect variables that proxy for "degrees of ruralization" to appear with a positive sign and, once this variable is held constant, we would expect the estimated income elasticity to be relatively unbiased and larger.

The restricted elasticity in column 2 is 1.31 (s.e.=.03), significantly larger than one. The F-statistic is now .42. Thus, *the hypothesis of a stable income elasticity cannot be rejected*, even at the 10% significance level.

Another possible measure of urbanization is the population density of a state. Population density did not seem to have an important effect on the estimates of Table II. For instance, when we included it along with the variables in column 3, we found it to be insignificantly different from zero in all 62 years.[42] The income elasticity was still 1.36 (s.e.=.03), compared with 1.36 (s.e.=.03) when density is excluded. Furthermore, our previous results for agricultural shares do not change when density is included; agricultural shares have positive coefficients and are statiscally significantly greater than zero in the 1950s, 1960s and 1970s. Hence, we dropped the density variable from the rest of the analysis. We also tried regional dummies (census regions) but they appeared not to be significant once the agricultural shares were held constant.

Including fixed state effects resulted in an even higher income elasticity, one of nearly 1.5! The final two rows in Table II report the restricted income elasticity and its standard error when state dummies are included. The income elasticity is 1.45 (s.e.=.02) in the univariate case (column 1) and 1.48 (s.e.=.02) when we add the conditioning variables of columns 2 and 3.

As argued in section III, aggregation of families and firms into states may imply that a relevant variable to incorporate is the stock of people (POP) in the state. Column 3 in Table II reports the results at five year intervals. Two features are worth highlighting. First, the coefficient on log population is fairly stable over time (close to .1). Second, the coefficient on income does not change substantially. The restricted estimate is 1.36 (s.e.=.03). The F-statistic to test the stability of β over the whole sample is .69, which is below the 5% critical value of 1.32:

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42 We can reject the null hypothesis that all the coefficients on density are zero in a regression of MX1 on time effects, personal income (a single income elasticity is estimated) and density.

again, income elasticity is very stable over the years of interest.

C. New York.

It could be argued that New York City, a major world financial center, may be distorting our estimates of the income elasticity. It is true that New York State has relatively more demand deposits per capita (a large fraction of which are owned by non-New Yorkers) than the other 47 states. It is also true that for some of the years included in our sample, New York was also among the states with highest per-capita income in the country. Hence, one could think of New York as an outlier that biases our point estimates.

We re-estimated all the regressions in Table II, excluding the Empire State, and found little difference in our original estimated elasticity or the stability of the coefficients over time. For instance, the restricted point estimate when we include thc agricultural share excluding New York is 1.26 (s.e.=.02), while with New York we found a value of 1.31 (s.e.=.03). Here the F-statistic is .96, well below the 5% critical value of 1.32. When population is included, the estimate without New York is 1.31 (s.e.=.02) while with New York we found 1.36 (s.e.=.03). The F-statistic in this case is 1.20, again below the 5% critical value. Thus, our conclusions about the magnitude and stability of the income elasticity are not driven by the influence of New York.

D. Do the Data Prefer Consumption or Income?

We now use retail sales as a measure of consumption to analyze an alternative scale variable. Mankiw and Summers (1986) estimate time-series money demand equations and argue that consumption is a better scale variable than income, because it more accurately reflects permanent income.

As mentioned in section 1, the census of retail businesses is not conducted every year. In order to achieve comparability, the first column of Table III runs the money demand regressions with the log of personal income per capita as the scale variable for the years where retail sales are available. As we found in Column 1 of Table II, the coefficient is stable over the whole sample with a restricted estimate of 1.28 (s.e.=.04). The F-statistic is 1.4, below the 5% critical value of 1.79. Column 2 of Table III substitutes consumption, C (or retail sales per capita) for personal income as the scale variable. We observe that the consumption elasticity is estimated to be above one for all periods before 1972. The point estimate falls and the standard error increases after that date. The restricted point estimate over the whole sample period is 1.26 (s.e.=.06). A test of the stability of the coefficients fails to reject the hypothesis that they are stable over time. Hence, consumption also seems to be a good scale variable.

A key question posed by Mankiw and Summers (1986) is: which of the two scale variables do the data prefer? We can answer this question by putting them in the same regression. If we restrict the coefficients of both consumption and income over time, we find that the coefficient on income is 1.30 (s.e.=.08) and the one on consumption is not significant (-.03, s.e.=.10). Thus, unlike the time-series findings of Mankiw and Summers (1986), if we allow our data to choose between consumption and income, the latter is chosen.

E. A Broader Definition of Money

Table IV reproduces Table II except that the dependent variable is MX2 (total deposits) rather than MX1 (demand deposits). Column 1 in Table IV shows the univariate relations between the log of total deposits per capita and the log of personal income per capita. The coefficients, plotted as the solid line in Figure 6, fluctuate between .34 for 1956 and 1.51 for 1935. The restricted point estimate is 1.24 (s.e.=.02), which is statistically different from one. The F-statistic for the test of stability of coefficients is 2.52, higher than the 5% critical value of 1.32. Thus, the univariate cross sectional regressions from MX2 are NOT stable over time.

In Column 2, we include the agricultural share (AGRY) as an explanatory variable. All the point estimates for β, which are plotted as the dashed line in Figure 6, lie above one except for five (in 1983-87). The restricted coefficient is 1.30 (s.e.=.02) and the F-statistic is .63. Hence, *we cannot reject the hypothesis that the MX2 elasticity is 1.30 for the years 1929-1990.*

Column 3 adds the stock of population (POP) as a regressor. The estimated money demand elasticity is now 1.37 (s.e.=.02), and we cannot reject the hypothesis of stability over the sample period. Hence, as in Table II, the inclusion of the population variable does not add much in terms of changes in the results.

The inclusion of state effects tends to increase the estimated income elasticity - as it did for MX1. The final two rows of Table IV display the estimated income elasticities and their standard errors when state effects are included in addition to time effects. Our estimates are nearly 1.5, regardless of the inclusion of population or an agricultural variable. It is notable that - if both state and time effects are included - we estimate an income elasticity of 1.5 for BOTH money concepts.

Table V replicates Table III to incorporate consumption into the analysis. In the first column we report the individual cross- sectional regressions when personal income is used as a scale variable. The years used correspond to the years where the consumption variable is available.

Because we rejected the hypothesis of stability of the income coefficients in the univariate case (Column 1, Table IV), we estimated each regression with the agricultural shares and the population variables. All the point estimates of the elasticity of money with respect to income are larger than one. The restricted coefficient is 1.42 (s.e.=.04). The hypothesis that the elasticities are stable over time cannot be rejected at the 5% level.

Column 2 repeats the exercise with consumption as the relevant scale variable. The conditioning variables and the time periods are otherwise identical to those in Column 1. The point estimates for the consumption elasticity are significantly larger than one for every year until 1977. The point estimate drops below one in 1977 and remains below one throughout the 1980s. The restricted estimate is 1.27 (s.e.=.08), but the F- statistic is 1.91, slightly above the 5% critical value, 1.79. Hence, the stability of the consumption elasticity for MX2 (total deposits) is rejected.

When we introduce both consumption and income in the same panel set. we find that the restricted point estimate for income is 1.37 (s.e.=.16) and the one for consumption is -.03 (s.e.=.17). Hence, the data seem prefer income, not consumption, as the scale variable in the MX2 demand equation.

E. Conclusions from the Empirical Analysis.

A number of lessons arise from this empirical work. First, the income elasticity of both MX1 and MX2 has been very stable between 1929 and 1990. Second, the estimated elasticity is substantially higher than unity (and close to 1.3-1.5) for both measures of money. Given the small size of the standard errors, these elasticities are significantly larger than one. Third, the relevant scale variable is income, not consumption. Our estimated consumption elasticities, however, do not differ much from those for personal income. Finally, the inclusion of state effects in addition to the time effects yields very similar income elasticity estimates (of nearly 1.5) for both money concepts. This final conclusion is robust to the inclusion of agricultural and population variables.

Our finding of such a high income elasticity is not new. Milton Friedman (1959) argued that U.S. secular trends in real balances and income during the period 1870-1954 suggested an income elasticity of 1.8. He noted that transitory fluctuations in income could lead to two biases of an estimated income elasticity. First, to the extent that money demand depends on permanent income, income elasticities are biased down. Our results suggest that the quantitative importance of this bias is minimal; "income elasticities" and "consumption elasticities" were quite similar.

Friedman noted a second potential bias: income elasticities are biased upward to the extent that money balances absorb transitory income fluctuations. He conjectured that such effects would be important only at very high frequencies, not at annual frequencies. Our answer to this criticism is twofold. First, demand deposits may have been an important "shock absorber" fifty years ago but by the 1980'stechnological advances should have motivated people to absorb shocks with other assets, such as savings accounts or money market funds. If the "shock absorber" bias was ever important, technological advances should have the effect of reducing the bias and introducing a downward trend in the income elasticity. But we found the income elasticity to be stable over the 1929-1990 period! Second, the tendency to absorb transitory income shocks should be even greater for broader definitions of money; the upward "shock absorber" bias should be stronger for MX2 than for MX1. But we estimated very similar income elasticities for MX1 and MX2. If anything, the MX2 elasticity was *lower*! Thus, we do not think that our high income elasticities are a statistical artifact.

V. Isolating Money Demand Shifts

With an estimate of the income elasticity in hand, one can quantify any money demand shifts that may have occurred during our sample period. The first step is to obtain the estimated time effects, which we denote as α_t in (2), from one of our panel money demand regressions. In years when the time effect is large, we say that a typical state had a relatively strong demand for nominal money balances, given its nominal income.

Since our estimated income elasticity is statistically larger than one, the second step is to correct these time effects for inflation and nominal interest rates so that we can study the shifts of a real money demand function. According to our equation (2), and given the assumptions we made in Section II, the estimated constant term in a cross section for year t is given by:

$$\alpha_t = a_t + (1-\beta) \ln CPI_t - \delta \ln R_t \quad (3)$$

where a_t is some factor that determines the real demand for money (which we identify with technology). Equation (3) would allow us to compute a time series for the real money demand factor α_t if we had an estimated interest elasticity, δ. However, we begin by removing only the term $(1-\beta)\ln CPI_t$ from the time effects.[43] Figure VIIa shows these deflated time effects estimated in the column (2) system of Tables 2 and 4. The solid line, from Table 2, corresponds to MX1 while the dashed corresponds to MX2. We notice that the money demand functions for MX1 and MX2 experienced quite similar

[43] This is equivalent to assuming that (like in the quantity theory) money demand is interest inelastic (δ=0).

shifts during the first half of our sample period. There was a sharp downward shift from 1929-1933 which was offset by 1939. World War II coincided with a very dramatic upward shift. During the 1950's, both money demand functions shifted downward at about one to two percent per year. MX1 continued shifting at this rate until the early 1970's. After a small increase in 1971-1972, the decline continued at about the same rate until the late 1970s. In the 1980s, there is a dramatic change in trend: the slope changes from 1.5% to 13%!.

MX2, on the other hand, experienced a steady increase in the 1950s that lasted until the mid-1980's. There was a sharp decline between 1985 and 1990.

We fail to find a noticeable decline of either monetary aggregate during the mid-1970's - the era of "missing money". We do not understand why our cross-section analysis fails to find any money missing in the mid-1970s while the time series analysis of Goldfeld (1976) does. We offer three (admittedly unsubstantiated) conjectures. First, the time series estimates tend to be biased downwards. If one is equipped with a small income elasticity, then one tends to overpredict money during recessions. Hence, the money was perceived to be "missing" during the recession of the mid-1970s. Second, the dynamic specification used by Goldfeld may lead him to predict that the small 'blip' that occurred in 1970-71 (we can see that the net constant terms for MX1 suffer a small shift in the beginning of the 1970s) would be maintained for a while longer.

Figure VIIa fails to account for the time series behavior of nominal interest rates. In order to obtain estimates of the real money demand factor a_t we need a value for the interest rate elasticity δ and subtract the product of such elasticity times the nominal interest rate. Time series estimates of (3) delivered a variety of interest elasticities ranging from 0 to .95, depending on the interest rate used, the sample period and whether (3) included a time trend or was differenced. Moody's AAA corporate bond index (in logs) fitted the best and yielded an interest elasticity of .4 in the full sample and .2 during the postwar period.

In Figure VIIb we graph the time series of constants once we subtract the price level effect and the interest rate effect for two different values of δ, namely δ=.25 and δ=0. In other words, we graph a time series of $\tilde{a}_t=\alpha_t-(1-\beta)\ln(CPI_t)+\delta\ln(R_t)$, where β is the income elasticity estimated in previous sections and where δ takes the value δ=.25 for the solid line and δ=0 for the dashed line. Fortunately, our main conclusion about the dramatic change in trend from the 1970s to the 1980s is robust to any interest elasticity between 0 and .4. The changes in nominal interest rates cannot explain the shift that occurred in the 1980s. In fact, the late 1980's - when nominal interest rates fell - looks no different than the early part of the decade. Figure VIIb also reveals that the magnitude of the trend between 1947 and 1970 is sensitive to the interest elasticity, but the trend for the 1980s is not.

Figure VIIa shows that a broader monetary aggregate did not exhibit such a dramatic downward shift in its demand function in the 1980s. We suspect that much of the MX1 shift must have been shifts out of traditional demand deposits in to other types of deposits.[44]

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[44] We argued in Section I that the main difference between our measure MX1 and the conventional M1 was that the latter included NOW accounts and other checkable deposits. In Appendix Figure A1 we saw that the two series behaved very differently in the 1980s: while MX1 fell between 1980 and 1985, M1 rose and the sharp increase in M1 in 1986 contrasted with only a moderate increase in MX1.

This, of course, could be the reason why the time trend of a_t's changed so dramatically between the 1970s and the 1980s. Unfortunately, our current data set does not allow us to distinguish between this and other forms of technological innovations that may have occurred during the same period. We are in the process of gathering the data that will allow us to

VI. Conclusions and Directions for Future Research.

We found four main empirical results. First, the income elasticity of money demand is significantly larger than one and somewhere between 1.3 and 1.5. Estimates of this magnitude were found both for a fairly narrow concept of money - demand deposits - as well as for a broader concept. Second, the income elasticity was remarkably stable over the 1929-1990 period - a period that included the Great Depression, World War II and the Reagan-Volcker years. Third, personal income was a better scale variable than consumption. And fourth, money demand *shifted* considerably during the period, even after allowing for the effects of interest rate and price level movements. The shifts were never substantial on a year-to-year basis but did accumulate over the 62 year period. More importantly, despite these continuous shifts, the income elasticty remained stable over the whole sample period. This leads to conjecture that the reason why time-series researchers find that the income elasticities are unstable over time is that the correlation between technological progress and income growth changes over time. This introduces time-varying biases in the estimated income elasticities which lead the researcher to believe that the true elasticities are unstable when they are not.

These findings have a number of implications for economic theory and policy. That money demand "is a highly stable function of a limited number of variables" is important for monetary policy. We have provided some

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answer this and other interesting questions.

We should note, however, that this cannot explain why time-series studies tend to find unstable income elasticities while we do not. If anything, our narrower measure of money should be more, not less, unstable.

remarkably strong evidence on this point. The fact that income elasticities are stable and that the growth rate of the constant seems to behave quite smoothly suggests that the targeting of monetary aggregates may constitute a viable policy. Furthermore, Keynesian economists may want to argue that other policy implications come from the fact that our estimates of the income elasticity are high: this suggests that monetary policy is relatively more potent than fiscal policy, as the 'LM curve' is relatively steep.

Our high estimates of the income elasticity of money demand pose a challenge for economic researchers. Milton Friedman (1959) insisted that an income elasticity greater that unity was difficult to reconcile with "transactions" theories of money demand, since he proclaimed that "it is dubious that there has been any secular increase in the ratio of transactions to income."[45] If Friedman was correct, then we need a theory of money demand that predicts that real balances are highly sensitive to the volume of transactions.[46]

Without trying to develop them in any detail, we want to finish by conjecturing three possible explanations for these high elasticities. The first explanation would suggest that the process of economic development and growth is associated with a larger number of vertically disintegrated firms (using more complicated technologies with more varieties of inputs and having to interact with a larger number of suppliers). To the extent that firms need money to transact with other firms but not to transact with themselves, higher level of income will be associated with a more than proportionally higher level of money demand.

45 Friedman (1959) p. 136.

46 Friedman's story was that monetary services are a luxury good.

A second explanation could be that richer economies tend to have more firms that use relatively more money. One example of such firms are financial institutions. If the process of economic development is associated with an increasing relative importance of these financial institutions, higher income will be associated with more than proportionally higher demand for money.

Note that these two explanations work at the firm level. An explanation that works at the household level is given by Mulligan and Simpson (1992). They insist that, within the family, there are economies of scale in the use of money: larger families tend to use less money per person than smaller ones. Using a stochastic model of optimal fertility and marriage choice, Mulligan and Simpson (1992) show that substitution effects dominate in the determination of the number of children while wealth effects dominate the decision to divorce. In a sense, children are an inferior good while divorce is a luxury good. With this in mind, they show that higher income is associated with less children, more divorce and, consequently, smaller families and larger demand for money. It follows that the income elasticity in such a clever stochastic model of money demand and divorce is larger than one.[47]

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[47] The alert reader will realize the important implications of this theory. For example, it makes clear that the Republican Party's recent emphasis on family values is not based on political propaganda. It is, in fact, the economic agenda of President Bush: the elimination of Murphy Brown-type single parenthood, divorce, and abortion will tend to increase the size of the family. This, in turn, will reduce aggregate money demand which, because of the equilibrium in the money market, will put upward pressure on the price level. The well known properties of the Phillips curve, will put an end to the 1991-92 recession. Hence, we find that those who claim that President Bush lacks a clear economic agenda base their criticisms on totally unsubstantiated grounds.

Table I
Some Time Series Estimates with U.S. MX1 Aggregates

Table Ia. 1932-1990

Trend Method	Interest Rate	Income Elasticity		Interest Elasticity	
Differenced	None	1.04	(.18)	--	
	Tbill	1.32	(.18)	-.04	(.01)
	Commer'l Paper	1.11	(.16)	-.09	(.03)
	AAA	0.94	(.14)	-.38	(.07)
Trend	None	2.71	(.24)	--	
	Tbill	2.66	(.03)	.03	(.02)
	Commer'l Paper	2.80	(.25)	.06	(.05)
	AAA	2.11	(.23)	-.34	(.07)
Level	None	-.01	(.08)	--	
	Tbill	0.02	(.15)	-.01	(.04)
	Commer'l Paper	0.42	(.15)	-.22	(.06)
	AAA	0.47	(.12)	-.65	(.06)

Table Ib. 1932-1979

Trend Method	Interest Rate	Income Elasticity		Interest Elasticity	
Differenced	None	0.97	(.16)	--	
	Tbill	1.21	(.16)	-.04	(.01)
	Commer'l Paper	1.03	(.15)	-.08	(.03)
	AAA	0.88	(.14)	-.38	(.08)
Trend	None	2.12	(.20)	--	
	Tbill	2.13	(.20)	-.01	(.02)
	Commer'l Paper	1.88	(.23)	-.09	(.05)
	AAA	1.35	(.12)	-.43	(.04)

Table Ic. 1947-1990

Trend Method	Interest Rate	Income Elasticity		Interest Elasticity	
Differenced	None	1.25	(.35)	--	
	Tbill	1.68	(.33)	-.08	(.02)
	Commer'l Paper	1.73	(.33)	-.10	(.03)
	AAA	1.34	(.28)	-.31	(.06)
Trend	None	2.76	(.31)	--	
	Tbill	2.66	(.33)	.03	(.03)
	Commer'l Paper	2.69	(.34)	.02	(.04)
	AAA	2.83	(.34)	-.03	(.07)

Table Id. Using M1 Aggregates. 1932-1990

Trend Method	Interest Rate	Income Elasticity	Interest Elasticity
Differenced	None	.91 (.20)	--
	Tbill	1.42 (.16)	-.07 (.01)
	Commer'l Paper	1.04 (.17)	-.11 (.02)
	AAA	0.84 (.16)	-.35 (.07)
Trend	None	2.32 (.21)	--
	Tbill	2.38 (.02)	-.04 (.02)
	Commer'l Paper	2.08 (.19)	-.15 (.04)
	AAA	1.50 (.13)	-.46 (.04)

Notes to Table I:

The dependent variable is (the log of) our measure of demand deposits summed over the 48 states and is differenced when applicable. The income variable is personal income summed over the 48 states.

Standard errors are in parentheses. Trend method denotes any transformations of regression (1) in the text. "Trend" means that a time trend was included on the RHS. "Differenced" denotes that (1) was estimated in first differences. "Level" denotes no transformation.

MX1 and personal income are converted to constant price using the U.S. implicit price deflator for personal consumption expenditures.

The frequency is annual.

All interest rates are in logs. A level specification for the interest rate seems to make a difference to the income elasticity in only one instance.

Table II
MX1 Demand Shifts, but the Income Elasticity does not

Year	(1)		(2)		
	ln(Y) (s.e.)	R^2 s.e.	ln(Y) (s.e.)	AGRY (s.e.)	R^2 s.e.
1930	1.26 (.10)	.78 .26	1.15 (.14)	-.07 (.06)	.79 .26
1935	1.44 (.12)	.74 .29	1.37 (.20)	-.04 (.09)	.74 .29
1940	1.42 (.13)	.73 .31	1.33 (.19)	-.05 (.08)	.73 .31
1945	1.31 (.17)	.57 .28	1.48 (.20)	.08 (.05)	.58 .05
1950	1.32 (.16)	.59 .26	1.50 (.18)	.10 (.05)	.62 .25
1955	1.11 (.18)	.45 .27	1.37 (.22)	.11 (.05)	.49 .26
1960	1.14 (.19)	.44 .25	1.42 (.21)	.11 (.05)	.49 .24
1965	.90 (.20)	.29 .24	1.20 (.36)	.10 (.04)	.36 .23
1970	.81 (.20)	.24 .22	1.12 (.24)	.09 (.04)	.31 .21
1975	.91 (.25)	.20 .23	1.16 (.24)	.10 (.03)	.36 .20
1980	.92 (.30)	.16 .27	1.26 (.31)	.11 (.04)	.25 .25
1985	1.15 (.21)	.38 .22	1.24 (.24)	.03 (.04)	.37 .22
1990	1.31 (.23)	.40 .25	1.37 (.26)	.02 (.04)	.39 .25
constr.	1.25 (.02)	-- --	1.31 (.03)	-- --	-- --
	F=1.17		F=.42		
constr. & state effects	1.45 (.02)	-- --	1.48 (.02)	-- --	-- --

Table II Cont

Year	(3)			
	ln(Y) (s.e.)	AGRY (s.e.)	ln(POP) (s.e.)	R^2 s.e.
1930	1.27 (.14)	.01 (.07)	.10 (.04)	.81 .25
1935	1.51 (.19)	.04 (.09)	.11 (.04)	.78 .27
1940	1.53 (.18)	.06 (.08)	.14 (.04)	.77 .28
1945	1.59 (.19)	.14 (.05)	.11 (.04)	.63 .26
1950	1.57 (.17)	.15 (.05)	.09 (.04)	.66 .24
1955	1.44 (.21)	.16 (.06)	.09 (.04)	.54 .24
1960	1.46 (.20)	.15 (.05)	.09 (.04)	.54 .23
1965	1.18 (.21)	.13 (.04)	.08 (.03)	.42 .22
1970	1.08 (.23)	.11 (.04)	.06 (.03)	.35 .20
1975	1.10 (.23)	.12 (.03)	.07 (.03)	.41 .20
1980	1.17 (.31)	.12 (.04)	.06 (.04)	.28 .25
1985	1.06 (.24)	.04 (.04)	.09 (.03)	.46 .21
1990	1.21 (.25)	.04 (.04)	.10 (.04)	.47 .24
constr.	1.36 (.03)			
	F=.69			
constr. & state effects	1.48 (.02)			

Notes to Table II:

Column 1 includes the log of personal income per capita as the only independent variable.

Column 2 adds the log of the share of agricultural income in personal income (see text for sources).

Column 3 includes personal income per capita, agricultural shares and the log of population as independent variables.

A constant for each year (not shown in the Table) is estimated in all regressions.

The F-test is based on the null hypothesis that the β coefficients are the same across all 62 years. The .05 critical value with 61 degrees of freedom for the numerator and more than 1000 for the denominator is 1.32. The 10% critical value is 1.24.

The rows labelled "constr. & state effects" report income elasticities and their standard errors when a constant is estimated for each state as well as for each year, while a single income elasticity is estimated. As above, coefficients on AGRY and POP are not restricted over time.

Table III
Retail Sales and Income Elasticities are Similar

Year	(1)		(2)	
	ln(Y) (s.e.)	R^2 s.e.	ln(C) (s.e.)	R^2 s.e.
1929	1.37 (.09)	.83 .22	1.46 (.14)	.69 .30
1935	1.44 (.12)	.74 .29	1.25 (.17)	.55 .39
1939	1.39 (.13)	.72 .30	1.28 (.17)	.53 .39
1948	1.38 (.17)	.57 .26	1.24 (.18)	.50 .29
1954	1.16 (.18)	.47 .27	1.39 (.21)	.48 .27
1958	1.19 (.19)	.44 .26	1.39 (.23)	.43 .26
1963	1.00 (.19)	.36 .24	1.28 (.25)	.36 .24
1967	0.90 (.21)	.28 .24	1.21 (.29)	.36 .23
1972	0.90 (.21)	.26 .21	0.81 (.35)	.08 .23
1977	0.82 (.27)	.15 .24	0.41 (.36)	.01 .26
1982	1.11 (.25)	.28 .23	0.65 (.34)	.27 .05
1989	1.33 (.21)	.46 .24	0.86 (.32)	.12 .31
constr.	1.28 (.04)		1.26 (.06)	
	F=1.40		F=1.14	

Notes to Table III:

Column 1 includes the log of personal income per capita as the only regressor. The difference from column 1 of Table II is that here we include only the years for which retail sales are available so as to achieve comparability.

Column 2 includes retail sales only.

The F-test is based on the null hypothesis that the β coefficients are the same across the 12 sub-periods. It follows an F-distribution; the .05 critical value with eleven degrees of freedom is 1.79. The 10% critical value is 1.58.

Table IV
MX2 Regressions

Year	(1)			(2)		
	ln(Y) (s.e.)	R^2 s.e.		ln(Y) (s.e.)	AGRY (s.e.)	R^2 s.e.
1930	1.27	.88		1.27	-.00	.87
	(.07)	.19		(.10)	(.05)	.26
1935	1.51	.83		1.39	-.06	.83
	(.10)	.24		(.16)	(.07)	.24
1940	1.39	.80		1.27	-.06	.80
	(.10)	.25		(.15)	(.06)	.25
1945	1.32	.63		1.43	.05	.63
	(.15)	.24		(.17)	(.05)	.24
1950	1.31	.69		1.45	.08	.71
	(.13)	.21		(.14)	(.04)	.20
1955	1.12	.54		1.40	.11	.59
	(.15)	.23		(.18)	(.05)	.22
1960	1.16	.52		1.42	.11	.57
	(.16)	.22		(.18)	(.04)	.21
1965	1.06	.37		1.37	.10	.44
	(.20)	.24		(.22)	(.04)	.23
1970	.82	.23		1.29	.13	.38
	(.21)	.23		(.23)	(.04)	.21
1975	.97	.20		1.21	.09	.32
	(.27)	.24		(.26)	(.04)	.23
1980	.66	.08		1.05	.12	.22
	(.30)	.27		(.30)	(.04)	.25
1985	.40	.02		.83	.14	.17
	(.28)	.29		(.30)	(.05)	.27
1990	.85	.14		1.11	.08	.18
	(.29)	.31		(.32)	(.05)	.31
constr.	1.24	--		1.30	--	--
	(.02)	--		(.02)	--	--
	F=2.52			F=.63		
constr. & state effects	1.45	--		1.49	--	--
	(.02)	--		(.02)	--	--

Table IV (cont)

Year	ln(Y) (s.e.)	AGRY (s.e.)	ln(POP) (s.e.)	R^2 s.e.
	(3)			
1930	1.36 (.11)	.05 (.05)	.07 (.03)	.89 .18
1935	1.52 (.15)	.00 (.07)	.10 (.03)	.86 .22
1940	1.47 (.14)	.04 (.06)	.14 (.03)	.85 .21
1945	1.56 (.15)	.13 (.04)	.13 (.03)	.73 .21
1950	1.53 (.13)	.12 (.04)	.09 (.03)	.76 .19
1955	1.46 (.17)	.16 (.05)	.08 (.03)	.63 .20
1960	1.45 (.18)	.14 (.04)	.06 (.03)	.60 .23
1965	1.36 (.22)	.13 (.04)	.07 (.03)	.48 .22
1970	1.25 (.23)	.14 (.04)	.06 (.03)	.41 .20
1975	1.17 (.26)	.10 (.03)	.05 (.03)	.33 .22
1980	1.01 (.31)	.12 (.04)	.02 (.04)	.21 .25
1985	.87 (.31)	.13 (.05)	-.02 (.04)	.15 .27
1990	1.20 (.32)	.07 (.05)	-.07 (.05)	.19 .19
constr.	1.37 (.02)			
	F=.73			
constr. & state effects	1.48 (.02)			

Notes to Table IV:

Column 1 includes the log of personal income per capita as the only independent variable.

Column 2 adds agricultural shares.

Column 3 includes personal income per capita, agricultural shares and the log of population as independent variables.

A constant for each date (not shown in the Table) is estimated in all regressions.

The F-test is based on the null hypothesis that the β coefficients are the same across all 62 years. The .05 critical value with 61 degrees of freedom for the numerator and more than 1000 for the denominator is 1.32.

The 10% critical value is 1.24.

The rows labelled "constr. & state effects" report income elasticities and their standard errors when a constant is estimated for each state as well as for each year, while a single income elasticity is estimated.

Table V
Retail Sales and Income Elasticities are Similar for MX2

<u>Year</u>	(1)		(2)	
	ln(Y) (s.e.)	R^2 s.e.	ln(C) (s.e.)	R^2 s.e.
1929	1.47 (.11)	.89 .17	1.22 (.13)	.83 .21
1935	1.52 (.15)	.86 .22	1.09 (.16)	.78 .27
1939	1.49 (.14)	.85 .21	1.21 (.15)	.79 .25
1948	1.49 (.13)	.73 .19	1.47 (.12)	.76 .18
1954	1.47 (.15)	.67 .20	1.56 (.16)	.69 .19
1958	1.52 (.18)	.62 .20	1.63 (.18)	.65 .19
1963	1.48 (.20)	.55 .21	1.63 (.22)	.54 .21
1967	1.36 (.23)	.45 .22	1.52 (.26)	.44 .22
1972	1.29 (.26)	.36 .22	1.07 (.40)	.14 .26
1977	1.10 (.29)	.25 .23	0.58 (.38)	.06 .26
1982	1.07 (.32)	.24 .26	0.52 (.38)	.07 .29
1989	1.17 (.32)	.19 .31	0.99 (.39)	.07 .33
constr.	1.42 (.04)		1.27 (.08)	
	F = .53		LR= 1.91	

Notes to Table V:
Column 1 includes the log of personal income per capita as the only regressor. The difference between Equation 1 and Equation 4 is that the latter is only run for the years where retail sales are available, so as to achieve comparability. Column 2 includes retail sales only. All equations in this table have been estimated conditional on agricultural shares, the log of population levels and a constant (none of them are shown in the Table).

The F-test is based on the null hypothesis that the β coefficients are the same across the 12 sub-periods. It follows an F distribution; the .05 critical value with eleven degrees of freedom is 1.79. The 10% critical value is 1.58.

Appendix

Aggregation of Money Demand Functions:

Some Statistical Artifacts

This Appendix argues that when individual's money demand functions are aggregated, the error term in the aggregate money demand function depends positively on the level of population. It is also a function of the distribution of income.

We suppose that a money demand relationship like (2) holds for agent j in state i,[48]

$$\log M_{ij} - \log P = \alpha + \beta \log [Y_{ij}/P] - \delta \log R + \phi z_i + \eta_{ij} \qquad \textbf{(2)'}$$

M_{ij} is agent j's nominal balances, P is the U.S. price level, Y_{ij} is j's nominal income and R is a U.S. interest rate. z_i is a vector intended to proxy for the tendency of residents of state i to hold money (our agricultural variable is an example), and η_{ij} is household j's error term.

State i has N_i residents. We assume that the vector of random variables $\{\eta_{i1}, \eta_{i2}, \ldots, \eta_{iN_i}\}$ has joint distribution with anonymous second moments:

$$\text{var}(\eta_{ij}) = \sigma_i^2 \text{ for all } j$$
$$\text{corr}(\eta_{ij},\eta_{ik}) = \rho_i \text{ for all } j,k \text{ such that } j \neq k$$

We do not take a stand on whether j is a consumer or a firm.

We also assume that the variance of shocks is the same in every state.[49] The mean of multiplicative shocks to money demand is the same; α in (2)' is normalized.

$$E\left\{ e^{\eta_{ij}} \right\} = 1 \quad \text{for all i}$$

$$\sigma_i = \sigma \text{ for all i}$$

When (2)' is aggregated, we have an average money demand function for state i,

$$\log M_i - \log P = \alpha + \phi\, z_i + \log \left(\sum_{j=1}^{N_i} (Y_{ij}^{\beta} e^{\eta_{ij}})/N_i \right)$$

Consider the case when every individual in state i has the same income ($Y_{ij} = Y_i$) but different η shocks,

$$\log M_i - \log P = \alpha + \beta \log [Y_i/P] + \phi\, z_i + \varepsilon_i(N_i)$$
$$\varepsilon_i \equiv \log \left(\sum_{j=1}^{N} (e^{\eta_{ij}})/N_i \right)$$

M_i is state i's per capita average nominal money balances. Y_i is state 'isper capita average nominal income.

Using a Taylor approximation of order two for the logarithmic function, one finds that the expectation of ε_i depends positively on N_i,

$$E\{\varepsilon_i\} = -(1/2N_i)\, \sigma^2 (1 - \rho_i) - \rho_i\, \sigma^2/2$$

The first term depends positively on state i's population, although it

[49] Remember that σ^2 is the variance of the distribution for an *individual's* money demand shocks. We see no reason to allow for systematic differences across states.

is probably negligible as N approaches one million as it would for states.[50] However, larger states may be "more heterogeneous" - the correlation between individuals' money demand shocks may depend negatively on population.[51] The second term depend positively on the heterogeneity of the the states. To the extent that more populated states are more heterogeneous, stock of population would enter the expression for the expectation with a positively sign.

When incomes Y_{ij} differ for individuals within a state, the state's aggregate money demand function will also depend on the distribution of income within the state.

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50 Empirically, we find that including the log of population in the money demand equation fits better than including the inverse as suggested in the first term.

51 A state's area might be another good proxy for this effect.

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Figure IXa: U.S. M1 vs. Demand Deposits

Real Balances per capita 1929-1990

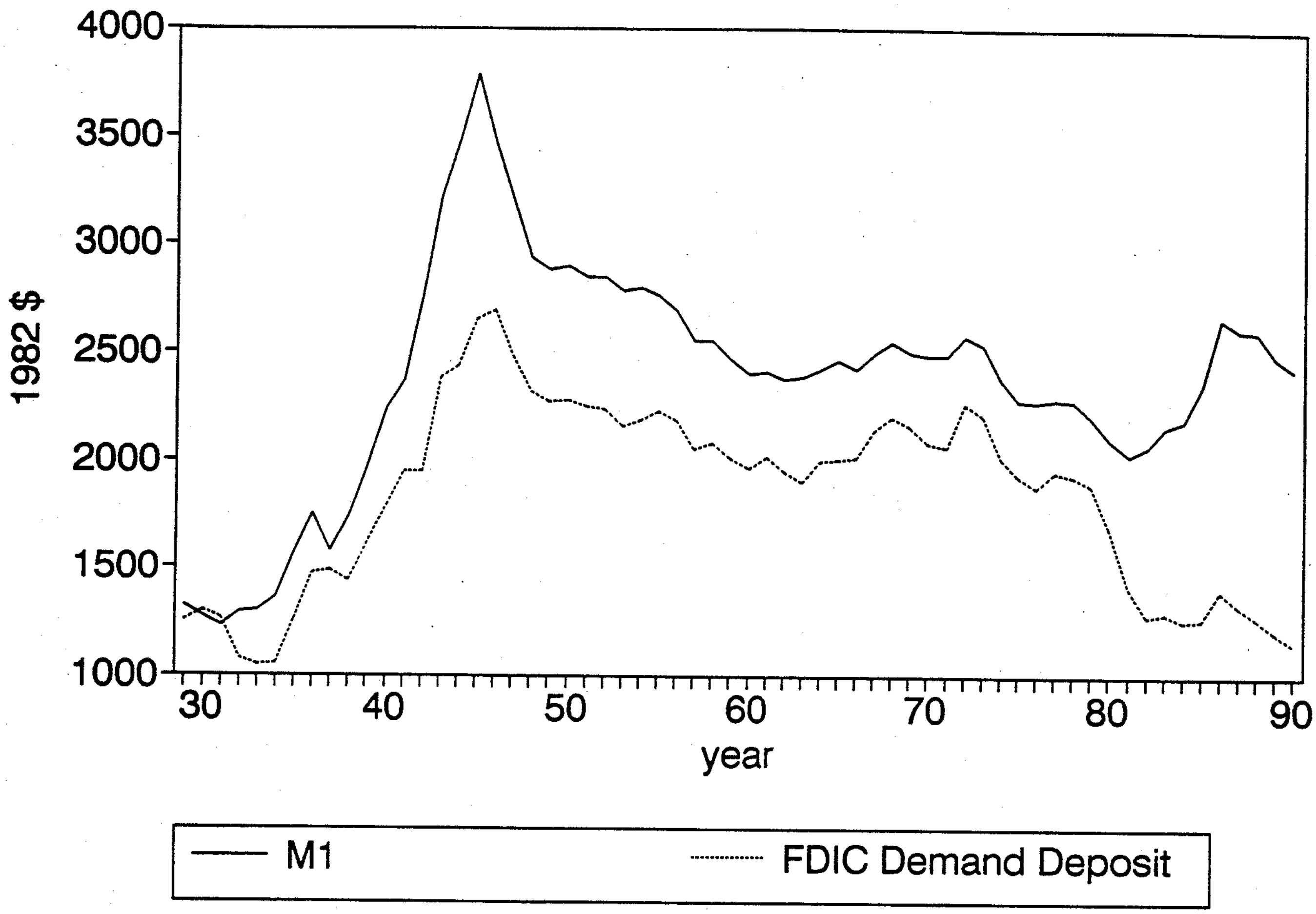
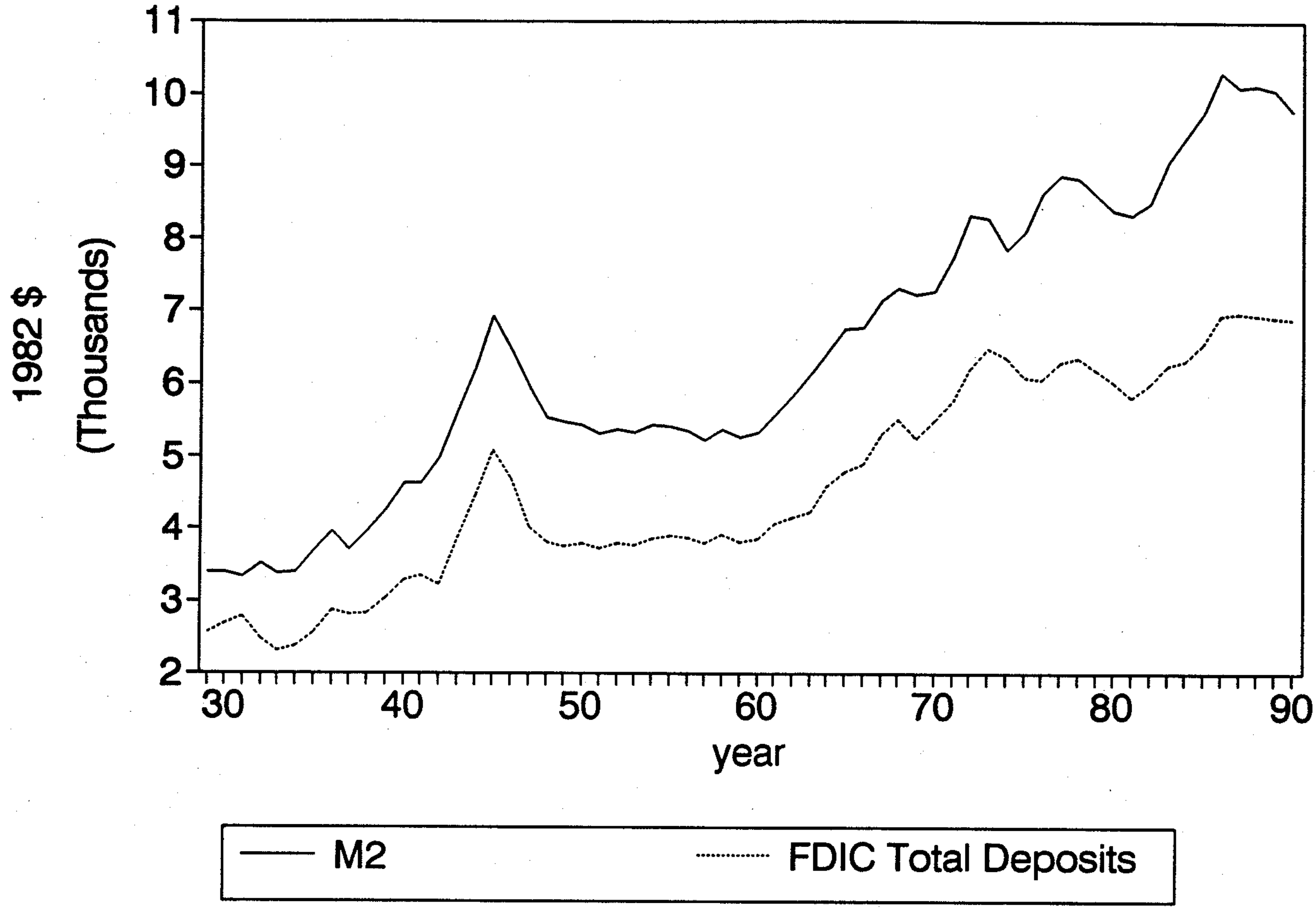


Figure IXb: U.S. M2 vs. Total Deposits

Real Balances per capita 1929-1990



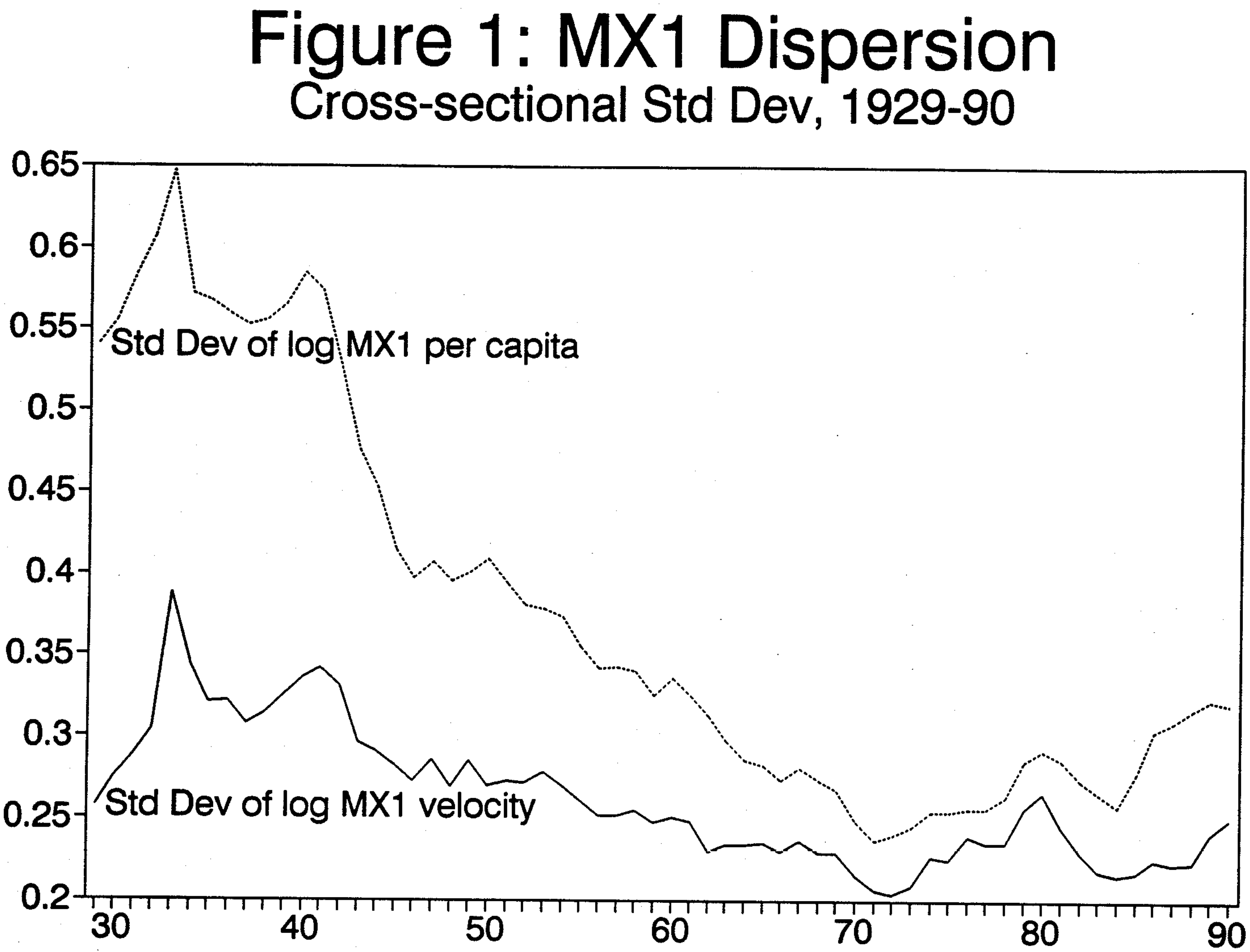


Figure 1: MX1 Dispersion
Cross-sectional Std Dev, 1929-90
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
30
40
50
60
70
80
90
Std Dev of log MX1 per capita
Std Dev of log MX1 velocity

Figure 2: MX2 dispersion

Cross-sectional Std Dev, 1929-90

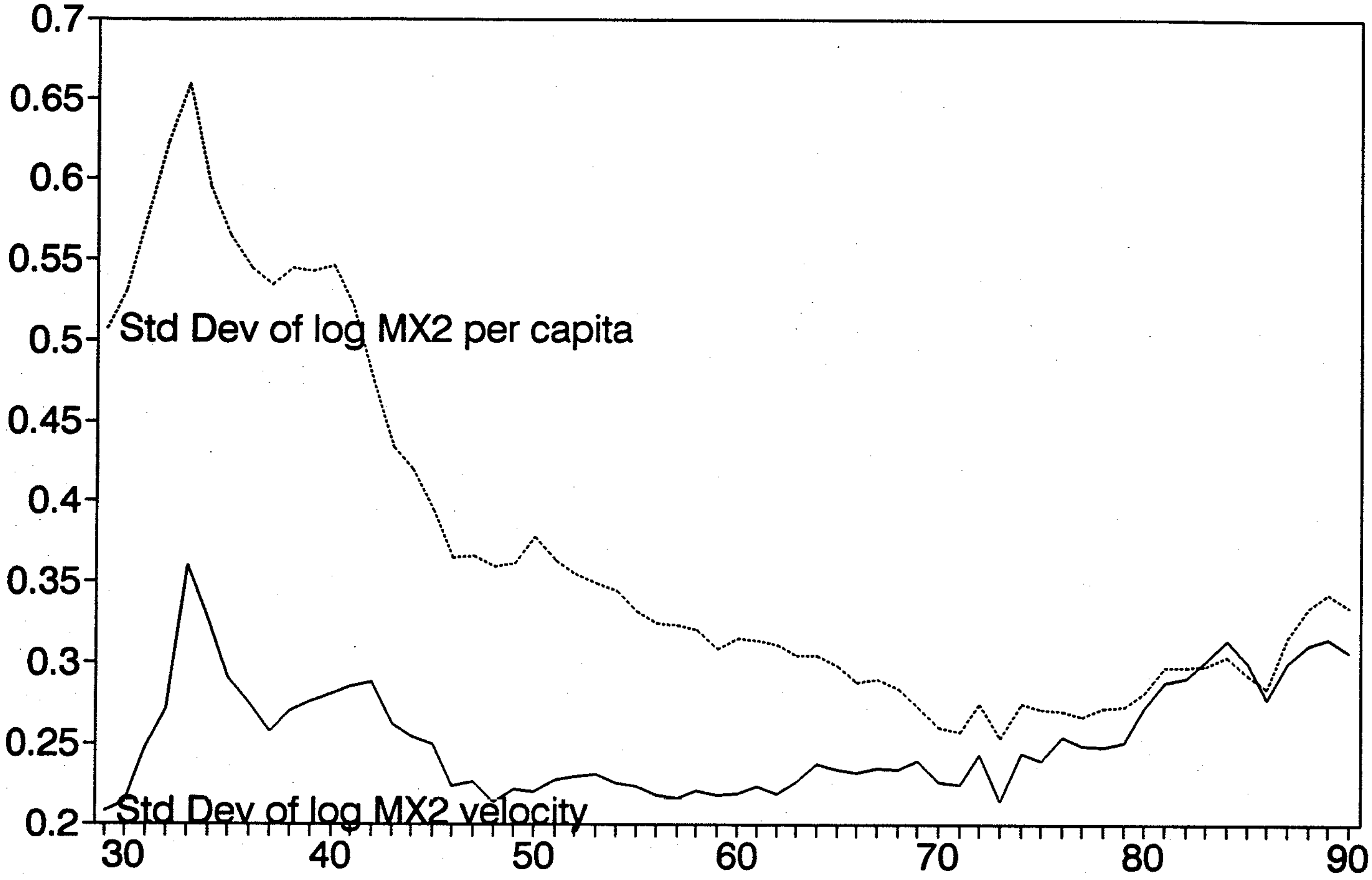


Figure 3: Table 2 estimated income elasticities

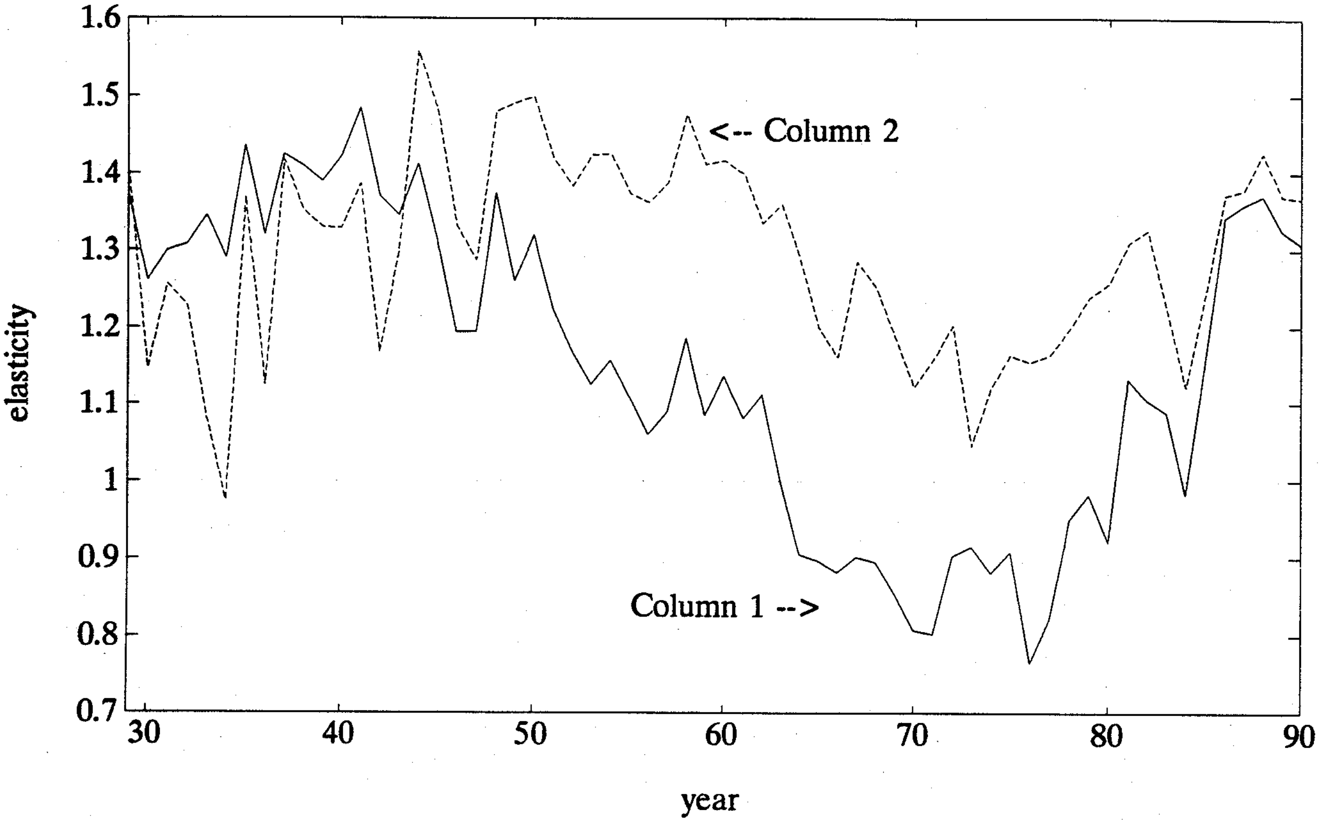


Figure 4a: MX1 and Personal Income, 1930 Cross-Section

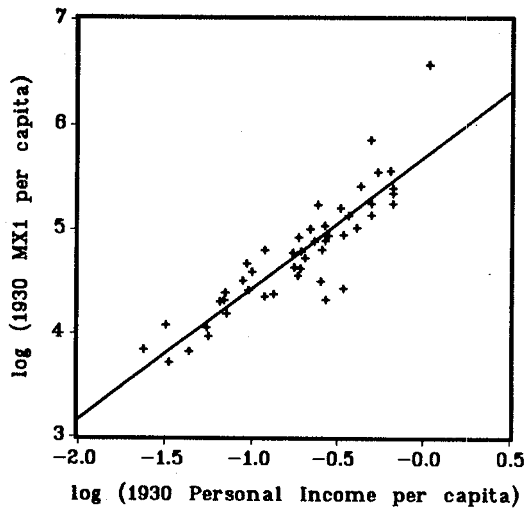


Figure 4b: MX1 and Personal Income, 1950 Cross-Section

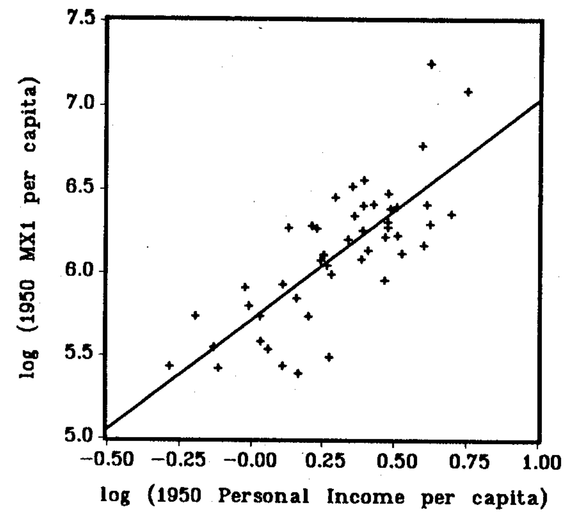


Figure 4c: MX1 and Personal Income, 1970 Cross-Section

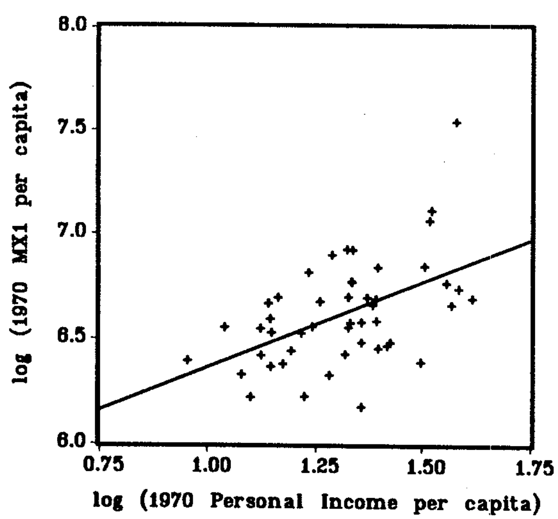


Figure 4d: MX1 and Personal Income, 1990 Cross-Section

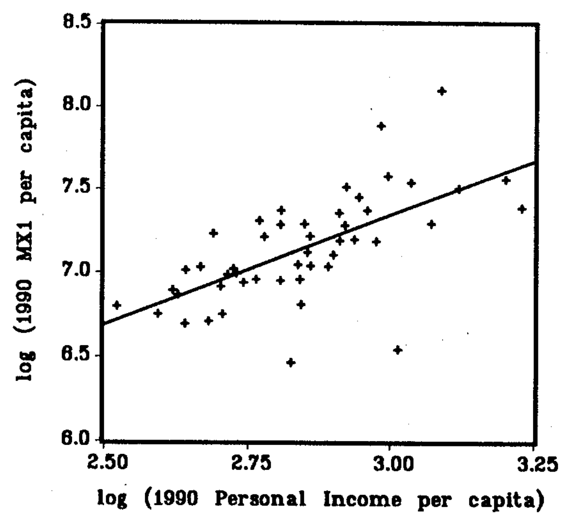


Figure 5: MX1 vs. Personal Income, 48 States & 62 Years (1929–90)

Both Series are Corrected for State and Time Effects

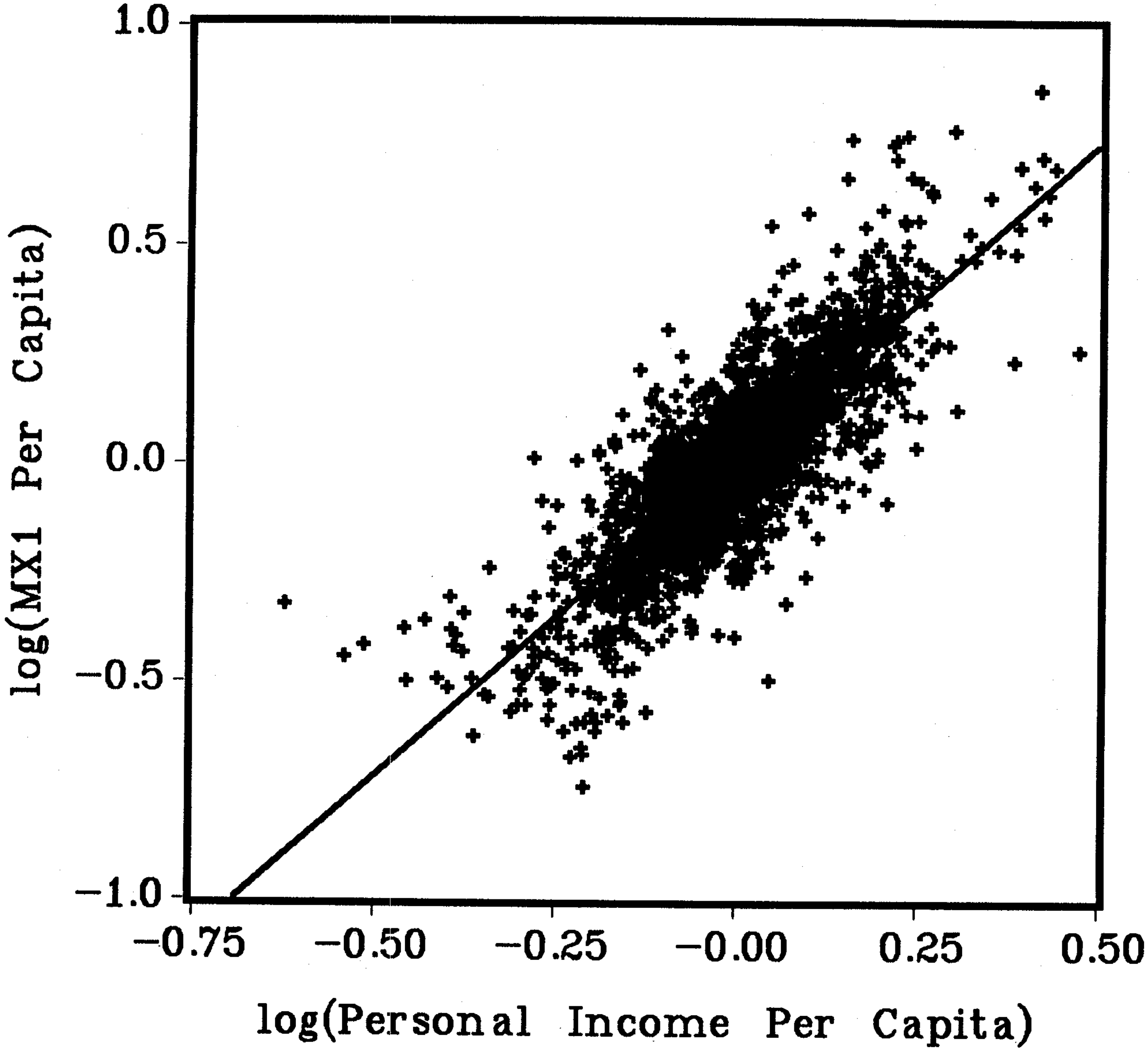


Figure 6: Table 4 estimated income elasticities

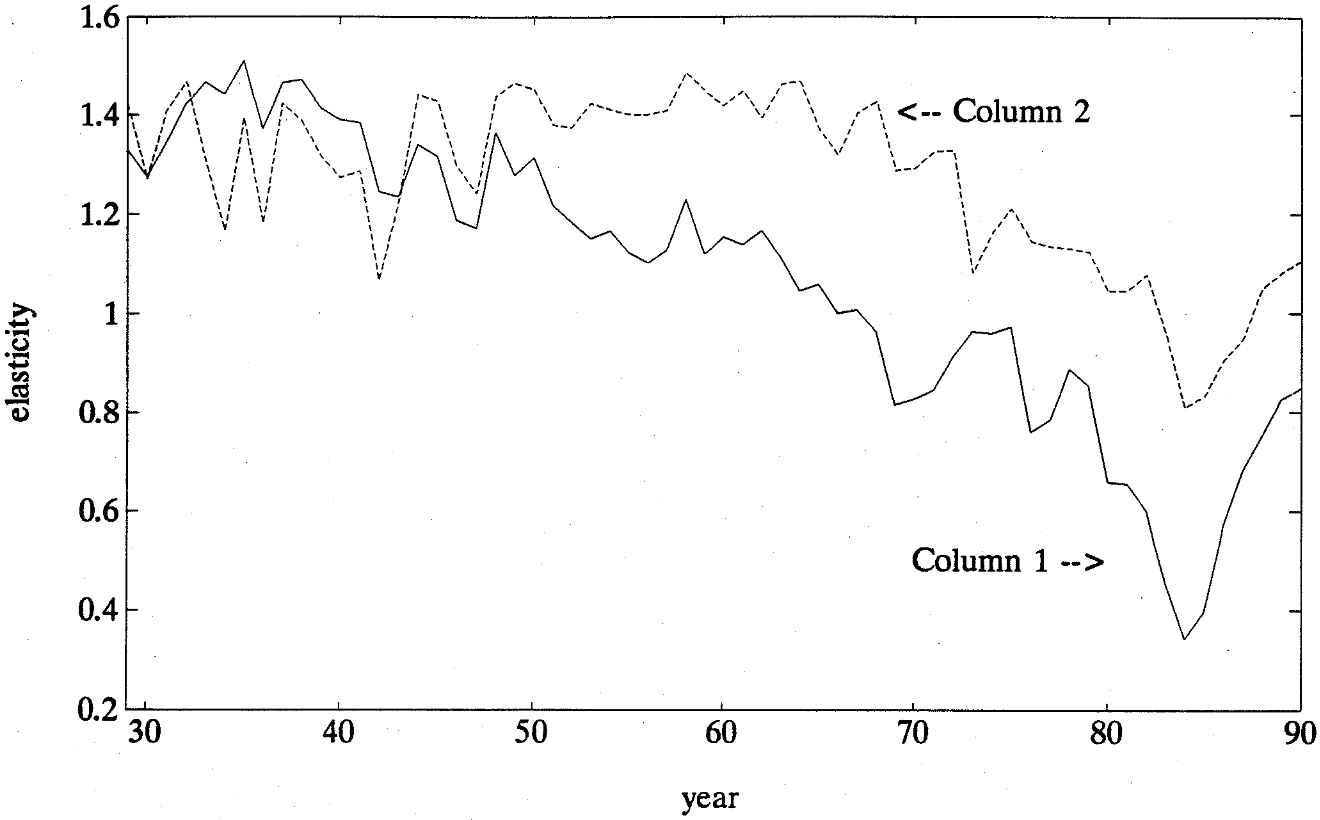
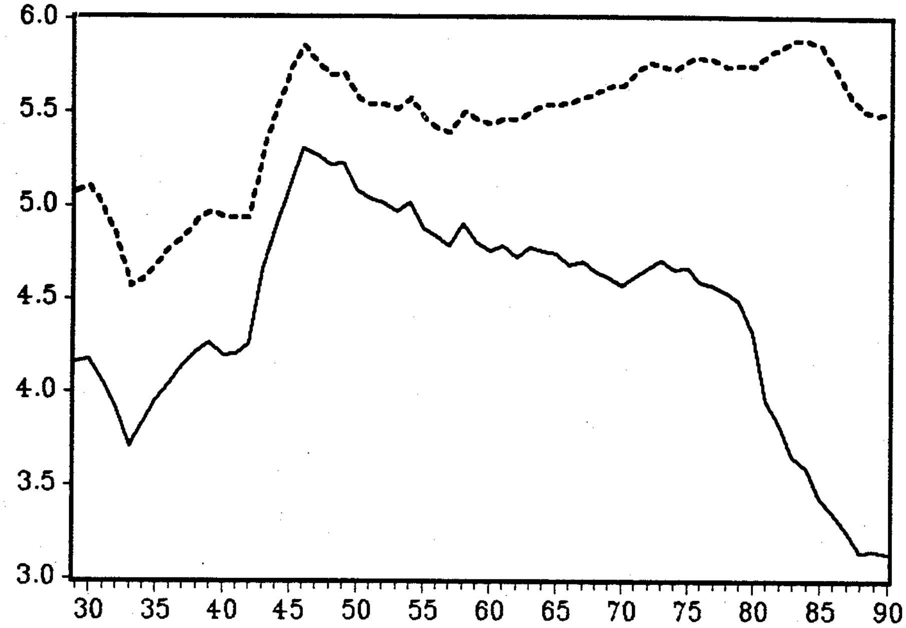
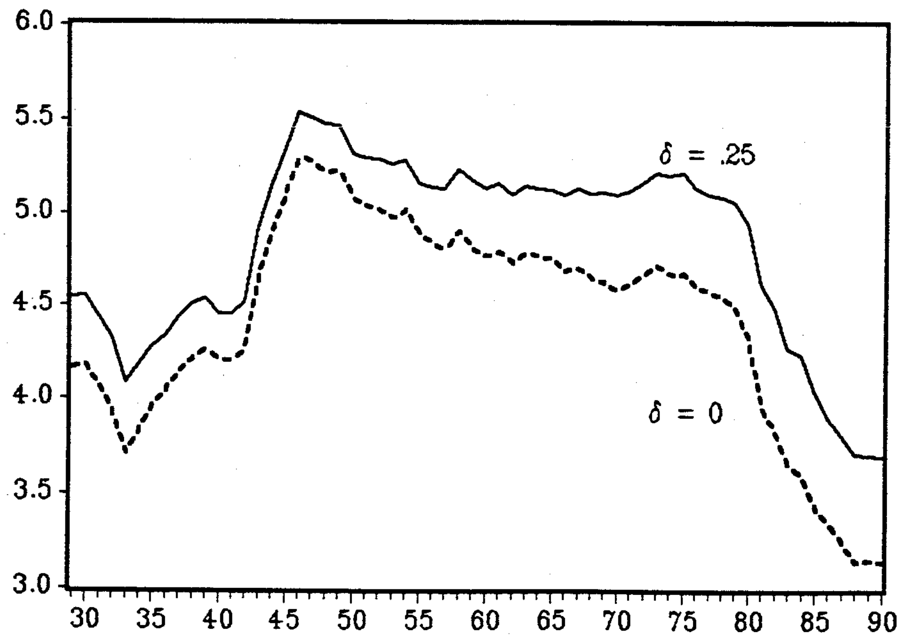


Figure 7a: MX1 & MX2 Time Effects (deflated)



—— MX1 time effect ----- MX2 time effect

Figure 7b: MX1 Time Effects corrected for Interest Rates



—— MX1 Time Effect + .25*(Interest Rate) ----- MX1 Time Effect