stic is denoted by H. When the null is linearity, ed by Z. In both cases, the distribution of the o produce a one-sided test, in which the null is ic is large.

Hinich (1986, p. 174) presented an equivalence at the Hinich bispectral linearity test statistic is of the data. This important result proves that *the d either to the raw series or to the residuals of a data*. Hence there is no need to choose between detrending or prefiltering the data. An addition- of the theorem is that if $x(t)$ is found to be als of a linear model of the form $y(t) = f(x(t))$ ce the nonlinearity in $x(t)$ will pass through any article further reported tables on the power of the etecting violations of the linearity and Gaussian- nber of sample sizes and M values. The table r for both tests, even when N is as small as 256, if tween 12 and 17. For this sample size, the power increases above 17.

eries conventions, we equate Gaussianity of the process with

d order polyspectrum, while the ordinary power spectrum is Strictly speaking, the polyspectrum of order k is the Fourier tion (not the moment function) of order k.

the coefficients of the terms in the power series expansion of stic function of a distribution, while the moments are the power series expansion of the *level* of the characteristic nlike the moments, the cumulants have the merit of being stationary time series with zero mean, the second and third entical to the second and third order moment functions. Only do the cumulant functions differ from the moment functions. second and third orders under the assumption of stationarity no distinction between moments and cumulants.

Commentary: Monetary Aggregates and Their Uses

by Julio J. Rotemberg

I agree completely with the thrust of the article by William Barnett, Melvin Hinich, and Piyu Yue (BHY). In common with earlier work by Barnett, they suggest that the widely used monetary aggregates M1 through L be replaced by aggregates which take into account the different "money-ness" of different monetary assets. Moreover, they recommend that these new aggregates be anchored in notions of money that make economic sense. To me these ideas seem unimpeachable, and my main question is why traditional aggregates remain so popular in the face of superior alternatives.

Barnett has long been on a campaign against the standard, numbered monetary aggregates. This is a good campaign; the use of M1, M2, M3, and L is indefensible. These standard aggregates are obtained by adding together things that clearly should not be a added together. Kuznets did not obtain a Nobel prize for suggesting that GNP be measured by adding together the tons of output produced in different industries. Nor did he have to come up with GNP1 through GNP20 to denote aggregates in which tons of ever more types of goods are added together.

Kuznets reasoned that it would be more economically meaningful to add together the tons of apples and raspberries by weighting them by the amount people are willing to pay for them. In the case of monetary assets, what people pay for them is the interest foregone from holding a relatively liquid asset. People give up more interest when they hold one additional dollar of currency than when they hold one additional dollar in a money market account. Currency costs more which, if people are rational, means that it performs some other service better. It is more "liquid" or "money-like." This suggests that simply adding together currency and money market accounts will give a misleading measure of the amount of liquidity services that people are purchasing.

Let m_t^i denote the units (dollars) of monetary asset i that people hold at t. Let r_t^i be the interest rate earned on asset i at t. More precisely, let $(1 + r_t^i)$ denote the total return (in dollars) at $t + 1$ from holding one unit of asset i at t. Finally, let r_t^b be the interest earned on a benchmark asset. This benchmark asset is one that provides no liquidity services. Because it provides fewer such services, this interest rate must exceed those on monetary assets. Following Kuznets, a naive measure of nominal expenditure on liquidity service at t is then:

$$\sum_i (r_t^b - r_t^i)m_t^i. \tag{1}$$

Note that this measures nominal $t+1$ expenditure on monetary assets held at t.

To obtain an index of quantity (or more accurately of change in quantity), Kuznets proposed that expenditure be computed also at the prices in some base period. Let r_0^i denote interest rates in the base period. Then, a Laspeyres index of monetary assets (which corresponds to measurements of GNP at base prices) is:

$$\sum_i (r_0^b - r_0^i)m_t^i. \tag{2}$$

This Laspeyres index was used in Barnett (1983).

These indices measure flows of expenditure on assets. Note that we are not measuring directly the flows of services provided by these assets. Measuring the services provided by a durable presents certain well-known difficulties. Even in the case of a physical asset such as an airplane the income produced by the asset is generally not a satisfactory measure of the service flow. The reason is that even an idle airplane offers some services by being available should the need arise. A more satisfactory measure of services can be obtained if one imagines that people equate (at least at the margin) the services they obtain to the cost of holding the durable. Then, one can measure the services by the amount foregone in order to hold the asset. That is what the indices advocated by Barnett achieve.

The indices (1) and (2) as well as the Divisia indices I discuss below measure flows, not stocks. Their dimension is dollars spent on assets (or percent changes of dollars spent on assets) as opposed to dollars of monetary assets. This does not seem like a big problem as long as one knows the prices (difference in returns) that convert stocks of assets into expenditures. In any event, it is easily remedied. Consider in particular the following index:

$$\mathrm{CE} \equiv \sum_i \frac{r_t^b - r_t^i}{r_t^b} m_t^i, \tag{3}$$

a stock measure which I call the currency equivalent (CE) measurement of liquidity. I give it this name because, as long as currency gives no interest, units of currency are added together with a weight of one. Other assets are added to currency but with a weight that declines toward zero as that asset's return increases. Assets whose return equals that of the benchmark return get a weight of zero as in (1) and (2). One advantage of CE over (2) is that the latter is sensitive to the choice of the base period if the level of the benchmark return varies over time. Since the CE measure does not involve a base period, it has the additional advantage that it is straightforward to add new monetary assets to the measure as these are created.

For many years, Barnett has advocated the use of Divisia aggregates. The Divisia aggregate at t can be approximated by D_t:

$$\log D_t = \log D_{t-1} + \left(\sum_i \frac{(r_t^b - r_t^i)m_t^i}{\Sigma_j (r_t^b - r_t^j)m_t^j}[\log m_t^i - \log m_{t-1}^i]\right). \tag{4}$$

Like its more naive counterparts (1), (2) and (3), the Divisia index gives more weight to the rate of growth of those monetary assets whose return is relatively low. The advantage of the Divisia index over the others is that, under certainty, it approximates well the change in the utility derived from monetary assets. For this approximation to be useful, the demand for monetary assets must be well approximated by the behavior of a representative individual whose utility function is given by:

$$E_t \sum_j \rho^j U\left(C_{t+j},\ V\left(\frac{m_{t+j}^1}{P_{t+j}} \cdots \frac{m_{t+j}^n}{P_{t+j}}\right)\right) \tag{5}$$

where E_t takes expectations conditional on information available at t, C_t represents consumption at t and P_t represents the dollar price of a unit of the aggregate consumption good at t.

Much has been written on the merits of the representative agent in macroeconomics, and here I can do little to advance this debate. I should mention however, that the fact that monetary assets are held for payment *between* agents may mean that distributional considerations are important and that aggregation of individual asset demands into the behavior of a representative individual is problematical.[1] Nonetheless, the only behavior-based currently available model of demand for liquid assets that is tractable and relatively general involves assets in the utility function of the representative agent.[2]

Under certainty, the Divisia index approximates (to third order) the changes in the V. This is an attractive feature because, as BHY show, changes in V have important consequences for individual behavior.

Unfortunately, these approximation properties appear to be lost when there is uncertainty and individuals are risk averse. Suppose that asset returns are random. Then, the ex post returns do not measure the expected opportunity cost of holding monetary assets. So, it is not appropriate to use ex post returns in (1), (3), and (4). Under risk neutrality, one could replace these ex post returns with the corresponding ex ante returns and I return to this idea below. First, I illustrate the problems introduced by risk aversion.

Consider an individual who maximizes (5) subject to the usual lifetime budget constraint. If the individual holds one more unit of monetary asset i (and one less unit of the benchmark asset), he will have to reduce his consumption at some point. Randomness in returns precludes reducing consumption only at t and leaving future consumption unaffected. Because the returns are random, the individual must wait until $t + 1$ to learn by how much consumption must be reduced. On the other hand, if the individual is optimizing, he is indifferent between reducing consumption only at $t + 1$ (the first time that he knows by how much consumption must fall) or reducing it partially in future periods as well. This means that the individual must be indifferent between holding one additional unit of asset i at t and consuming $(r_t^b - r_t^i)P_t/P_{t+1}$ less at $t + 1$. In other words:

$$\frac{\partial V}{\partial m_t^i/P_t} = E_t \frac{(r_t^b - r_t^i)P_t}{P_{t+1}} \frac{\partial U}{\partial C_{t+1}}. \tag{6}$$

The left-hand side of (6) gives the benefit from holding an additional unit of the monetary asset while the right-hand side gives the cost. The problem is that, with risk aversion, the ex post return on the benchmark asset is generally correlated with the marginal utility of consumption at $t + 1$. This means that the cost of holding monetary assets does not depend only on the expected return on the various assets. It also depends on their consumption "betas."

As a result formulae such as (1), (3), and (4) with expected returns substituted for ex post returns cannot approximate well the change in utility V. While this is a weakness, it is apparent even from (6) that the basic principle of more heavily weighting assets whose rate of return is lower in monetary aggregates is sound. Changes in these assets have a bigger effect on total utility because, as their cost is larger, their marginal utility must be larger as well.

An alternative solution is to estimate a parametric version of the utility function V directly. Estimation of such utility functions has a long history (see Chetty, 1969) though uncertainty and risk aversion have been incorporated only recently (Poterba and Rotemberg, (1987). This estimation involves fitting equations such as (6). After estimation of the utility function's parameters it is a simple matter to compute estimates of the monetary aggregate V.

Here I want to record two quibbles with the way the estimation is actually carried out by BHY. The first concerns their choice of benchmark return. They use the maximum ex post return among the assets included in the aggregate L. However, there is no asset in existence that actually has

this pattern of returns. More seriously, the assets in L all provide some liquidity services. It would be better to use the return on an asset that provides no such services. It is also important that the asset that is chosen be one for which returns are easily observable. This led Poterba and me to chose the returns on common stocks.

The second quibble is that BHY have not completely abandoned the use of numbered aggregates. They construct a utility-based measure for M1 and one for M2. In other words, they are still arbitrarily including and excluding assets from their measures. I would prefer that, once a benchmark asset is chosen, the utility be specified so that essentially all assets be permitted to contribute to utility directly. If an asset provides no liquidity services, that will be picked up in the estimation. Inspection of (6) reveals that estimation of these first order conditions implies that assets whose return is similar to that of the benchmark return will be deemed to provide no liquidity services.

Monetary aggregates have at least two uses. The first is as an input into elaborate forecasting models. Models such as these are used in practice to predict the effect of various monetary policies. The second is to convey a sense of the monetary stance to a vast audience of relatively informed observers of the economy. This vast audience does not rely on elaborate parametric models. Members of this audience gather a relatively small number of aggregate statistics on the economy and use either simple models or their intuition to interpret these aggregates. This audience seeks at least two properties of monetary aggregates. The first is that there be a relatively small number of aggregates that convey a relatively large fraction of monetary information. The second is that the numbers be relatively easy to interpret.

I agree with BHY that, for this second audience, aggregates of the form (1), (2), (3), or (4) are likely to be much superior to current monetary aggregates. I also agree that these aggregates should be monitored by estimation of utility functions. Big departures of the aggregates from estimated versions of V should lead to revisions in the compilation of the aggregates.

The main mystery here is why the existing monetary aggregates have proved so durable in spite of Barnett's demonstration that Divisia aggregates are more useful in forecasting, say, changes in income.[3] My own interpretation is that virtues of the new aggregates have not been contrasted sufficiently to the deficiencies of the old.

The deficiencies of the old are not just theoretical. Because essentially irrelevant compositional shifts affect the traditional measures, intelligent

Table 1. Monetary Indicators and Short-Term Inflation; Log Change in CPI Is Dependent Variable

Independent Variable			
Log change in CPI(−1)	0.407 (0.042)	0.429 (0.049)	0.431 (0.050)
Log change in CPI(−2)	0.325 (0.049)	0.347 (0.049)	0.347 (0.050)
Log change in Base(−1)	0.177 (0.042)		
Log change in M1(−1)		0.056 (0.024)	
Log change in M2(−1)			0.043 (0.037)

Notes: Monthly data from February 1959 to June 1989. Standard errors in parentheses. Constants omitted.

observers must keep track of several monetary aggregates at once. They cannot afford to focus on just one monetary aggregate. I will illustrate this by looking at the prediction of inflation.

People are interested in predicting inflation in the next month and also in getting a sense of the long-term trend in inflation. Ideally a single monetary aggregate would convey information about both. Unfortunately, of the current aggregates some are better for short-term forecasting, others for long-term forecasting. Table 1 reports regressions of the monthly inflation in the CPI on two lags of inflation and the lagged value of three monetary aggregates. Of these three, the base has the biggest and most significant coefficient followed by M1 with M2 performing poorest.

For long-term forecasting, it is better to look at the stability of velocity. This is the basis of the P^* method of Hallman, Porter, and Small (1989) who recommend using M2 velocity for long-term inflation forecasting. If velocity is stable and one has some confidence in one's long-run forecast for output, then long-term inflation can be predicted from monetary growth numbers. If velocity is unstable then, even if one is certain of long-term output growth, long-term inflation has little to do with long-term trends in money.

The velocity of M2 is more stable than either that of the base or of M1. If one divides monthly observations of personal income by monthly observations of the three aggregates, one obtains an estimate of the three

Table 2. Long-Term Stability of Velocity; Log Velocity Is Dependent Variable

Independent Variable	*Base Velocity*	*M1 Velocity*	*M2 Velocity*
Velocity(−1)	0.996 (0.006)	0.997 (0.004)	0.981 (0.008)
Change in velocity(−1)	0.011 (0.053)	0.131 (0.052)	0.179 (0.052)
Change in velocity(−1)	0.083 (0.052)	0.137 (0.053)	0.171 (0.052)
Trend	6.2e–7 (1e–5)	1.8e–6 (1e–5)	5.9e-6 (3.2e-6)

Notes: Monthly data from April 1959 to June 1989. Standard errors in parentheses. Constants omitted.

velocities. The standard deviation of the logarithm of the level of velocity is 0.19, 0.24, and 0.04 when one uses the base, M1, and M2, respectively. Not surprisingly, given this fact, M2 velocity also returns fastest to its normal value. This is demonstrated in table 2.

This table reports regressions of each (logarithmic) level of velocity on a constant, a linear trend, the lagged level of velocity, and two lags of the changes in velocity. A random walk (which never returns to normal) would involve a coefficient of 1 on the lagged dependent variable. It is apparent from the table that M2 velocity has the smallest coefficient on the lagged dependent variable so that it returns to normal fastest. Thus the evidence for a unit root in the velocity series is weakest in the case of M2. This and the low variance of M2 velocity both suggest that M2 is indeed the most attractive measure if one is to adopt the P^* method.

My interpretation for the differing behavior of the aggregates for short-term and long-term prediction is the following. What matters for inflation is the amount of liquidity in the economy. Because assets with low interest rates are more liquid, the changes in these assets convey most information about short-term inflation. Unfortunately, there exist also essentially irrelevant compositional shifts like the shift (for those with large savings accounts) from super NOW accounts at commercial banks to money market accounts at commercial banks. These shifts affect the base and M1 but occur sufficiently slowly that they do not degrade very much their usefulness for short-term forecasting. On the other hand, because these shifts are long lasting, they make aggregates such as the base and M1 very poor at predicting long-term trends in inflation. For that purpose, it is better to use broader aggregates which are less affected by compositional shifts.

The major advantage of the aggregates given in (1) through (4) is that, while they are affected mostly by changes in the assets with zero interest, they are also less likely to be affected by irrelevant compositional shifts. Thus, a single aggregate of this type might end up conveying useful information about *both* short-term and long-term inflation.

In terms of leading to a stable level of velocity there is some reason to expect the CE index to behave better than the Divisia index if both are measured using expected returns. It is impossible to measure expected returns perfectly. Such measures will contain some error. Unfortunately, any error in measuring expected returns at time t affects the level of the Divisia index forever. The reason is that the Divisia index is a chained index; current measurements affect only the change in the index. By contrast, any measurement error affects the CE index only during the interval where the measurement error actually occurs. This suggests that the need for checking that the measured indices do not drift apart from the underlying theoretical aggregate V is particularly acute in the case of Divisia aggregates.

One additional advantage of the CE index is that it involves one less measurement. While the Divisia requires that we measure the expected nominal return on all assets, the CE index requires only that we measure the expected values of the relative returns r^i/r^b. These considerations as well as its ease of interpretation suggest that the CE measure deserves further study even though, under certainty, its use would be less justifiable than that of the Divisia aggregate.

So far I have only discussed the use of monetary aggregates by the informed public at large. I now turn to their use by those who employ elaborate econometric models. Such models are regularly used to inform monetary policy. Should such models use the new aggregates? Certainly, this seems appropriate if these models are to consist of a series of equations only loosely related to economic behavior. Such models are best interpreted as reduced forms and the new monetary aggregates are likely to be more closely related to the variables economic agents actually care about.

But, once the process of monitoring the behavior of monetary aggregates involves the estimation of parametric utility functions, it is hard to see why these estimated utility functions are not used directly for forecasting. In other words, like the usual econometric models, the estimated utility function is parametric. These parameters are not just useful for obtaining monetary aggregates. They also can be used to derive coherent

systems of asset demand equations.[4] These coherent systems of demand equations can be used directly to gauge the effect of open market operations and the like. My hope is that, as the utility approach to thinking about the aggregation of liquid assets comes to be accepted, its usefulness for obtaining estimates that are useful in gauging the effects of monetary policy will come to be appreciated as well.

Notes

1. See Grossman and Weiss (1983) and Rotemberg (1984) for models where these distributional considerations are important.
2. Or equivalently, assets that affect the transactions cost of the representative agent. See Feenstra (1986).
3. See, for instance, Barnett, Spindt, and Offenbacher (1984).
4. They are coherent in that they embody the restrictions stressed by Tobin and Brainard (1968).

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