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Introduction to the St. Louis Monetary Services Index Project

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Economists have long recognized that equilibrium between the demand for and supply of money is the primary long-run determinant of an economy's price level. There is far less agreement, however, on how to measure the aggregate quantity of money in the economy. The Federal Reserve Bank of St. Louis' monetary services index project seeks to provide researchers and policymakers with an extended database of new measures of monetary aggregates—the monetary services indexes (MSIs)—and related data.¹

The monetary services indexes differ considerably from the monetary aggregates that have been published by the Federal Reserve Board for more than 35 years, even though both begin with the same basic observation: Consumers hold monetary assets in equilibrium because the assets provide valuable services and hence increase utility.² The increased utility arises, in part, because some of the assets are media of exchange. Other things equal, a larger quantity of such assets reduces shopping time, permits immediate purchase of bargain-priced goods, provides a cushion against unanticipated expenses, and reduces the amount of time spent on cash management. Assets that are not media of exchange, such as mutual fund shares and savings and time deposits, may also increase utility, especially if they are

readily convertible to an asset that is a medium of exchange. Samuelson (1947), for example, noted that

... it is a fair question as to the relationship between the demand for money and the ordinal preference fields met in utility theory. In this connection, I have reference to none of the tenuous concepts of money, as a numeraire commodity, or as a composite commodity, but to money proper, the distinguishing features of which are its indirect usefulness, not for its own sake but for what it can buy, its conventional acceptability, its not being "used up" by use, etc., etc.

Possession of an average amount of it [money] yields convenience in permitting the consumer to take advantage of offers of sale, in facilitating exchanges, in bridging the gap between receipt of income and expenditure, etc. The average balance is both used and at the same time not used; it revolves but is not depleted; its just being there to meet contingencies is valuable even if the contingencies do not materialize, ex post. Possession of this balance then yields a real service, which can be compared with the direct utilities from the consumption of sugar, tobacco, etc., in the sense that there is some margin at which the individual would be indifferent between having more tobacco and less of a cash balance, with all of the inconvenience which the latter condition implies (pp. 117-18).

The monetary services indexes are based on microeconomic models of consumer and firm decision making that do not impose strong *ex ante* assumptions regarding the elasticities of substitution among monetary assets. Consumer demand for monetary assets, for example, can be modeled as arising from the choices made by a representative consumer maximizing a utility function, subject to a

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¹ Monetary services indexes have sometimes been referred to as Divisia monetary aggregates because their construction uses a discrete approximation to Divisia's (1925) continuous-time index. We label our monetary quantity indexes MSI to emphasize that they measure a flow of monetary services, not a stock of monetary assets.

² See Anderson and Kavajecz (1994), Kavajecz (1994), and Whitesell and Collins (1996) for descriptions of the Federal Reserve Board's monetary aggregates.

budget constraint, that includes both stocks of real monetary assets and quantities of non-monetary goods and services.³ In this model, monetary assets are treated as durable goods that furnish a flow of monetary services to the consumer. The appropriate opportunity cost for a durable good is its rental equivalent price, or user cost. The consumer's user cost of a monetary asset is the present value of the interest foregone by holding the monetary asset, discounted to account for the payment of interest at the end of the period.

This decision problem may be formalized by assuming that the consumer maximizes the utility function, $U(m_1, \dots, m_n, q_1, \dots, q_m)$, subject to the budget constraint

$$\sum_{i=1}^n \pi_i m_i + \sum_{j=1}^m p_j q_j = Y,$$

where $m = (m_1, \dots, m_n)$ is a vector of the stocks of real monetary assets, $\pi = (\pi_1, \dots, \pi_n)$ is a vector of user costs of monetary assets, $q = (q_1, \dots, q_m)$ is a vector of quantities of non-monetary goods and services, $p = (p_1, \dots, p_m)$ is a vector of prices of non-monetary goods and services, and Y is the consumer's total current-period expenditure on monetary assets and on non-monetary goods and services. The solution to this problem yields demand functions for real monetary assets and for quantities of non-monetary goods and services:

$$m_i^* = f_i(\pi, p, Y), \text{ for } i=1, \dots, n, \text{ and}$$

$$q_j^* = g_j(\pi, p, Y), \text{ for } j=1, \dots, m.$$

The monetary aggregation problem is to combine the quantities of various individual monetary assets, m_1, \dots, m_n , and their user costs, π_1, \dots, π_n , into a smaller number of aggregate quantity and opportunity cost measures.

The monetary aggregates published by the Federal Reserve Board are constructed by summing the dollar values of the stocks of the monetary assets included in each aggregate. Summation implicitly assumes that the assets' owners regard them as perfect substitutes. Yet, according

to microeconomic demand theory, if these assets were in fact perfect substitutes, rational consumers would choose to hold only a single asset, unless all the assets had the same user cost. Thus, measuring a monetary aggregate by summing the dollar values of the included assets is not generally consistent with the economic theory of consumer decision making.

A method of aggregation that is consistent with microeconomic theory was suggested by Barnett (1980). In his formulation, the consumer's utility function is assumed to have a special form, in which the quantities of monetary assets held during the current decision period are said to be *weakly separable* from the quantities of other goods and services. In this case, the utility function $U(m_1, \dots, m_n, q_1, \dots, q_m)$ may be written as $U[u(m_1, \dots, m_n), q_1, \dots, q_m]$. The function, $u(m_1, \dots, m_n)$, called a *category subutility function*, measures the amount of monetary services that the consumer receives from holding the monetary assets, m_1, \dots, m_n . During any single period, the marginal rate of substitution between monetary assets m_i and m_j may be expressed in terms of the derivatives of $u(m_1, \dots, m_n)$ as

$$\frac{\partial u(m_1, \dots, m_n)}{\partial m_i} / \frac{\partial u(m_1, \dots, m_n)}{\partial m_j}.$$

Note that these derivatives, and hence the consumer's willingness to substitute among monetary assets during the current period, do not depend on the quantities of the other goods consumed, q_1, \dots, q_m , but solely on the quantities of monetary assets, m_1, \dots, m_n , that the consumer holds during the current period.

Barnett's approach allows us to discuss the representative consumer's choice problem as if it were solved in two stages. In the first stage, the consumer selects (1) the desired total outlay on real monetary services (but not the quantities of individual monetary assets), and (2) the quantities of all non-monetary individual goods and services. In the second stage, the consumer selects the quantities of the individ-

³ Note that the quantities of real, not nominal, monetary assets enter the utility functions. The stock of a real monetary asset equals its nominal dollar quantity, deflated by an index of the economy's overall price level, such as the CPI or the GDP deflator. See the next paper in this issue for further discussion.

ual real monetary assets, m_1, \dots, m_n , conditional on the total outlay on monetary services selected in the first stage, that provide the largest possible quantity of monetary services.

This two-stage budgeting model of consumer behavior implies that the category subutility function, $u(m_1, \dots, m_n)$, is an *aggregator function* that measures the total amount of monetary services received from holding monetary assets. If we let m_1^*, \dots, m_n^* denote the optimal quantities of monetary assets chosen by the consumer, we can regard the aggregator function as defining a *monetary aggregate*, M , via the relationship $M = u(m_1^*, \dots, m_n^*)$.⁴ A major difficulty remains, however: The specific form of the aggregator function is usually unknown. Diewert (1976) and Barnett (1980) have established that, in this model, the aggregator function at the optimal quantities, $M = u(m_1^*, \dots, m_n^*)$, may be approximated by a statistical index number. The monetary services indexes presented in this issue of the *Review* are *superlative statistical index numbers*, as defined by Diewert (1976).⁵

Our methodology for measuring the monetary services indexes lies solidly in the mainstream of current macroeconomic research. The theory and methods are the same as those that underlie the Department of Commerce's recently adopted measures of economic aggregates, such as GDP (Triplett, 1992; Young, 1992, 1993) and those suggested by the Advisory Commission to Study the Consumer Price Index (1996). Prior to recent revisions, the Department of Commerce measures were fixed-base Laspeyres index numbers; the new measures are chained superlative indexes. The Advisory Commission to Study the Consumer Price Index (1996) recommends that the Bureau of Labor Statistics calculate the CPI as a superlative index number, and that rental-equivalent user costs be used for consumer durable goods. The indexes presented in our article, "Building New Monetary Services Indexes: Concepts, Methodology, and Data," in this issue of the *Review*, are chained superlative indexes and hence have the same statistical properties as Com-

merce's new measures and those suggested by the Advisory Commission.

In addition to its consistency with other aggregation methods, a second advantage of the index-number approach to monetary aggregation is that it produces internally consistent dual opportunity costs. These cost measures are related to the monetary services indexes in the same way that the Department of Commerce's measure of the GDP deflator is related to GDP. Finally, we note that our methodology is consistent with the foundations of modern general-equilibrium business cycle theory, which often begins with the hypothesis of an optimizing microeconomic representative agent (Cooley and Hansen, 1995). As a result, the monetary services indexes may be a particularly valuable improvement in measurement that complements innovations in economic business-cycle modeling.

Recent empirical research suggests that conclusions regarding issues such as the interest and income elasticities of money demand, and the long-run neutrality of money, may be sensitive to the method of measurement of monetary aggregates. In other words, empirical conclusions may differ when money is measured by the flow of monetary services, rather than by summation of the dollar amounts of monetary assets (see Barnett, Offenbacher, and Spindt, 1984; Barnett, Fisher, and Serletis, 1992; Chrystal and MacDonald, 1994; and Belongia, 1996). Such findings have spurred the construction of MSI data for many countries. Academic studies include la Cour (1996), for Denmark; Janssen and Kool (1994), for the Netherlands; and Lim and Martin (1994), for Australia. Central bank studies include: Herrmann, Reimers, and Toedter (1994), for Germany; Ishida and Nakamura (1994), for Japan; Longworth and Atta-Mensah (1994), for Canada; and Fisher, Hudson, and Pradhan (1993), for the United Kingdom. Unique among central banks, the Bank of England publishes monetary services indexes alongside other monetary aggregates.

Although several previous measures of monetary services have been produced for

⁴ See Green (1964).

⁵ Diewert (1992) provides a concise, authoritative survey of index number theory.

the United States, our indexes are not extensions of previous series.⁶ We have fully reexamined the sustainability and credibility of the assumptions and methodology used to construct previous indexes, retaining some and discarding others, to create the new measures presented in this issue. We also have reexamined the sources of the component data that were used in earlier indexes. Where we have been unable to document previously used data, we have replaced the data with series obtained or constructed from known, documented sources.

The first article following this introduction, "Monetary Aggregation Theory and Statistical Index Numbers," surveys the literature on the aggregation of monetary assets and summarizes theoretical results not readily available elsewhere. The article develops a dynamic, intertemporal consumer decision model and explains how monetary aggregation conditions may be obtained from a model of a competitive firm. Because the analysis is based on dynamic microeconomic theory, some aspects are necessarily technical.

Readers primarily interested in understanding the construction of the monetary services indexes and related series might prefer to move directly to the second article, "Building New Monetary Services Indexes: Concepts, Data, and Methods." This article describes the indexes' construction in detail and provides a road map of the St. Louis MSI database. The database contains the MSIs and their dual price indexes; quantities, user costs, and own-rates of return for the indexes' components; the currency-equivalent (CE) monetary index suggested by Rotemberg, Driscoll, and Poterba (1995); heretofore unpublished second moments of the MSIs, which were suggested by Barnett and Serletis (1990) as useful measures of the amount of (statistical) aggregation error contained in the MSIs; and a measure of aggregate total expenditures on the services of monetary assets. In addition to these derived series, the database includes the computer programs used to construct the MSIs and related aggregates. To facilitate comparison with monetary aggregates

published by the Federal Reserve Board, the MSIs and related data in the database are provided for the same groupings of monetary assets—M1, M2, M3, and L—as well as for other widely-used aggregates such as M1A (currency plus non-interest-bearing checkable deposits) and MZM (M2 less small time deposits). The indexes are provided at monthly, quarterly, and annual frequencies. The empirical properties of these data are explored in a third paper, "The Monetary Services Index Numbers: Analysis and Extensions," forthcoming in this *Review* later in 1997.

Our monetary services indexes and related data are available on the Federal Reserve Bank of St. Louis' World Wide Web server at www.stls.frb.org/research. The data will be updated and revised by the staff of the Federal Reserve Bank of St. Louis as new numbers become available. We hope that the indexes and related data provided by the St. Louis MSI project will stimulate further research on the aggregation of monetary and financial assets, and on the roles of such variables in the conduct of monetary policy. Further, the wide range of data included in the MSI database likely will allow researchers to develop better models of the demand functions for individual monetary assets, as well as for monetary aggregates.

REFERENCES

- Advisory Commission to Study the Consumer Price Index. *Toward a More Accurate Measure of the Cost of Living*, Final Report to the Senate Finance Committee, December 1996.
- Anderson, Richard G., and Kenneth A. Kavajecz. "A Historical Perspective on the Federal Reserve's Monetary Aggregates: Definition, Construction and Targeting," this *Review* (March/April 1994), pp. 1-31.
- Barnett, William A. "The Microeconomic Theory of Monetary Aggregation," *New Approaches to Monetary Economics: Proceedings of the Second International Symposium in Economic Theory and Econometrics*, William A. Barnett and Kenneth J. Singleton, eds., Cambridge University Press, 1987, pp. 115-68.
- _____. *Consumer Demand and Labor Supply: Goods, Monetary Assets, and Time*, Amsterdam: North Holland Publishing Company, 1981.

⁶ See Barnett (1980, 1981, 1987), Barnett and Spindt (1982), Farr and Johnson (1985), and Thornton and Yue (1992).

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- _____. "Economic Monetary Aggregates: An Application of Index Number and Aggregation Theory," *Journal of Econometrics* (Summer 1980), pp. 11-48.
- _____ and Apostolos Serletis. "A Dispersion-Dependency Diagnostic Test for Aggregation Error: With Applications to Monetary Economics and Income Distribution," *Journal of Econometrics* (January/February 1990), pp. 5-34.
- _____ and Paul A. Spindt. "Divisia Monetary Aggregates: Compilation, Data, and Historical Behavior," Staff Studies 116, Board of Governors of the Federal Reserve System, May 1982.
- _____, Douglas Fisher, and Apostolos Serletis. "Consumer Theory and the Demand for Money," *Journal of Economic Literature* (December 1992), pp. 2086-119.
- _____, Edward K. Offenbacher, and Paul A. Spindt. "The New Divisia Monetary Aggregates," *Journal of Political Economy* (December 1984), pp. 1049-85.
- Belongia, Michael T. "Measurement Matters: Recent Results from Monetary Economics Reexamined," *Journal of Political Economy* (October 1996), pp. 1065-83.
- Chrystal, K. Alec, and Ronald MacDonald. "Empirical Evidence on the Recent Behavior and Usefulness of the Simple-Sum and Weighted Measures of the Money Stock," this *Review* (March/April 1994), pp. 73-109.
- Cooley, Thomas F., and Gary D. Hansen. "Money and the Business Cycle," *Frontiers of Business Cycle Research*, Thomas F. Cooley, ed., Princeton University Press, 1995, pp. 175-216.
- Diewert, W. E. "Index Numbers," *The New Palgrave Dictionary of Money & Finance*, Peter Newman, Murray Milgate, and John Eatwell, eds., Stockton Press, 1992, pp. 364-79.
- _____. "Exact and Superlative Index Numbers," *Journal of Econometrics* (May 1976), pp. 115-45.
- Divisia, Francois. "L'Indice Monétaire et la Théorie de la Monnaie," *Revue d'Economie Politique* (1925), pp. 980-1008.
- Farr, Helen T., and Deborah Johnson. "Revisions in the Monetary Services (Divisia) Indexes of the Monetary Aggregates," Staff Studies 147, Board of Governors of the Federal Reserve System, December 1985.
- Fisher, Paul, Suzanne Hudson, and Mahmood Pradhan. "Divisia Indices for Money: An Appraisal of Theory and Practice," Working Paper Series No. 9, Bank of England, April 1993.
- Green, H. A. John. *Aggregation in Economic Analysis: An Introductory Survey*, Princeton University Press, 1964.
- Herrmann, Heinz, Hans-Eggert Reimers, and Karl-Heinz Toedter. "Weighted Monetary Aggregates for Germany," working paper, Deutsche Bundesbank, July 1994.
- Ishida, Kazuhiko, and Koji Nakamura. "Broad and Narrow Divisia Monetary Aggregates for Japan," working paper, Bank of Japan, 1994.
- Janssen, Norbert G.J., and Clemens J.M. Kool. "The Measurement and Relevance of Weighted Monetary Aggregates in the Netherlands," working paper, University of Limburg, August 1994.
- Kavajecz, Kenneth A. "The Evolution of the Federal Reserve's Monetary Aggregates: A Timeline," this *Review* (March/April 1994), pp. 32-66.
- la Cour, Lisbeth F. "On the Measurement of 'Money': Results From the Experience with Divisia Monetary Aggregates for Denmark," working paper, University of Copenhagen, 1996.
- Lim, G.C., and Vance L. Martin. "Weighted Monetary Aggregates: Empirical Evidence for Australia," working paper, University of Melbourne, September 1994.
- Longworth, David, and Joseph Atta-Mensah. "The Canadian Experience with Weighted Monetary Aggregates," working paper, Bank of Canada, October 1994.
- Rotemberg, Julio J., John C. Driscoll, and James M. Poterba. "Money, Output, and Prices: Evidence from a New Monetary Aggregate," *Journal of Business and Economic Statistics* (January 1995), pp. 67-83.
- Samuelson, Paul A. *Foundations of Economic Analysis*, Harvard University Press, 1947.
- Thornton, Daniel L., and Piyu Yue. "An Extended Series of Divisia Monetary Aggregates," this *Review* (November/December 1992), pp. 35-52.
- Triplet, Jack E. "Economic Theory and BEA's Alternative Quantity and Price Indexes," *Survey of Current Business* (April 1992), pp. 49-52.
- Whitesell, William C., and Sean Collins. "A Minor Redefinition of M2," Finance and Economics Discussion Series paper no. 96-7, Board of Governors of the Federal Reserve System, February 1996.
- Young, Allan H. "Alternative Measures of Change in Real Output and Prices, Quarterly Estimates for 1959-92," *Survey of Current Business* (March 1993), pp. 31-41.
- _____. "Alternative Measures of Change in Real Output and Prices," *Survey of Current Business* (April 1992), pp. 32-48.