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CONSTRUCTION OF NEW MONETARY AGGREGATES: THE CASE OF MEXICO

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1. Introduction.

Monetary aggregates are typically generated using the simple sum approach, in which total holdings of monetary assets are simply added together. However, this implicitly assumes that the assets (currency, demand deposits, savings accounts, etc.) are perfect substitutes; clearly, this method is adding up "apples and oranges," since these assets are far from perfect substitutes. Thus, the simple sum procedure renders a distorted aggregate.

The purpose of this study is to create a new set of monetary aggregates for the Mexican economy which sidesteps this problem, using aggregation theory and statistical index number theory. The purpose of this study is to apply this method to construct new monetary aggregates for the Mexican economy, thus providing monetary data of high quality to researchers, monetary authorities, and students of the economics.

Section two focuses on how these new aggregates are constructed. They are then compared to the simple sum aggregates which are currently used by the monetary authorities. The bases for comparison are standard tests for monetary aggregates which are relevant in designing the shape of the monetary policy. These tests are (1) the ability of each aggregate to provide meaningful estimates of the ordinary demand for money function, (2) the forecasting properties of these demand for money functions, (3) the "controllability" of each aggregate, and (4) the ability of each aggregate to explain the behavior of the velocity of money. The results of all these comparisons are presented in section three. The data used in this study consists of Mexican quarterly time series (1972:2-1987:4) of the stock balances of monetary assets and their corresponding rates of interest.

2. Construction of Monetary Aggregates.

Index number and aggregation theory have become very popular in the construction of meaningful economic aggregates such as the Consumer Price Index, the Implicit Price deflator, real GNP, and the Dow Jones stock market index. A sizeable literature on the use and construction of statistical index numbers has been developed, providing a class of index numbers capable of aggregating over components to obtain quantity and price indexes. More recently, this area of study has been applied to the construction of monetary aggregates in an attempt to measure the quantity and price of money in the economy.

The purpose of aggregation theory is to provide unique answers to the problem of summarizing all the available data, and construct a meaningful quantity and price aggregate over certain components. Here the purpose is to construct a unique monetary aggregate, allowing us to treat money as a single commodity. Recently, several studies have used statistical index number theory and aggregation theory to construct unique monetary indexes.

The goal of this section is to construct a monetary index which incorporates the proper procedures and to compare it with "conventional" indexes or simple sum aggregates. This result leads to the next step of this work, which consists of the comparison between the two aggregates based on their ability to produce meaningful and reliable information about the actual monetary assets in the economy.

2.1 Aggregation Theory.

Since the main concern is to measure money (quantity and price) it becomes necessary to define what is meant by "money." This has long been a matter of controversy, and it begins with the need to establish a set of characteristics that money must have (see Fisher, 1980). In this context we can find arguments suggesting that money must be a medium of exchange, store of value, unit of account and enjoy general acceptance. Furthermore, we can find that given the wide variety of candidates which suitably meet those features, some of them perform better than others for a given characteristic, but not for all the remaining set of characteristics; for instance, a time-deposit asset is clearly a store of value (wealth) but not a medium of exchange, and currency could be more easily recognized as a medium of exchange rather than a store of value.

Since no single monetary asset represents the total quantity of money in the economy, one must include all of them to measure "the total quantity of money." The most common way of computing these aggregates is to add up all the monetary assets in the market (called simple sum, this is a universally accepted procedure in central banks worldwide). However, this assumes that all monetary assets in the market --namely currency, checking accounts, treasury bills, etc.-- are perfect substitutes; clearly this procedure is adding up "apples and oranges."

Given that simple sum approach is valid when all monetary assets are perfect substitutes, and since monetary assets are far from perfect substitutes the use of the simple sum procedure can distort the aggregate (Friedman and Schwartz, 1970; Barnett, 1981b, 1982). To illustrate this problem,[1] assume someone is asked to measure the transportation capacity of a city that only has 100 automobiles (each carrying 3 passengers), 10 buses (40 passengers), and 1000 pairs of roller skates (1 user); if we add them up (simple sum) we will end up with the conclusion that this city has 1110 "transportation facilities." Now suppose the transportation capacity increases from 1110 to 1210 units; we might conclude that the increase in transportation is 100 units (9%). However, the real quantity depends on whether those 100 "units" were buses, automobiles, or roller skates. This measurement method is inadequate because it does not clearly reflect the real transportation capacity of the city. This is analogous to the measurement problem in aggregating over monetary assets.

In the monetary aggregation literature there have been some attempts to construct weighted average monetary aggregates in order to solve this problem (see Friedman, 1963, 1970, and Moroney, 1976). In fact, anyone can construct a weighted average monetary aggregate by assuming arbitrary degrees of "moneyness" of the monetary components--like assuming the number of users of buses, automobiles, and roller skates.[2] But those aggregates are not derived from economic theory nor from aggregation theory; rather, they depend only upon the subjective specification attached to each

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[1] A similar example is used by Barnett in several papers.

[2] Several variables can be seen useful in constructing monetary aggregates, such as bid-ask spreads, turnover rates, price variances, etc

component (some people may say that automobiles can carry only one or five passengers, and buses from one to 50, and roller skates one or two!).

Barnett's (1980) Divisia indexes provide a unique and non-arbitrary procedure based upon statistical theory, approximation theory, and neoclassical microeconomic theory. This method aggregates directly over monetary assets to obtain the quantity and price aggregates.

2.2 Statistical index numbers.

Statistical index theory has been widely used in the construction of economic aggregates. They do not require either a prior specification or estimation of unknown parameters to construct the aggregate; they are parameter-free (non-parametric) and thus are a natural choice when aggregation problems arise. Furthermore, the aggregate depends only on available data (prices and quantities). In fact, when using index numbers, one is forced to make a trade-off between an arbitrary estimation of a nonlinear function or else accepting the assumption that the aggregate quantity depends upon both quantities and prices.[3]

A major contribution made it possible to use statistical index numbers in the process of aggregating over monetary assets. Barnett (1978) derived a formula to calculate the price of monetary assets or "user cost," which is necessary for the construction of any superlative index number. The superlative index used makes no difference since the discrepancy between their growth rates is very small (they differ only by a third-order remainder term).[4] Although some indexes provide the same results each one can be more useful in particular situations. For instance the Divisia index is extremely easy to interpret, while the Fisher ideal index is less intuitive. However, the Fisher ideal index is useful in solving the "new" goods problem, while the Divisia index is not capable of solving this problem. These two issues are discussed in more detail in Sandoval Musi's (1989).

2.3 The Divisia and Fisher ideal indexes.

The discrete-time approximation of Divisia's (1925) index is defined as follows: Let X_{it} be the quantity of good i during period t, and let P_{it} be the price of good i during period t. Now let S_{it} be the expenditure share of good i in period t, defined as $(P_{it}\, X_{it}) \,/\, (\Sigma_i P_{it} X_{it})$, and let

$$S^*_{it} = (S_{it}+S_{i,t-1})/2.$$

Then the Divisia quantity index Q_t over components X_{it} during period t is defined as

$$\log Q_t - \log Q_{t-1} = \Sigma_i\, S^*_{it}\, (\log X_{it} - \log X_{i,t-1})$$

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[3] Actually, the user costs are not there at all. This index depends only upon quantities; prices appear in the weights because they are used to eliminate the marginal products from the first order conditions of the maximization problem, which are unknown. These marginal products depend only upon quantities.

[4] Diewert (1976) has constructed a theory of superlative index numbers in discrete time. He defines an index number to be "superlative" if it is exact for some aggregator function, f, which can provide a second-order approximation to any linearly homogeneous aggregator function. In this paper Diewert has proved that both the Fisher Ideal and Törnqvist-Theil Divisia indexes are Diewert-superlative. Hence, both indexes are identical to three decimal places. For a numerical example see Barnett (1981a, pp. 223).

Here it is clearly seen that the growth rate of the Divisia Quantity Index is defined as the weighted average of the growth rates of the components, the weights being the arithmetic average of the expenditure shares for consecutive periods (S^*_{it}).

The Fisher Ideal Index (Fisher, 1922) is defined as follows:

$$\frac{Q_t}{Q_{t-1}}=\sqrt{\frac{(\Sigma_i P_{it}X_{it})(\Sigma_i P_{i,t-1}X_{it})}{(\Sigma_i P_{it}X_{i,t-1})(\Sigma_i P_{i,t-1}X_{i,t-1})}}$$

Here it is not quite simple to interpret the meaning of the Fisher ideal index as opposed to the Divisia Index since it involves a square root. However, the Fisher Ideal Index is extremely useful when the problem of "new" goods arises.

2.4 The data.

The data consist of quarterly prices and quantities for 33 Mexican monetary assets from 1972:1 to 1987:4.[5] The first step in constructing the index is to acquire data on the quantities and rates of return for each monetary asset. Table 2.1 shows all the monetary assets recognized by the Central Bank as the sources of monetary services in the Mexican economy. In this study, I will use the same asset categorization as the Central Bank. As Table 2.1 shows, M1 includes currency plus demand deposits; M2 includes M1 plus demand deposits denominated in foreign currency; M3 includes M2 plus the assets in lines 4 through 14; M4 includes M3 plus assets in lines 15 through 28. Finally, M5 includes M4 plus assets in lines 29 through 33.

The second step in the construction of an index is to calculate the user cost of each monetary asset. Barnett (1978) developed the appropriate price of an asset (durable good) and found that the current period price (user cost) of good i in period t is $P_{it}= R_t-r_{it}$, where R_t is the maximum available expected holding period yield available in the economy (usually known as the Benchmark rate) and r_{it} is the own current-period holding yield on asset i. The process of imputing the own interest rates for each specific asset is straightforward, except in two cases; first, when demand deposits do not earn interest and, secondly, when assets denominated in foreign currencies are held (usually when a devaluation is expected).[6]

Given the prohibition of interest payments on checking accounts, some studies on the demand for money assume that the yield on checking accounts is zero (some authors argue that this return is negative), hence the user cost equals the benchmark rate or the user cost of currency. However, some other studies (Klein, 1974, Becker, 1975) assume that those who maintain checking

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[5] Some monetary assets were not always available; such as the own rate of return or in other cases the stock balances were unavailable; those missing assets are: other deposits for 9 and 12 months, and 3 month bankers' acceptances are omitted before 1981:2. The following assets were found in the following manner: 6 month treasury bill stock balances are included in the 3 month treasury bill balances, 1 month commercial paper balances are included in 3 month commercial paper balances, 1 month bankers' acceptances are included in 3 month bankers' acceptances balances. The missing stock balances are omitted throughout, and they represent less than 4% of the total monetary aggregates.

[6] For more details see Barnett (1978). In constructing an aggregate of durable goods, it is necessary to employ the user cost (rental price) of the good; then, the corresponding quantity index will measure the service flow (monetary services) provided by the components of the aggregate.

account deposits benefit from non-cash financial services, such as preferential treatment on loans, or generally superior service on all financial transactions. Since there is a service flow to these depositors, we must impute its value in calculating the index.

Several methods have been proposed to estimate this implicit rate of return (see Klein, 1974). The method used in this study follows Klein. This procedure assumes that banks earn the benchmark rate on checking deposits less required reserves on those deposits; then as agents operating in a competitive market for financial services, the banks are assumed to pass on these earnings to the checking account depositors in the form of banking services. Thus, the implicit rate of return on checking balances in period t, r_{dt} is given by

$$r_{dt} = R_t\ (1-R_{dd})$$

where R_t is the benchmark rate in period t and R_{dd} is the reserve ratio on demand deposits.[7]

We are left with the problem of imputing an interest rate on deposits denominated in foreign currency. Barnett's (1978) user cost formula is developed on the basis of certainty theory, hence it requires that all assets must be risk-free.[8] In other words the depositors are assumed to know in advance what their rate of return will be on all monetary assets. For the Mexican data one finds that three assets are partially denominated in foreign currency: demand deposits, savings accounts, and long-term CD's. However, the rate of return on these foreign-denominated deposits are a function of the expected rate of devaluation during the holding-period, hence its yield is not risk-free. To solve this problem one has two alternatives: first, omit those assets from the index and, secondly, include those assets with some modifications. In this study I will use the second option. The modifications are described below.

The return on deposits denominated in foreign currency is defined as the product of one plus the own rate of return times one plus the expected rate of devaluation in that period (Howard, 1983). Then the own rate of return for each asset is defined as follows:

$$r_{1t} = e_t \qquad \text{for demand deposits} \quad (2)$$

$$r_{2t} = r_{st}{}^*e_t \qquad \text{for savings accounts} \quad (3)$$

$$r_{3t} = r_{lt}{}^*e_t \qquad \text{for long-term deposits} \quad (4)$$

[7] Klein (1974, pp. 935-938) provides details regarding the underlying assumptions. In applying this method it must be recognized, as does Klein, that business firms are the most likely depositors to take advantage of these kinds of services, hence this imputed interest rate should be applied only to business firm depositors; for household depositors this rate of return should be zero. However, in the present study, I will not make this distinction since disaggregated data by type of depositors are not available. The next step in this study will be the inclusion of an accurate estimate of the fraction of demand deposits held by firms and households.

[8] Some limitations arose regarding the available data for those specific monetary assets. In the case of savings denominated in foreign currency, it also includes short-term deposits. For the case of long-term deposits, it includes all deposits for which the maturity greater than 1 month. The theory of aggregating over monetary assets under risk-averse preferences is now in progress (see Yue, 1989). Time series techniques, namely ARMA and ARIMA models, could provide better estimates for this yield, however, the index will then be subject to the choice of the technique. In addition, it is our belief that the results would not be dramatically altered since these assets are only a small part of the total quantity of money.

where e_t is the expected rate of devaluation, r_{st} is the rate of return on savings accounts denominated in foreign currency, and r_{lt} is the rate of return on long-term deposits denominated in foreign currency. Thus, the actual rates of return used in the computation of their corresponding user cost are r_{1t}, r_{2t}, and r_{3t}.

Since e_t is not observable, a proxy for e_t must be used. Several alternative measures for e_t may be used. One possibility is to estimate e_t based on the historical path of the exchange rate, which will enable equations (2), (3), and (4) to be calculated directly. Among those (time series) procedures one of the most popular models of exchange rate is the random walk time series model (also the simplest); in this study, such model a is used to generate exchange rate expectations, then the devaluation rate for period t is expected to equal the devaluation rate experienced in period t-1, then

$$e_t = \frac{E_{t-1}}{E_{t-2}}$$

where E_t is the actual exchange rate (peso/dollar). The final step is to compute the Divisia Index (or the Fisher Ideal Index) for each of the five monetary aggregates for the entire sample, applying the formulas provided above.

Table 2.1
Monetary Assets in the Mexican Economy

Component		
1. CURRENCY		
2. DEMAND DEPOSITS		M1
3. DEMAND DEPOSITS IN FOREIGN CURRENCY		M2
4. SAVINGS ACCOUNTS		
5. SAVINGS ACCOUNTS IN FOREIGN CURRENCY		
6. SHORT-TERM BONDS		
7. SHORT-TERM ORDINARY BONDS		
8. CERTIFICATE OF DEPOSIT 1 MONTH		
9. DEPOSITS 1 MONTH		
SPECIAL CERTIFICATE OF DEPOSITS (10-13)		
10. - TWO TIMES A WEEK		
11. - ONCE A WEEK		
12. - TWO TIMES A MONTH		
13. - ONCE A MONTH		
14. SHORT-TERM CD'S FOREIGN CURRENCY		M3
15. CERTIFICATE OF DEPOSIT 3 MONTHS		
16.	6 MONTHS	
17.	12 MONTHS	
18.	18 MONTHS	
19.	24 MONTHS	
20. OTHER DEPOSITS 3 MONTHS		
21.	6 MONTHS	
22.	9 MONTHS	
23.	12 MONTHS	
24. CD'S OVER 1 MILLION		
25. LESS THAN A MILLION CD'S		
26. LONG-TERM CD'S IN FOREIGN CURRENCY		
27. SPECIAL BONDS		
28. TREASURY BILLS 1 MONTH		M4
29.	3 MONTHS	
30.	6 MONTHS	
31. COMMERCIAL PAPER	1 MONTH	
32.	3 MONTHS	
33. BANKER'S ACCEPTANCES.		M5

Source: Bank of México. 1972-1987

3. Standard Tests for Monetary Assets.

The goal of this section is to compare the usual simple sum measurement and the Fisher ideal index aggregates developed in the previous section on the grounds of several standard tests for any monetary aggregate which are relevant in designing monetary policy. The bases for the comparison are (1) the ability of each aggregate to provide meaningful estimates of a usual demand for money function, (2) the forecasting properties of the estimated demand equations, (3) the controllability of each monetary aggregate; and (4) on the ability of each aggregate in explaining the behavior of the velocity of money (demand for money). Ten monetary aggregates will be used, five simple sum aggregates (M1 to M5) and the corresponding Fisher ideal index aggregates.

3.1 Demand for money function.

This section compares the Fisher ideal index monetary aggregates and the usual simple sum aggregates developed earlier in terms of their usefulness in estimating the usual demand for money function. The money demand functions estimated in this section take the following conventional specification form (Tobin, 1956, Fisher, 1978):

$$M_t/P_t = \alpha + \gamma M_{t-k}/P_t + \beta Y_t/P_t + \pi OC_t$$

where M_t is the simple sum or Fisher monetary aggregate, Y_t is nominal GNP, and OC is opportunity cost variable, and k is the number of lags allowed for the variable, and P_t is the geometric mean of the Consumer Price Index and the GNP Implicit Price Deflator[9]. All variables are in the form of logarithm changes, so that the estimated coefficients render income and price elasticities[10]; where β and π are the estimates for income and interest elasticities. This standard money demand formulation uses income (GNP) as a variable reflecting the transactions use of money and the interest rate or user cost price index as an opportunity cost variable which tries to capture the effect of the cost of holding money.

The opportunity cost variable for the simple sum aggregates is the interest rate on three months CDs[11]. For the case of the Fisher monetary aggregate, this variable takes the form of the corresponding Fisher price index obtained from the user-cost data for each monetary aggregate. The Fisher Ideal Price Index is defined as follows

$$\frac{P_t}{P_{t-1}} = \sqrt{\frac{(\Sigma_i P_{it}X_{it})(\Sigma_i P_{i,t}X_{i,t-1})}{(\Sigma_i P_{i,t-1}X_{it})(\Sigma_i P_{i,t-1}X_{i,t-1})}}$$

These equations are estimated in two ways; first, using the aggregate data, and second, per capita data, a procedure generally followed by the consumer demand approach and others[12]. In addition, the same equations are estimated for the entire sample (1975:1-1987:4) and for the period 1982:2-1987:4, when a structural shift occurred.[13]

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[9] CPI is a Laspeyres price index and Implicit Deflator index is a Paasche index, a geometric mean result in an unbiased price index. All data are quarterly averages.

[10] The variable M takes the form of the change of the logarithm ($\log M_t - \log M_{t-1}$) of the real balances of both simple sum and Fisher aggregates.

[11] These is the only interest rate data available since 1975:2.

[12] Many authors in the field suggest the use of per capita data; for instance, Milton Friedman (1970) uses per capita data in many of his papers. Also consumer approach authors suggest the use of per capita data, see Theil and Clements (1987), Barnett (1979).

[13] Also see the figures in section 3.4 of this study. All the figures show a shift in 1982:2 - 1982:4 period.

3.11 Results.

Table 3.1 shows the results of estimating simple sum and Fisher money demand functions using the specification form described earlier for the 1975:2-1987:4 sample period, for the five monetary aggregates considered here (M1 to M5) using the aggregate data. Table 3.2 shows the results when the sample for the aggregate data are for the period 1982:2- 1987:4. Table 3.3 shows the demand for money estimates using per capita data when the entire sample is used; and Table 3.4 shows the results for the per capita data case using the sample period 1982:2-1987:4.

In all four cases the Fisher Ideal Index generally outperforms simple sum; for the five Fisher monetary aggregates all the coefficients on real GNP have the correct sign, and are statistically more significant than their counterpart simple sum. The results for the simple sum aggregates show that in two cases these coefficients have the wrong sign.

Regarding the coefficient of the opportunity cost variable, the results show that the Fisher aggregates also outperform simple sum; only in four instances the Fisher aggregates (in the aggregate data case) shows the wrong sign, whereas the simple sum shows the wrong sign nine times.

Another interesting result is that in nearly every instance the coefficient on GNP for all Fisher aggregates is greater than the corresponding coefficient for the simple sum; furthermore, the Fisher aggregates are closer to one, and in the per capita case greater than one, which implies that the income-elasticity is greater than or equal to unity. This is the conventional result implying that money is a normal good.

For the simple sum aggregates, this coefficient is definitely less than one for all cases, implying that money is an inferior good at all levels of aggregation; a result that is contrary to the conventional result that money is a normal good.

Although it is clear that the Fisher aggregates generally perform better than the corresponding simple sum, it can be noticed that at high levels of aggregation, namely M4 and M5, the Fisher aggregates clearly outperform the simple sum aggregates.

Table 3.3 and 3.4 show the results obtained when using per capita data; in both cases the Fisher aggregates clearly outperform the simple sum aggregates in both criteria, the significance of the coefficients and the resulting sign for the GNP and opportunity cost variables.

It can be noticed in table 3.3 that all the coefficients for the GNP variable are highly significant and greater than one (between 1.04 for M1 and 1.42 for M5). In this case, all the coefficients for the GNP variable for the simple sum aggregates are not significant; and for the opportunity cost variable, the results are mixed since simple sum aggregates perform slightly better than Fisher aggregates for the M1 and M2 levels of aggregation, and Fisher aggregates perform better for the M3, M4, and M5 levels of aggregation.

TABLE 3.1
Demand for Money Functions
Aggregate Data, sample 1975:2 1987:4

	GNP		OC	
	Coeff	T-Stat	Coeff	T-Stat
SS1	.38	8.3	-.26	5.5
F1	.36	5.8	+.008	.10
SS2	.41	8.9	-.26	5.8
F2	.36	5.9	+.01	.22
SS3	.27	4.3	-.009	.22
F3	.43	5.99	-.03	.31
SS4	.51	10.5	+.00003	.01
F4	.82	20.6	+.03	.95
SS5	.51	10.9	+.002	.69
F5	.82	20.47	+.03	1.0

All data are quarterly series of the form ($\log X_t - \log X_{t-1}$)

SS/ Indicates simple sum aggregate. F/ Indicates Fisher aggregate.

TABLE 3.2
Demand for Money Functions
Aggregate Data, sample 1982:2 1987:4

	GNP		OC	
	Coeff	T-Stat	Coeff	T-Stat
SS1	.52	6.3	+002	.66
F1	.81	7.9	-.79	3.6
SS2	.50	6.5	+.003	.97
F2	.72	7.7	-.60	3.33
SS3	.63	9.1	-.40	3.33
F3	.85	8.75	-.65	3.45
SS4	.67	7.7	+.01	.15
F4	.80	18.37	-.05	.46
SS5	.53	6.39	+.05	.86
F5	.79	17.64	-.01	.08

All data are quarterly series of the form ($\log X_t - \log X_{t-1}$)

SS/ Indicates simple sum aggregate.F/ Indicates Fisher aggregate.

TABLE 3.3
Demand for Money Functions
Per Capita Data, sample 1975:2 1987:4

	GNP		OC	
	Coeff	T-Stat	Coeff	T-Stat
SS1	.047	.59	-.47	8.2
F1	1.04	5.8	-.63	7.5
SS2	.041	.52	-.48	8.3
F2	1.01	5.8	-.60	7.5
SS3	.027	.48	-.14	3.3
F3	1.37	6.7	-.76	8.7
SS4	-.06	.72	-.001	.37
F4	1.44	5.0	-.76	7.7
SS5	-.04	.53	+.004	.99
F5	1.42	4.8	-.71	7.2

All data are quarterly series of the form (log X_t - log X_{t-1})

SS/ Indicates simple sum aggregate. F/ Indicates Fisher aggregate.

TABLE 3.4
Demand for Money Functions
Per Capita Data, sample 1982:2-1987:4

	GNP		OC	
	Coeff	T-Stat	Coeff	T-Stat
SS1	-.50	2.2	+.005	.61
F1	.93	6.3	-1.06	11.2
SS2	-.46	2.2	+.006	.86
F2	.74	5.2	-.89	9.8
SS3	.02	.18	-.74	5.1
F3	.91	5.5	-.92	10.2
SS4	-.22	1.8	-.61	6.7
F4	.49	2.2	-.77	9.5
SS5	-.21	1.9	-.30	3.3
F5	.51	2.3	-.75	9.15

All data are quarterly series of the form (log X_t - log X_{t-1})

SS/ Indicates simple sum aggregate.F/ Indicates Fisher aggregate.

3.2 Forecasting.

In this section I compare the Fisher Index monetary aggregates with the simple sum aggregates in terms of the forecasting accuracy of the estimated demand for money equations in the previous section. Here we present only the results for those cases where the demand for money equations showed significant results -- in terms of significance and sign of the coefficients. The predictive performance of each equation is measured in two ways described below[14].

First, each equation is estimated using the 1975:2-1987:3 sample period, then the estimated parameters are used to forecast the next period (1987:4); the resulting root mean squared errors are presented in columns A on table 3.5 for the aggregate data case and the per capita data. The second way consists on estimating each equation using the 1975:2-1987:2 sample period, and then forecast for the next two periods (1987:3 and 1987:4). The results are presented in column B in table 3.5.

3.21 Results.

Table 3.5 shows that neither the simple sum aggregates nor the Fisher aggregates uniformly dominates each other for the M1 and M2 levels; however, the Fisher aggregate perform better for the M3, M4 and M5 levels of aggregation in terms of the root mean squared error. In addition, Table 3.5 shows the forecasting results for the per capita data case. It can be seen that this case follows the same pattern than the aggregate data case, in the sense that neither aggregate dominates each other for the M1 and M2 levels, but Fisher aggregates clearly outperform simple sum at higher levels of aggregation, namely M4 and M5.

[14] This is a in-sample forecasting test.

TABLE 3.5

Forecasting Properties of the Demand for Money Functions

	Aggregate Data				Per Capita Data			
	One period		Two periods		One period		Two periods	
Aggregate	A	B	A	B	A	B	A	B
SS1	.003	-	.16	-	.21	-	.16	-
F1	-	.01	-	.38	.38	.003	.20	.017
SS2	.04	-	.15	-	.16	-	.14	-
F2	-	.04	-	.04	.31	.04	.16	.03
SS3	.19	.24	.19	.13	.03	.25	.10	.13
F3	.06	.10	.27	.08	.32	.10	.17	.06
SS4	-	-	-	-	-	-	-	-
F4	-	.053	-	.03	.30	.17	.16	.10
SS5	-	-	-	-	-	-	-	-
F5	-	.02		.02	.31	.15	.16	.08

One period forecasting means to es...iate the equation before 1987:4, and then use that estimates to forecast 1987:4.

Two periods forecast means to estimate the equation before 1987:3, and then use these estimates to forecast for 1987:3 and 1987:4.

A. Using the entire sample data, 75:2-87:4. The figure is the Root Mean Squared Error.

B. Using the sample data 82:2 87:2. The figure is the average of the two periods Root Mean Squared Errors. Forecast

SS/ Indicates simple sum aggregate.

F/ Indicates Fisher aggregate.

-/ Means that this equation have insignificant coefficients and/or it has the coefficients have the wrong sign.

3.3 Controllability.

Another basis to compare the usefulness on a monetary aggregate as a intermediate target is its controllability; here, controllability is defined as the degree of relationship between instruments, namely the monetary base, total reserves, and currency, and intermediate targets (monetary aggregates). This implies that if an aggregate is close-related to a final target (GNP, unemployment) but it is not close-related to instruments, then it is not longer a useful target, from the monetary policy point of view .

The two tests performed in this section for the supply of money are related to the controllability properties of the money supply rather than to the transmission mechanism and the theoretical foundations of the supply of money function; Barnett (1986) provides an interesting approach regarding the theoretical microeconomic foundations of the supply of money function. He developed a model, based upon aggregation theory and on profit maximization neoclassical theory, of monetary production by financial intermediaries; this model provides the linkage between the behavior of the depository institution system (financial firms) and the supply of money (see also Ham, 1987).

In the literature of money supply (Havrilesky, 1978, Wrightsman, 1983) we found that the most common method to compute the "quantity of the money supplied" is to assume that it is a multiple of total banking reserves or the monetary base -- defined as the sum of currency and total reserves --. This relation can be expressed as

$$M = m\,R$$

where M is the money supply (monetary aggregate), R is the total banking reserves (or B for monetary base), and m is called the "money multiplier" since it represents the number of times by which the quantity of money supplied exceeds the volume of total reserves (or the monetary base).

One of the most common procedure[15] to manage the money supply is to pre-determine the level of total reserves (or monetary base) consistent with a given money supply target, assuming that the multiplier is known.[16] Thus, in order to control the quantity of money supplied, M, by setting the level of total reserves it becomes necessary that the money multiplier be predictable.[17] In the case that the money multiplier prediction were erratic then the policy-makers would not be able to know what level of reserves or monetary base to target in order to reach the desirable level of the money supply. Hence, the success of this procedure depends entirely upon the ability to forecast the money multiplier or its stability over time.

In order to test the degree of controllability of a monetary aggregate I will use two simple procedures. First I will use (Belongia, 1989) a procedure that implies that the growth rate of the monetary aggregate should have a contemporaneous correspondence with the growth rate of the monetary base (or total reserves or currency) if the monetary authorities want to have real control over the intermediate target; the actual method is to run a regression of the growth rates of the monetary aggregates on the growth rates in monetary base. This is another way to see the behavior of the multiplier since it is defined as the ratio of the monetary aggregate to the instrument (M/R). The criteria to evaluate these regressions are the goodness of fit and the significance of the coefficients: this will measure the degree of reliability of each monetary aggregate.

The suggested regression was estimated for each (10) of the monetary aggregates considered in this work. This regression was estimated over two sample periods, first over the entire sample (1975:2-1987:4), and secondly for the period of 1982:3-1987:4; the reason behind this is the belief of a structural shift in the demand for money in the second period (see figures of the demand for money in section 3.4). table 3.6 shows the results of those regressions using the 1982:3-1987:4 data sample for the case of monetary base, total reserves, and currency. Table 3.10 shows the results using the entire data for the case monetary base, total reserves, and currency cases.

The results using data sample 1982:3-1987:4 show that for all cases the Fisher monetary aggregates the goodness of fit is greater than those obtained from the simple sum. Two exceptions

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[15] This method is usually associated with the Federal Reserve Bank of St. Louis (see A. E. Burger, 1972).

[16] It is usually assumed that monetary authorities have a high degree of control over the size of the monetary base and total reserves; although the monetary authority does not have total control over the determinants of reserves -- like currency held by the nonbank public, monetary gold stock, and treasury deposits --.

[17] The monetary authorities have basically three methods to control total reserves or the monetary base, (1) open market operations, (2) the discount rate, and (3) the reserve requirement.

are found here; total reserves M3 on table 3.8, where the R^2 for the Fisher aggregate is .06 and for the simple sum .07, and second for the M1 aggregate both Fisher and simple sum aggregates have the same goodness of fit, as well as standard errors (see table 3.6).

Regarding the coefficient of the monetary base, total reserves, and currency variables, they are clearly more significant for all the Fisher monetary aggregates than the corresponding Simple Sum aggregates for the M2, M3, M4, and M5 levels of aggregation. For the M1 aggregate (and M2 currency case) the significance level for both Fisher and simple sum are equal.

It can be noticed that the Fisher aggregates perform better than the simple sum aggregates at all levels of aggregation, and this is more evident the higher the level of aggregation. For instance, for the M5 aggregate, the Fisher aggregates clearly performs better than the corresponding simple sum aggregate.

The results obtained from the 1975:2 1987:4 sample data are shown in table 3.6. Those results are quite similar to those obtained in the first case shown above; the Fisher aggregates clearly perform better than the corresponding simple sum under all bases of comparisons for the case of the monetary base, total reserves, and currency cases for the M3, M4, and M5 aggregates; here, the results for the M1 and M2 aggregates show that the simple sum and Fisher aggregates have the same t-statistic, size of the coefficient (or same standard error), and goodness of fit; The only case in which simple sum perform better than Fisher aggregates is found in the M2 currency case, where the t-statistic for the simple sum coefficient is 6.9 against 6.81 for the Fisher aggregate.

TABLE 3.6
Controllability of Monetary Aggregates
sample 1982:2 1987:4

	Currency			Total reserves			Monetary Base		
	Coeff	T-Stat	R^2	Coeff	T-Stat	R^2	Coeff	T-Stat	R^2
Aggregate									
F1	.35	4.23	.44	.48	1.97	.12	.76	3.86	.39
S1	.35	4.23	.44	.48	1.97	.12	.76	3.86	.39
F2	.33	3.93	.40	.47	1.93	.11	.73	3.64	.369
S2	.32	3.92	.40	.45	1.87	.10	.70	3.58	.360
F3	.34	3.85	.39	.42	1.60	.06	.71	3.27	.31
S3	.30	1.84	.10	.64	1.64	.07	.84	2.35	.17
F4	.23	2.84	.25	.36	1.66	.07	.53	2.84	.25
S4	.09	1.33	.03	.27	1.62	.07	.32	2.03	.13
F5	.24	2.95	.26	.35	1.63	.07	.53	2.86	.25
S5	.08	1.08	.008	.18	1.01	.001	.24	1.37	.04

T-statistic associated with the hypothesis that the coefficient is different from zero.

S/ Indicates simple sum aggregate. F/ Indicates Fisher aggregate.

TABLE 3.7
Controllability of Monetary Aggregates
sample 1975:2 1987:4

	Currency			Total reserves			Monetary Base		
	Coeff	T-Stat	R^2	Coeff	T-Stat	R^2	Coeff	T-Stat	R^2
Aggregate									
F1	.35	7.13	.50	.46	3.11	.15	.73	6.40	.44
S1	.35	7.11	.50	.46	3.11	.15	.72	6.39	.44
F2	.34	6.81	.48	.46	3.11	.15	.72	6.25	.437
S2	.34	6.9	.48	.45	3.07	.14	.70	6.26	.438
F3	.32	6.05	.42	.42	2.85	.12	.66	5.49	.37
S3	.29	3.19	.15	.59	2.7	.11	.74	3.84	.21
F4	.21	4.63	.29	.45	4.07	.24	.55	5.94	.41
S4	.10	1.96	.05	.43	4.0	.23	.40	3.90	.22
F5	.22	4.73	.30	.45	4.05	.23	.55	5.99	.41
S5	.10	1.73	.03	.41	3.30	.16	.38	3.20	.16

T-statistic associated with the hypothesis that the coefficient is different from zero.
S/ Indicates simple sum aggregate. F/ Indicates Fisher aggregate.

The second procedure to test the controllability of an intermediate target is to explore the stability of the multipliers between instruments and intermediate targets. The multiplier is defined as the ratio from the monetary aggregate to the instrument. The instruments used here are the monetary base, total reserves, and currency. The intermediate targets are the usual Fisher index and simple sum aggregates.

In order to test the stability of each multiplier I used a common procedure, which consists on regressing the multipliers on a time trend variable (extrapolation). The results for all those regressions are presented on table 3.8 for the monetary base, total reserves, and currency. The basis for comparisons in this section are the goodness of fit (R^2) and the significance of the coefficient.

The results show that the Fisher aggregates multipliers perform generally better than the corresponding simple sum aggregates in all cases and under both criteria for the M3, M4, and M5 aggregates, with the exception of the M5 currency case. The simple sum aggregates perform better for the M1 and M2 cases. The regressions with better goodness of fit (R^2) are clearly Fisher indexes for M5, M4, and M3.

In addition, the best fit are found on the following cases: currency multiplier Fisher M3 (0.69) and monetary base multiplier Fisher M4 (0.67); currency multiplier Fisher M4 (0.62), currency multiplier simple sum M5 (0.61), and monetary base multiplier Fisher M5 (0.60).[18]

[18] These results can be seen also by plotting the multipliers for each case; figures 3.13-3.27 as well as the residuals (deviation from trend) of each equation against time (figures 3.28-3.42) could be found in Sandoval Musi (1989). All these figures are presented Appendix III. It can be noticed that the Fisher multipliers are clearly more stable than the corresponding simple sum. Regarding the residuals, similar results are obtained.

TABLE 3.8
Multiplier Trend Regressions

	Monetary Base		Total reserves		Currency	
	R^2	T-Stat	R^2	T-Stat	R^2	T-Stat
Aggregate						
F1	.10	2.62	.04	1.90	.19	3.7
S1	.11	2.7	.05	1.96	.20	3.6
F2	.05	1.91	.016	1.3	.11	2.7
S2	.08	2.33	.036	1.7	.17	3.4
F3	.48	6.9	.35	5.39	.69	10.7
S3	.13	2.9	.11	2.7	.25	.4.2
F4	.67	10.18	.57	8.2	.62	9.21
S4	.23	4.0	.17	3.4	.52	7.5
F5	.60	8.8	.49	7.09	.58	8.41
S5	.35	5.28	.28	4.6	.61	8.96

T-statistic associated with the hypothesis that the coefficient is different from zero.
S/ Indicates simple sum aggregate. F/ Indicates Fisher aggregate.

3.4 Velocity.

In this section we compare Simple Sum monetary aggregates and the Fisher quantity index aggregates in terms of their ability to provide a meaningful explanation of the behavior of income velocity, which is defined as the ratio of the GNP to the quantity of money.

The intuition behind the behavior of the velocity of money suggests that the greater the velocity, the lower the fraction of GNP allocated to the consumption of monetary assets (i.e. the lower the demand for money). We might expect that in periods of rising interest rates and rising inflationary expectations, the portion of GNP allocated to the consumption of monetary assets should decrease. In other words, the velocity in those periods should be increasing

Figure 3.1 plots the velocity of the monetary aggregate M5 for both the Simple Sum and the Fisher Ideal Index. It can be seen that both indexes move very closely together (both stable) for the first period (1975-1981). For the remainder of the period (1981-1987), the velocity for Simple Sum remains fairly constant, while the velocity for the Fisher Index increases sharply. For M4, and M3 we have similar results (see Sandoval Musi, 1989).

Figure 3.2 plots the real balances for Simple Sum and the Fisher Ideal Index for M5 from 1975:2 to 1987:4 (similar results arise when using M3 or M4). These figures shows that according to the Simple Sum aggregates the quantity of money have not change dramatically during the period 1982:4 to 1987:4, whereas the Fisher Ideal Index shows a tremendous decrease (lower than 1975:2 level) in the quantity of monetary services demanded by the consumers from 1982 to 1987. Hence, according to the Fisher Index, consumers switched away from holding monetary assets during the period from 1982 to 1987; this can be seen if we compare figure 3.2 which plots M5 with figure 3.3 which plots the behavior of real balances M1 (almost pure money). M1 chart clearly shows a decrease in money holdings, implying that during this period consumers went away from assets in M1 to assets in M5 (higher yields, or even to other types of investments like real estate) in an attempt to hedge against inflation, and reacting to the presence of rising interest rates. However, since Simple Sum weighs all assets equally, the broadest aggregate M5 does not change (decrease in assets included in M1 by 1 dollar and increase in assets included in M5 by a dollar).[19]

The Superlative Index, as opposed to the Simple Sum, weighs more heavily the those assets in M1 relative to those assets in M5, -- at the margin one dollar in an asset included in M1 provides more monetary services than a dollar in an asset included in M5 -- shows that total monetary services have decreased, as expected (similar results are obtained for M3 and M4). Thus, when consumer switch one dollar away from M1 to M5, Fisher index weighs less heavily the assets in M5 level, consequently lower quantity of money. This phenomenon appears only at high levels of aggregation, namely, M3, M4, and M5, because all of them include high-yield monetary assets, as opposed to M1 and M2.[20]

This behavior can be explained by adding two more variables into this context; interest rates and inflation rates. First, figure 3.4 plots the 3 months certificate of deposit rate against the velocity of the M5 aggregates; it can be observed that the velocity of the Superlative Index tracks correctly the trend in the interest rate. On the other hand, the Simple Sum aggregate shows no change in the behavior in the presence of rising interest rates.

Secondly, figure 3.5 plots the inflation rate (Consumer Price Index) against the velocity of the M5 aggregates; here it can be seen that the velocity of the Superlative Index increases as the inflation rate increases, implying that this index makes economic sense, and the velocity for Simple Sum, as opposed to the Superlative Index, shows no change in the presence of inflation. Regarding the period where interest and inflation rates are fairly stable it can be said that both velocities are move very close together, although the velocity for the Fisher Ideal Index is slightly more stable.

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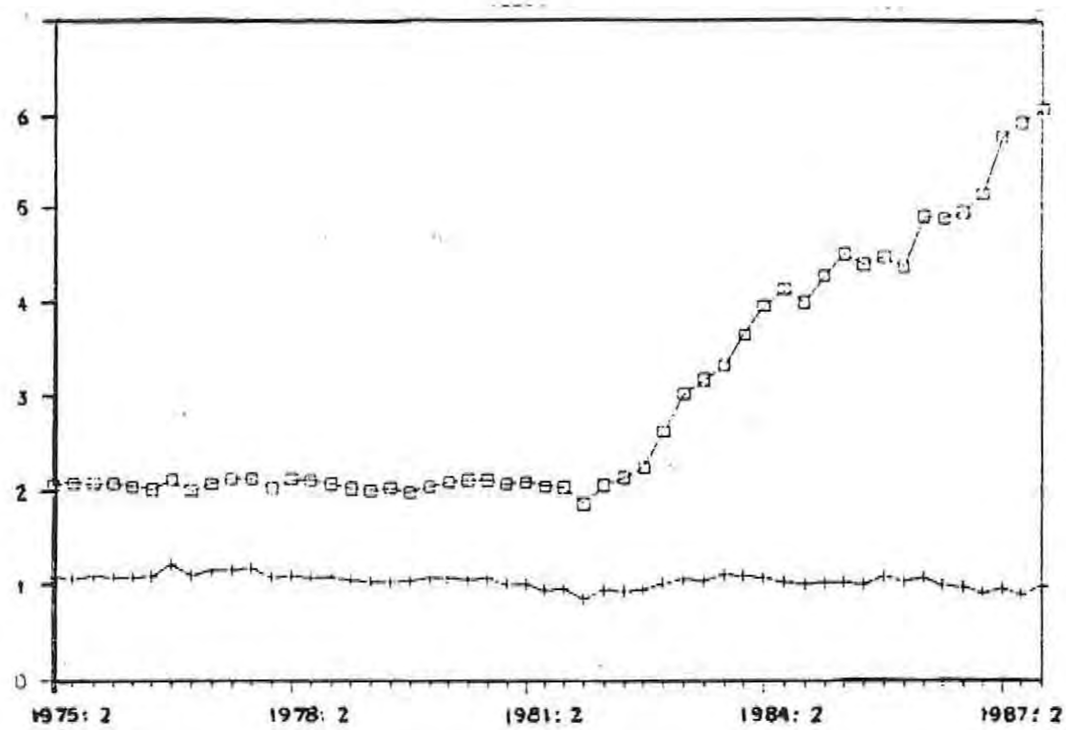
[19] This behavior is also very clear in the aggregate M3 (figure 3.8); in this case simple sum shows an increase in the quantity of money from 1982 to 1985; see Sandoval Musi, A., (1989).

[20] The following example will help to understand the behavior of each aggregate when the public switches from assets that are included in different aggregation level -- from high level to lower level of aggregation --. Let us assume first that the quantity of money in the economy is measured by the monetary authority using the highest level of aggregation (M5) which includes all the 28 assets considered here. Second, suppose that all treasury bills (government debt) are monetized, thus the public has exchange treasury bills for currency. Since M5 contains all assets included in M1 simple sum M5 will not suffer any change. However, the Fisher aggregates will treat this exchange in a different manner. Since currency is more heavily weighted than treasury bills the Fisher M5 will indeed increase. A similar example is used by Barnett (1984).

Figure 3.1

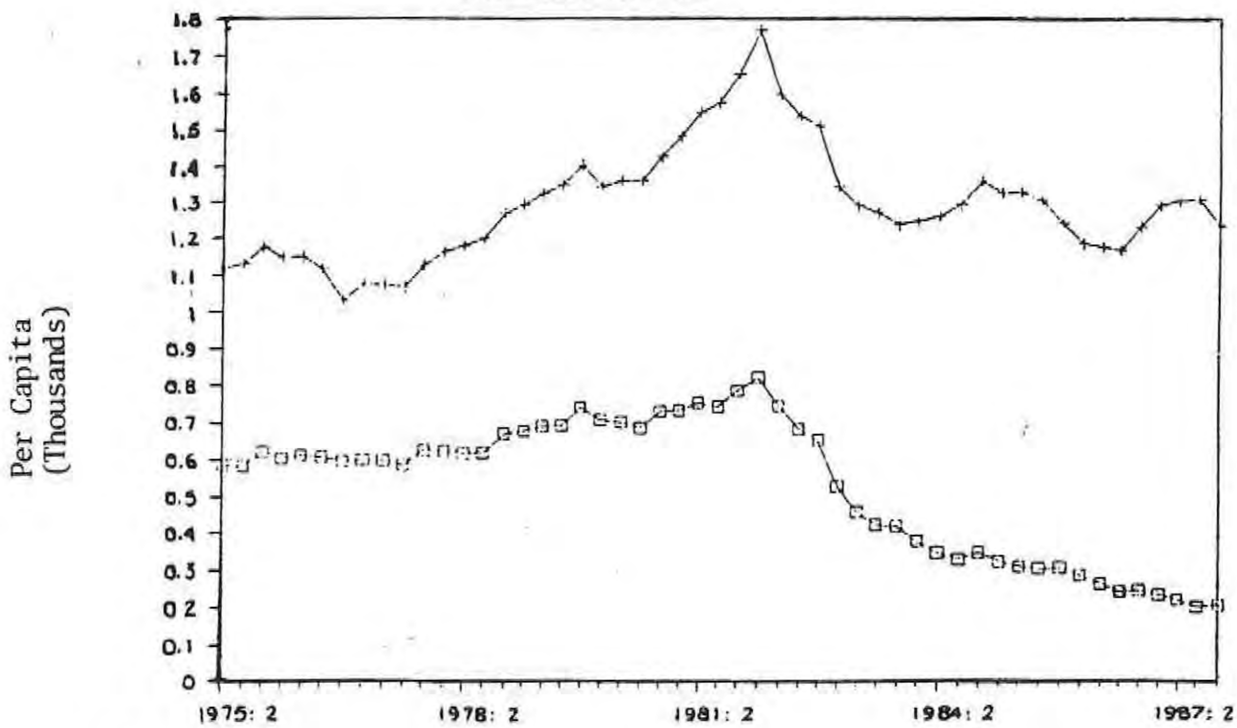
Income Velocity M5



□Fisher Index + Simple Sum

Figure 3.2

Real Balances M5



□ Fisher Index + Simple Sum

Figure 3.3
Real Balances M1

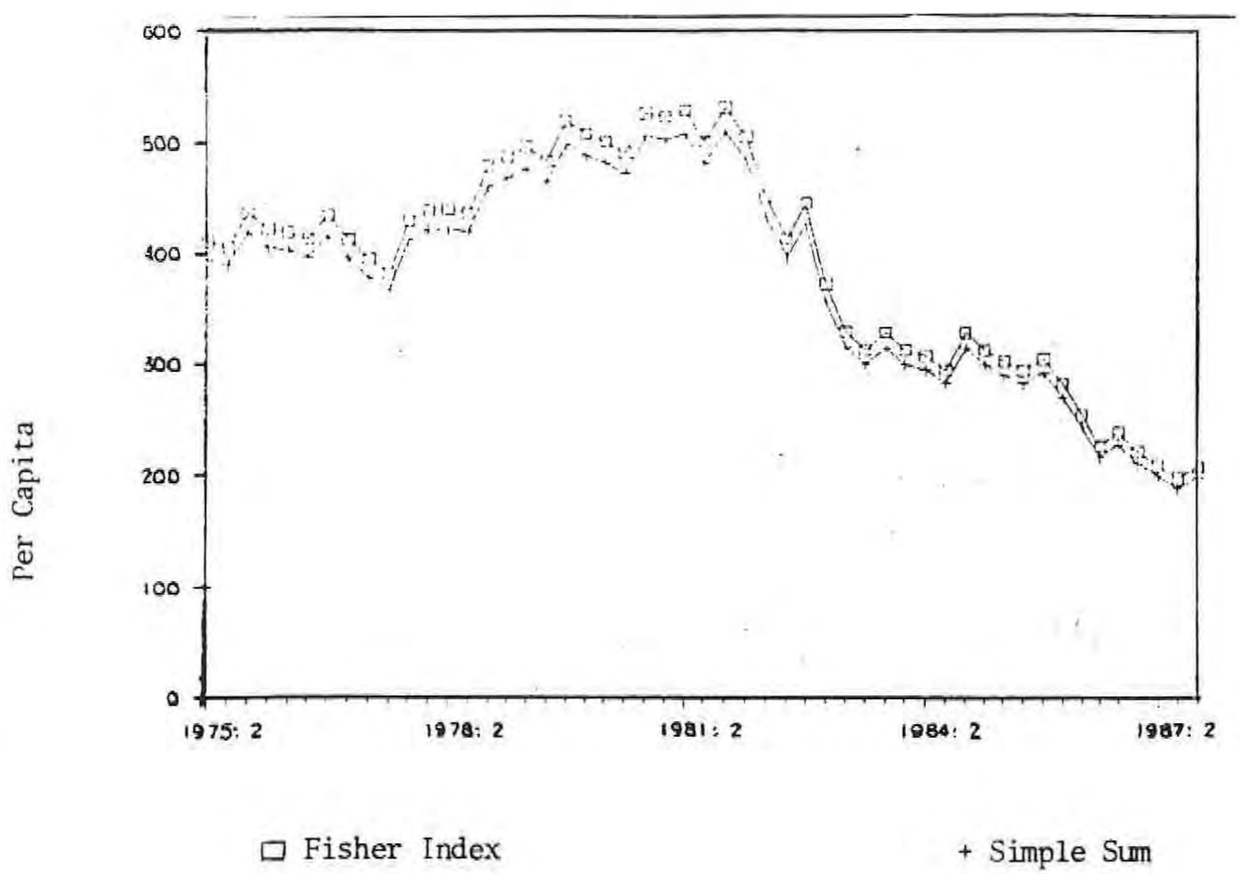


Figure 3.4
Velocity of Fisher M5 ("F5"), Velocity of Simple Sum M5 ("SS5"),
and Three-Month C.D. Rate
(1975.2 - 1987.4)

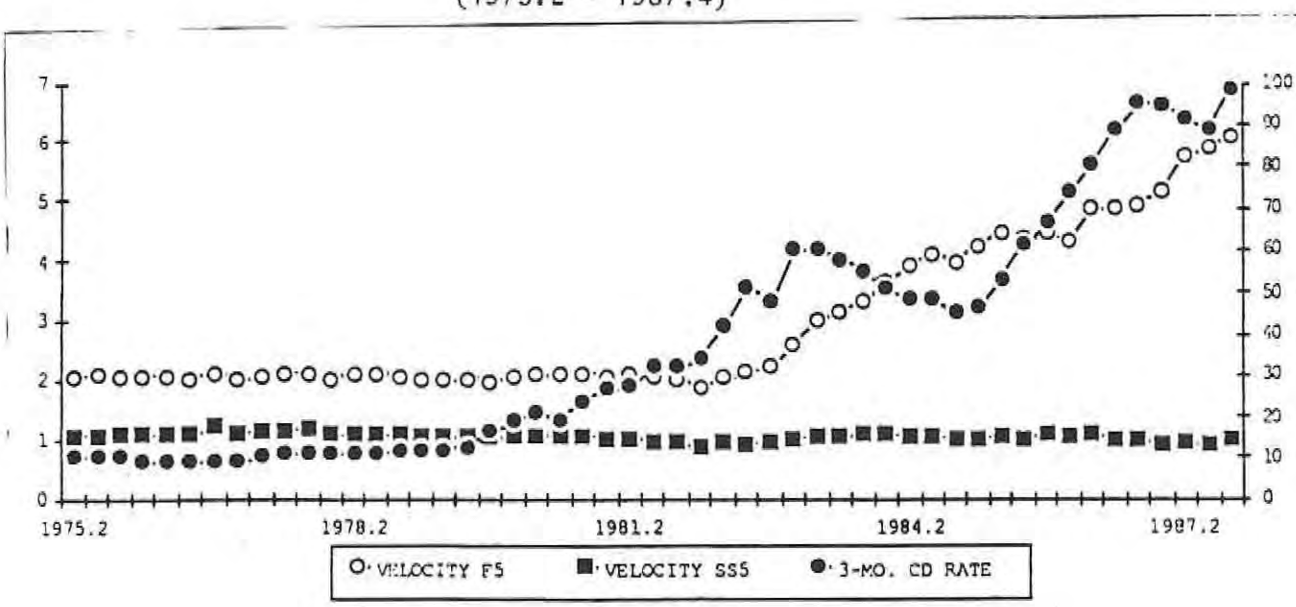
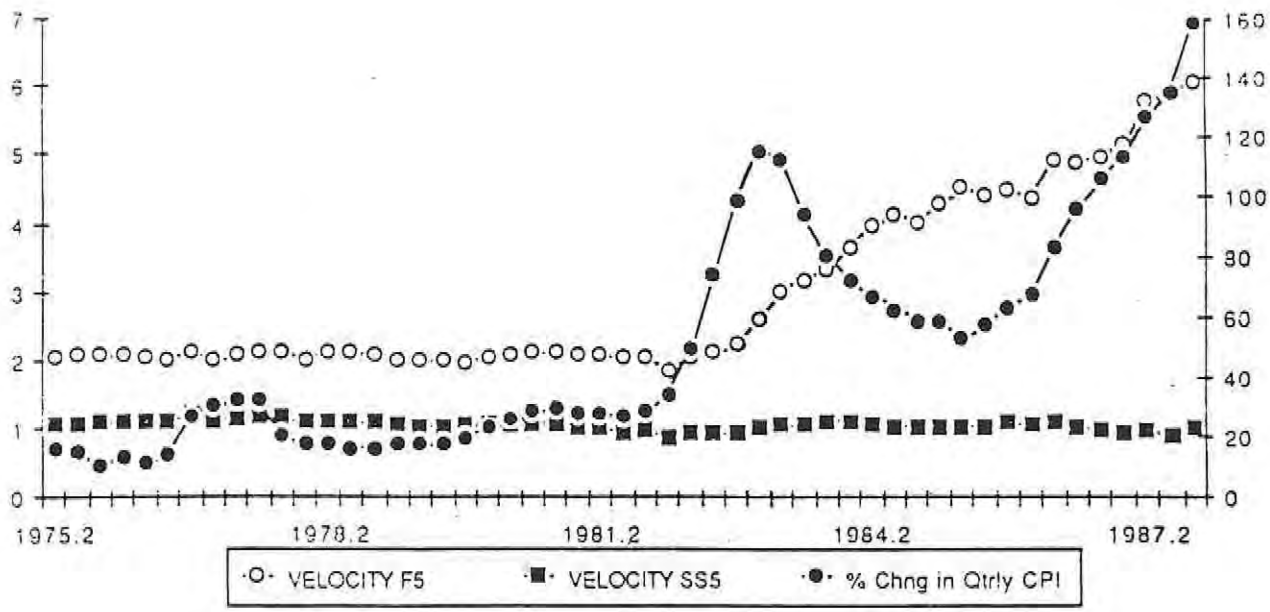


Figure 3.5

Velocity of Fisher M5 ("F5"), Velocity of Simple Sum M5 ('M5")

and Quarterly Inflation

(1975.2-1987. 4)



3.41 Results.

As stated above, the Simple Sum procedure, as opposed to any superlative index, is unable to internalize pure substitution effects, since changes in the interest rates result in changes in the simple sum aggregate, even when monetary services (quantity of money) flows do not change.

This section has shown the advantages of using a superlative index formula to measure the quantity of monetary services in the Mexican economy. The Fisher index correctly explains the behavior of the velocity of money (demand for monetary services) in the presence of rising interest rates and rising inflationary expectations; consumers switched away from monetary assets with lower rate of return to monetary assets with relatively higher rates of return. In other words, inflationary expectations make people to react in favor of higher yield assets in the attempt to cover their real wealth, thus decreasing the demand for monetary services. However, if we were to measure the real wealth the simple sum method is quite accurate, since adds up all the assets considered as real wealth.

Evidently the use of the simple sum procedure as a measure of the monetary services provides misleading signals; this matter has important policy implications because clearly provide inaccurate information about the real demand for money. Furthermore, the results in this section have shown that the simple sum monetary aggregates overestimates the real for monetary services -- relative to the Fisher Ideal, providing misleading signals about the real quantity of money in the economy; this may lead, eventually, to design improper monetary policies.

4. Conclusions.

This section has shown the advantages of using a superlative index formula to measure the quantity of money in the Mexican economy instead of the usual simple sum formula when applying several standard tests for a monetary aggregate. The bases for comparison are (1) the ability of each monetary aggregate to provide meaningful estimates of a usual demand for money function, (2) the forecasting properties of the estimated demand for money equations, (3) the degree of controllability of each aggregate; and (4) the ability of each monetary aggregate to explain the behavior of the income velocity.

All of these criteria of comparison are considered important in designing the shape of monetary policy. These tests include both sides of the market phenomenon, the demand and supply side. Under all these bases of comparisons the Fisher ideal quantity indexes (Fisher monetary aggregates) clearly perform better than their counterpart simple sum aggregates. Another general result is that the broader the level of aggregation, the more the Fisher aggregates outperform the simple sum indexes.

Regarding the results for the Demand for money functions, the Fisher aggregates using per capita data perform better than when the aggregate data are used. In this case the Fisher aggregates clearly outperform the simple sum aggregates. Simple sum aggregates perform better using aggregate data for the M1 and M2 levels.

In terms of the forecasting properties of the demand for money functions, the Fisher aggregates perform well for the M3, M4, and M5 levels of aggregation. Simple sum aggregates perform better than the Fisher aggregates for the M1 and M2 cases. In terms of the controllability criterion the Fisher aggregates clearly outperform simple sum for the M3, M4, and M5; although it can be noticed that neither aggregate dominates uniformly over the M1 and M2 levels of aggregation.

In terms of velocity, all Fisher aggregates and simple sum M1 and M2 perform rather well. However, we should point out that Fisher M5, M4, and M3 clearly provide the best results.

A logical step would be to select the best aggregate among all available candidates in order to propose and design monetary policy, but given the wide variety of the bases for the comparison, the selection procedure is quite complicated. The fact that the components of each aggregate are chosen subjectively makes it more difficult to select the best aggregate; the correct way to construct each aggregate is presented in Barnett (1981a). Belognia (1989) provides an interesting method based on aggregation theory to test which monetary assets can be used to construct a monetary aggregate. His method groups a set of financial assets which are weakly separable from other arguments in the utility function, namely other financial assets and consumer goods.[21]

Among all the Fisher monetary aggregates there is not a unique aggregate which dominates the others under all bases of comparison. Despite these drawbacks we recommend the use of all Fisher aggregates and simple sum M1 and M2, as the "best" aggregates now available to the policy makers for both the demand and supply side.

4. Suggestions for future research.

In this section we outline some ways in which this research could be extended in future work. First, the inclusion of more recent monetary data, namely 1988 and 1989 quarterly entries, and all the new monetary assets introduced after 1987; furthermore, the inclusion of the monetary holdings by various subgroups of economic agents would provide a different aggregate since they face different rates of return. Another suggestion for future research is to use alternative estimation procedures for the rate of return on assets denominated in foreign currency. The use of time series methods to forecast the expected rate of exchange would be a suitable approach.

[21] For a discussion of weak separability, see Barnett, (1981a) and Green (1964).

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