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# Divisia Monetary Services Indexes for Switzerland: Are They Useful for Monetary Targeting?

FROM 1973 TO 1989, INFLATION in Switzerland was roughly one-half that in the United States. For example, consumer prices in Switzerland rose 3.5 percent per year during this 16-year period compared with the 6.6 percent average annual rise in U.S. consumer prices. Similarly, Swiss wholesale prices rose at an annual rate of 2 percent during this period in contrast to the nearly 6 percent annual average increase in the U.S. producer price index. Indeed, the Swiss inflation experience, along with that of West Germany, is often cited as an excellent example of the gains that accrue to a nation whose central bank conducts monetary policy by announcing—and achieving—a target for the growth of a monetary aggregate.

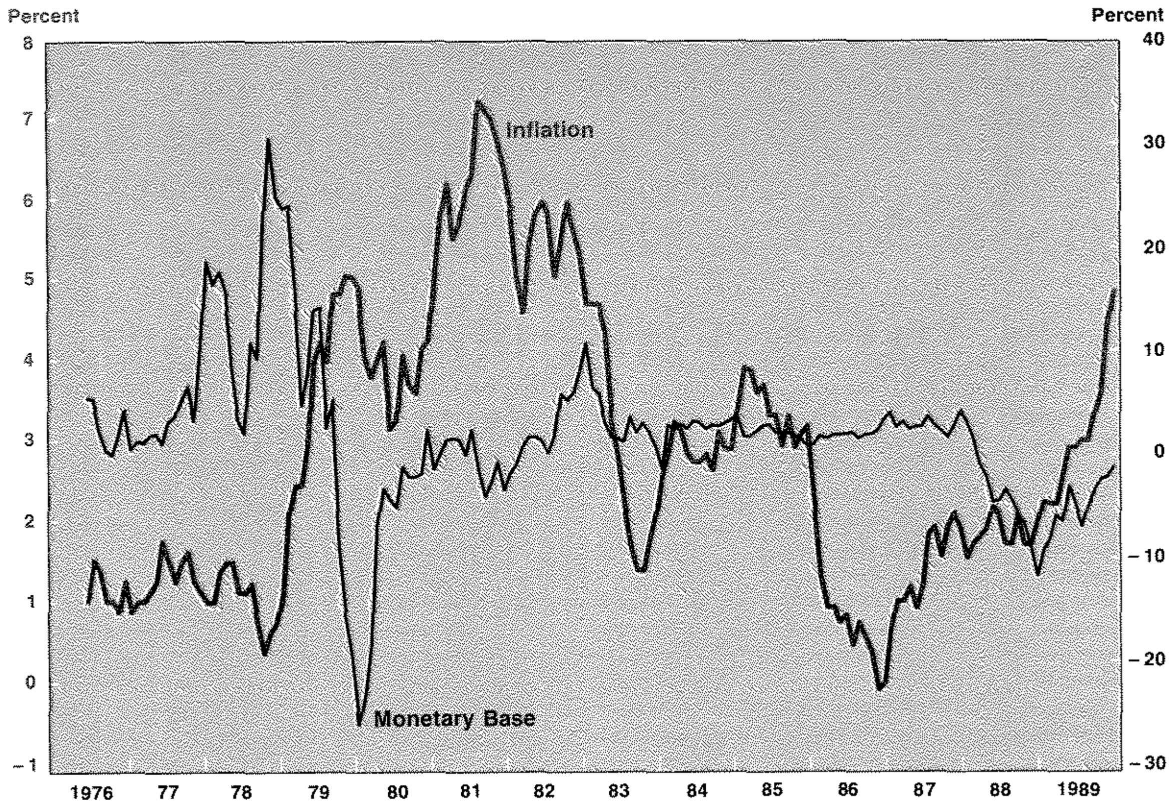
The Swiss central bank has used monetary base growth rate targets since 1980. Because the historical relationships between monetary base growth and economic activity have changed markedly since the end of the 1980s, the Swiss have begun to reconsider the use of annual monetary aggregate targets, and are considering the potential usefulness of broader monetary aggregates as indicators of monetary policy.

This paper develops two alternative broader monetary aggregate measures, Divisia M1 and M2, for Switzerland and compares their potential usefulness as monetary indicators with the Swiss M1 and M2 aggregates as usually defined. First, however, we show why questions have been raised about the continued usefulness of the annual monetary base growth rate target in Switzerland. We then discuss the methodology underlying the Divisia approach to constructing monetary aggregates and use this methodology to derive Swiss Divisia M1 and M2 measures. Next, we examine the relationship between Swiss inflation and the growth rates of Swiss M1 and M2 and the Swiss Divisia M1 and M2 aggregates to determine their relative usefulness as monetary policy indicators. Finally, we examine the relationships between these various monetary aggregates and the monetary base to assess the extent to which the Swiss central bank could control their growth.

## SOME BACKGROUND ON THE SWISS MONETARY BASE

Prior to 1986, the relationship between the monetary base and economic activity in Switzerland was quite close; this link, however, has broken down since then. The sudden change

Figure 1
**Inflation and Swiss Monetary Base Growth**




can be illustrated, in part, by looking at the relationship between inflation and the growth rate of the monetary base as depicted in figure 1. Until 1986, Swiss inflation movements lagged about three years behind corresponding variations in the base money growth rate. Since 1986, however, this pattern no longer holds. For example, the sharp drop in Swiss inflation in 1986 was attributable to substantial reductions in the prices of imported goods. Consequently, it appears that monetary base growth neither contributed to this decline nor provided any warning that it would occur; indeed, the growth of the Swiss monetary base was virtually constant from 1984-1987.

Similarly, movement in the Swiss monetary base from 1987-1989 (in particular, the sharp drop in 1988) yielded neither warning nor explanation of the sharp rise in Swiss inflation in 1989. This change followed two significant institutional innovations in the Swiss banking system. First, a new electronic interbank payment system (Swiss Interbank Clearing System, SIC) was introduced in the summer of 1987. Then, on January 1, 1988, reduced reserve requirements on Swiss bank deposits went into effect. In response to these changes, Swiss banks have sharply reduced their reserve balances at the Swiss National Bank (SNB). Swiss bank reserves dropped from more than SF8 billion (about $5.5 billion) at the end of 1987 to SF3 billion (about $2.1 billion) by the end of 1989.

As a result of changes in the relationship between the monetary base and inflation, the continued usefulness of the monetary base as a monetary policy indicator has been questioned. One suggestion is to rely more on broader monetary aggregates as monetary policy indicators.

## MONETARY AGGREGATION

Generally, central banks worldwide use essentially identical procedures to construct their nations' monetary aggregates. They first define the specific aggregate—that is, they determine which financial components it will include—and then they simply "add" its selected components together. Not too surprisingly, these monetary aggregates are called "simple-sum" aggregates.

Simple-sum aggregation has been criticized for failing to distinguish between the differing degrees of monetary (transaction) services and store-of-value services provided by the components in the monetary aggregate. Presumably, only the former (that is, monetary or transaction) services should be included when a monetary aggregate is considered. Friedman and Schwartz (1970) have described this problem:

> This [summation] procedure is a very special case of the more general approach discussed earlier. In brief, the general approach consists of regarding each asset as a joint product having different degrees of "moneyness," and defining the quantity of money as the weighted sum of the aggregate value of all assets, the weights for individual assets varying from zero to unity with a weight of unity assigned to that asset or assets regarded as having the largest quantity of "moneyness" per dollar of aggregate value. The procedure we have followed implies that all weights are either zero or unity. The more general approach has been suggested frequently but experimented with only occasionally. We conjecture that this approach deserves and will get much more attention than it has so far received. (pp. 151-52)

As Friedman and Schwartz surmised, economic aggregation theory and statistical index number theory have been used to provide both theoretical and empirical solutions to the problem of monetary aggregation.[1] This research has led to the development of alternative monetary aggregates, in particular, the Divisia monetary service measure.[2]

### *The Divisia Index Number*

Index numbers are widely used to provide a single broad measure for a disparate collection of items. Well-known examples of index numbers are the industrial production index, the consumer price index and the producer price index. These index numbers depend upon both the prices and quantities of items included in the index because the values of commodities involved are determined by their physical quantities and corresponding prices.

Because quantities of financial assets are measured in terms of "dollars," simply adding the balances of various monetary components would appear to be a natural approach to measuring monetary aggregates. Consequently, it is not surprising that simple-sum monetary aggregates have been used extensively throughout the world. However, economic theory suggests that various monetary aggregate components differ in terms of their "liquidity" and, thus, may have substantially different effects on economic activity. If this is so, the simple-sum procedure may actually be inappropriate for measuring "monetary service flows" in the nation. Instead, an alternative approach that involves calculation of Divisia indices may provide superior alternatives to measuring monetary aggregates when compared with the traditional simple-sum monetary measures.

Theoretically, the Divisia index number is derived from the economic aggregation theory and first-order conditions for utility optimization. An expanded discussion of the Divisia approach appears in appendix 1 of this paper. Empirically, the Divisia index number is estimated from a nonlinear function of the quantities and the corresponding *prices* of individual components that create the aggregate. Moreover, its growth rate is a linear combination of the growth rates of its components, where the weights (or coefficients) on the components are their average *expenditure* shares. In comparison, the simple-sum index is the linear sum of the quantities of the components in which the weight (coefficient) given to each component is *unity* and their prices have no effect on the index. The growth rate of the simple-sum index is also a linear combination of the growth rates of its

[1]See Barnett (1980).

[2]Use of Divisia monetary aggregates appears in Barnett and Spindt (1982), Donovan (1978), Farr and Johnson (1985), Belongia and Chalfant (1989), among others.

components, where the coefficients are equal to the quantity shares.[3]

Differences between the behavior of Divisia and simple-sum aggregates stem from the different weights assigned to the growth rates of the components, which measure their contributions to the monetary aggregates. Coefficients called "shares" are expressed by the notations $S^*_{it}$ and $S_{it}$ for various components used to determine the Divisia and simple-sum indexes, respectively, in the discussion that follows.

In calculating the Divisia index, the share of each component is the ratio of the expenditures on the monetary service flows it provides to the total expenditure on monetary service from all components in the aggregate; as such, it represents an "expenditure share." In contrast, shares for components in the simple-sum index are equal to the quantities of the balances held in each component divided by the total balances of all components in the aggregate. In general, these two types of shares yield different values and move diversely over time. For example, the expenditure share of time deposits in Swiss M2 in January 1980 was 0.0856; its quantity share, in contrast, was 0.3681. In January 1988, however, the expenditure share of time deposits in Swiss M2 was 0.2823, while its quantity share was 0.4527.

For the components of simple-sum monetary aggregates, the only data required to compute their respective shares are quantities of the components themselves. In contrast, for Divisia aggregates, the prices of the components—which involve their interest rates—must also be obtained in order to compute their expenditure shares.

## *The User Costs of the Monetary Assets*

As noted above, one major problem involved in computing Divisia index numbers for monetary aggregates is in determining the relevant prices of the individual monetary assets that make up the aggregate. In economic aggregation theory, monetary assets are treated as commodities and their prices are defined similarly to rental prices of durable goods. In this approach, it is assumed that people receive monetary services from holding money to finance their consumption. In doing so, they forego higher yields typically available on other financial assets. While monetary services are considered consumed during some given period, money stock (like any durable good) is not generally consumed during this period. Because monetary services are flow variables—*not* stock variables—they should be evaluated by their rental prices or user costs. Therefore, Divisia index numbers can be used to measure the monetary service flows provided by various monetary assets in the economy only if the user costs of these assets can be correctly defined and accurately measured.

The appropriate user costs of monetary assets are based on microeconomic theory and are derived by examining the representative consumer's optimal intertemporal consumption pattern and monetary asset portfolio allocation.[4] These user costs are measured as the opportunity costs of foregone interest associated with holding funds in different types of monetary assets. The opportunity cost is obtained by comparing each asset's rate of return to that on a *benchmark* asset with the highest rate of return.

Under the relevant consumer theory, the benchmark asset is assumed to provide no liquidity or other monetary services. Because it is held only for accumulating and transferring wealth across time, its interest rate is the highest in the economy. Consumer theory, however, does not specify other characteristics of the benchmark asset that would enable researchers to identify the actual benchmark asset to be used in empirical studies.

Barnett and Spindt (1982) have suggested that, while human capital might best fit the theoretical concept of the benchmark asset, no satisfactory empirical data exists on its rate of return. In their research, they found that

[3]By definition, the simple-sum aggregate is denoted such that

$SIM_{it} = \Sigma\, mc_{it}$

$dSIM_t/SIM_t = \Sigma\, (mc_{it}/SIM_t)(dmc_{it}/mc_{it})$

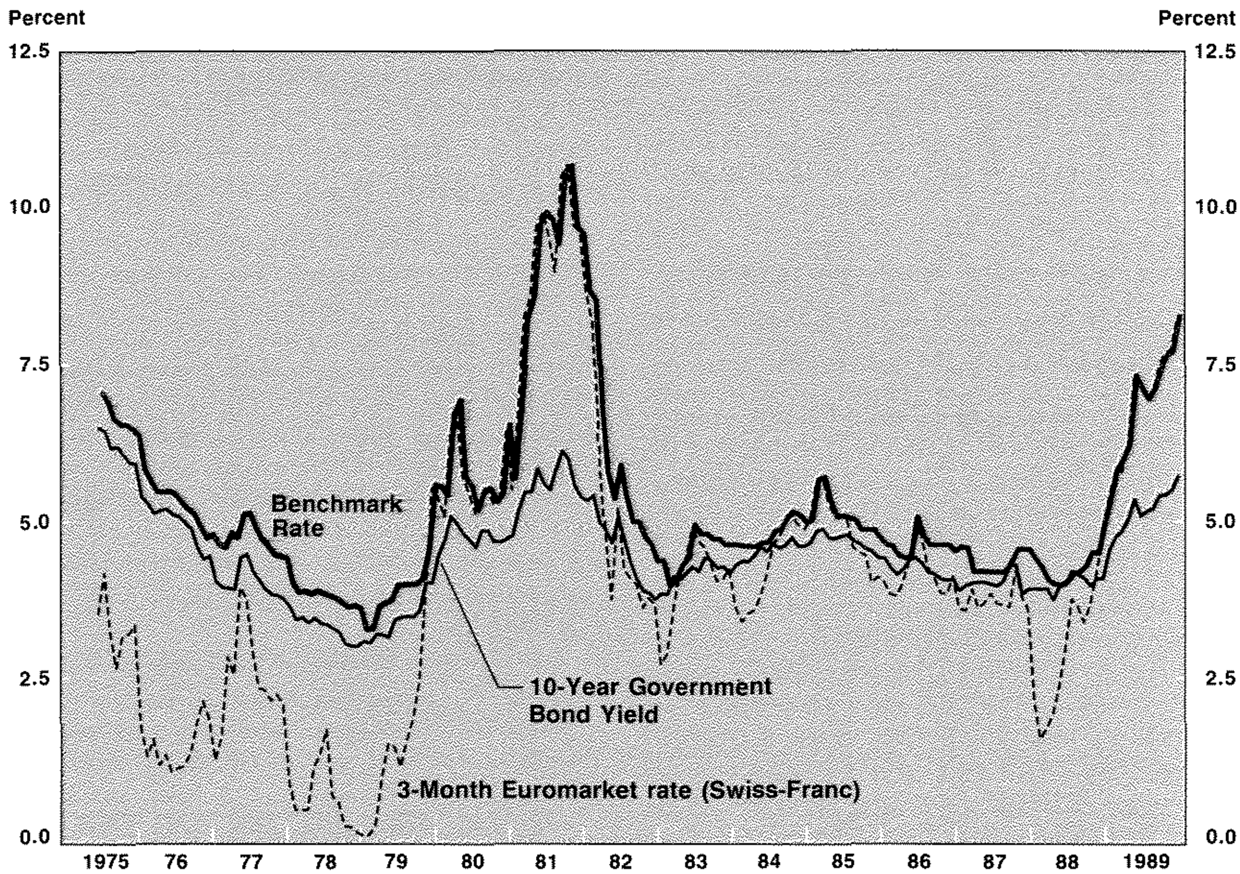
where $mc_i$ is the quantity of the i–th component. Thus, approximately

$\ln(SIM_t) - \ln(SIM_{t-1}) = \Sigma S_{it}(\ln(mc_{it}) - \ln(mc_{it-1}))$,

where $S_{it} = mc_{it}/SIM_t$ is the quantity share of the i–th component. This equation shows that the growth rate of the simple-sum aggregate is a linear combination of the growth rates of its components with weights equal to the fractions of the quantities of the components to the simple-sum aggregate.

[4]See Barnett (1978).

# Figure 2
## Selected Swiss Interest Rates




$R_t = \max[r_{baa}, r_{it}, i=1,2, .. n]$

provided the best available *proxy* for the theoretical benchmark rate, where $r_{baa}$ is Moody's series of seasoned Baa corporate bond rates and $r_{it}$ is the own rate of return on each of the components of L (the broadest U.S. monetary aggregate defined by the Federal Reserve Board).[5] Although Donovan (1978) used the nominal rate of return on "bonds" to compute the rental price of interest-bearing money for Canada, many researchers have used the approach adopted by Barnett and Spindt.

In this paper, we use the Barnett-Spindt approach to generate a proxy for the Swiss benchmark asset rate (see appendix 2 for further details). The benchmark asset is either the long-term Swiss bond or short-term Euro-Swiss deposits, depending on which yield is higher. Thus, as shown in figure 2, the benchmark asset was long-term Swiss bonds before 1980, Euro-Swiss deposits during 1980-1981 (due to an

[5]In the user cost formula, $R_t$ is the maximum available yield in the economy on any monetary asset which is a uniquely defined theoretical maximum available yield. Empirically, the proxy variable is defined by a long-term bond yield relative to the rates of return on all monetary components. The need for a long-term bond yield in measuring short-term holding-period yields is demonstrated by R. Shiller (1979). The Baa bond rate is used as a representative yield for long-term debts of average risk. See Barnett and Spindt (1982).

inverted term structure of Swiss interest rates during this period), long-term Swiss bonds from 1982 to 1987 and Euro-Swiss deposits again in 1988-1989.[6]

The formula for the real user costs of monetary assets in period t is expressed as

$$u_{it} = (R_t - r_{it})/(1 + R_t),$$

where $u_{it}$ is the user cost of the i-th monetary asset, $R_t$ is the nominal interest rate on the benchmark asset and $r_{it}$ is the nominal interest rate on the i-th monetary asset in period t.[7]

## COMPARISON OF THE BEHAVIOR OF SWISS DIVISIA AND SIMPLE-SUM MONETARY AGGREGATES

Divisia monetary aggregates and simple-sum aggregates for M1 and M2 were calculated using the Swiss monetary data described in appendix 2.[8] The monthly simple-sum and Divisia monetary aggregates are indexed to equal 100 in June 1975.[9] Figures 3 and 4 show the 12-month growth rates of these aggregates and the Swiss consumer price index from June 1976 to December 1989. While Divisia and simple-sum M1 indices display virtually identical growth rates in this period, the growth rates of Divisia and simple-sum M2 indices differ substantially beginning in 1979 (see figure 4).

From 1980-1981, for example, the growth of simple-sum M2 rose rapidly while that of Divisia M2 slowed markedly. From 1982 to 1983, in contrast, the opposite pattern can be observed in their respective growth rates. In 1989, however, the divergent pattern observed from 1980-81 occurs once again.

These widely divergent growth rates over extended periods for the simple-sum and Divisia M2 suggest that discussions about the appropriateness of alternative procedures used to construct monetary aggregates are not merely "academic." In general, the direction and magnitude of growth in monetary aggregates are presumed to provide useful information about the current stance of monetary policy and the future course of economic conditions. Such extreme differences in the growth of alternative M2 measures (as shown in figure 4), however, may produce considerable difficulty in assessing that information.

### *Simple-Sum Vs. Divisia Monetary Aggregates: What's the Difference?*

In Switzerland, M1 consists of currency (C), demand deposits with banks (DB) and demand deposits with the postal giro system (DP). To compare simple-sum and Divisia M1, we calculated the shares ($S_{it}$, $S^*_{it}$) for each component of M1. For most of the period, the respective shares of each monetary component for simple-sum and Divisia M1 moved so uniformly that their respective contributions to these aggregates are roughly equal. Therefore, the growth in simple-sum and Divisia M1 was essentially the same over the sample period (as already noted in figure 3).

In May 1989, however, the explicit interest rate on demand deposits with the postal giro system (DP) rose from zero to two percent, reducing the user cost of DP, $U_3$ (as shown in figure 5). Since expenditure shares depend both on quantities of the components and their user costs, DP's share ($S^*_3$) fell, reducing its weight in calculating Divisia M1. Therefore, since the introduction of explicit interest payments on DP had no effect on its weight in calculating simple-sum M1, the values $S^*_3$ and $S_3$ diverged after May 1989. Since the values of $S^*_3$ and $S_3$ are quite small, however, the difference between the growth of simple-sum and Divisia M1 after May 1989 is trivial.

Figure 5 shows that the user costs of the three Divisia M1 components (U1-U3) follow

[6]Needless to say, such shifts in the benchmark asset raise questions about the validity of this approach and have resulted in criticisms of Divisia indices by a number of economists. We do not address this issue in this paper.

[7]The nominal user costs of monetary assets usually are expressed as

$$u_{it} = p^*_t \left[ \frac{(R_t - r_{it})(1 - \tau_t)}{1 + R_t(1 - \tau_t)} \right],$$

where $u_{it}$ is the user cost of the i-th monetary asset in period t, $R_t$ is the benchmark rate in period t, $r_{it}$ is the nominal interest rate on the i-th monetary asset; $\tau_t$ is the marginal income tax rate, and $p^*_t$ is the true cost-of-living index used to deflate all nominal quantities to real quantities. Since taxes are not considered here, we use the simplified formula.

[8]Weak separability conditions should be satisfied first to calculate a meaningful aggregate. However, we did not conduct weak separability tests; instead, we used the actual Swiss definitions of M1 and M2 and simply assumed that they are admissible aggregates. For details, see Belongia and Chalfant (1989).

[9]See appendix 2.

Figure 3
**Inflation and M1 and Divisia M1 Growth**

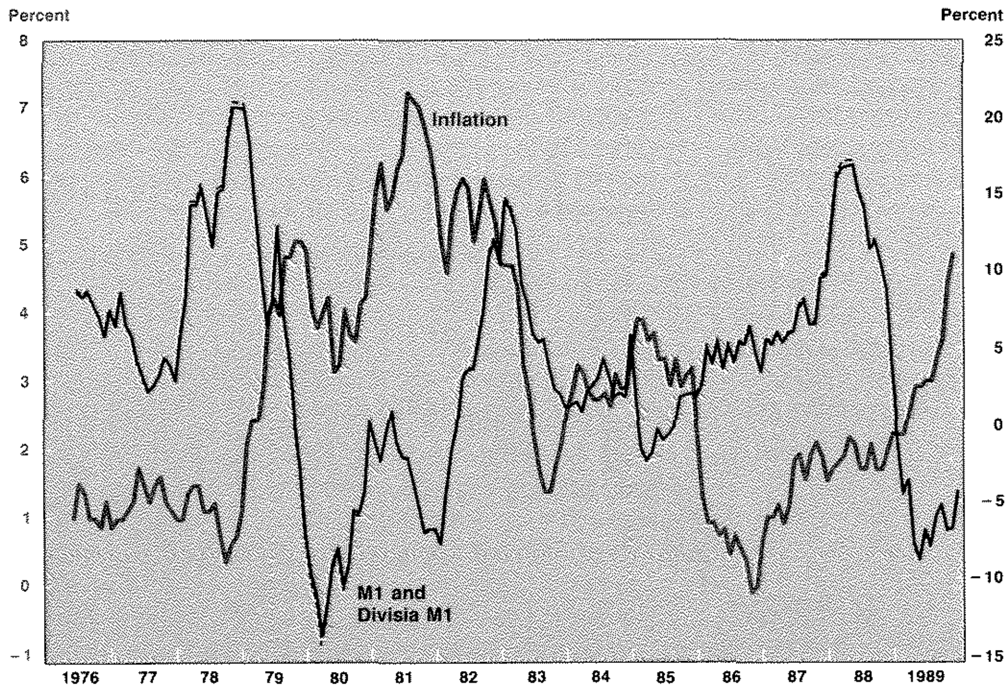
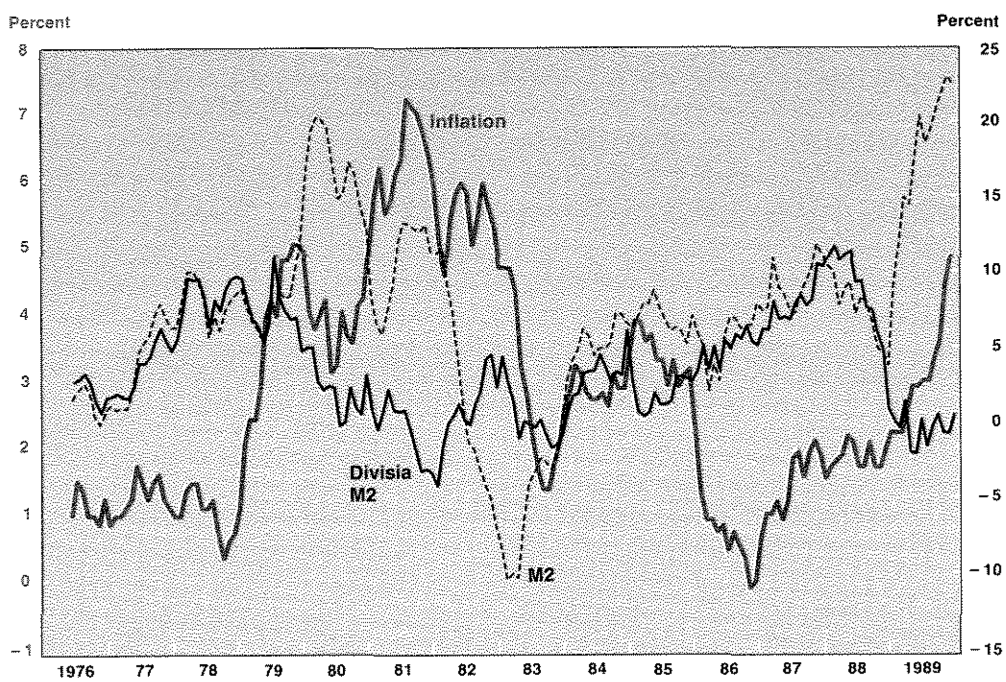
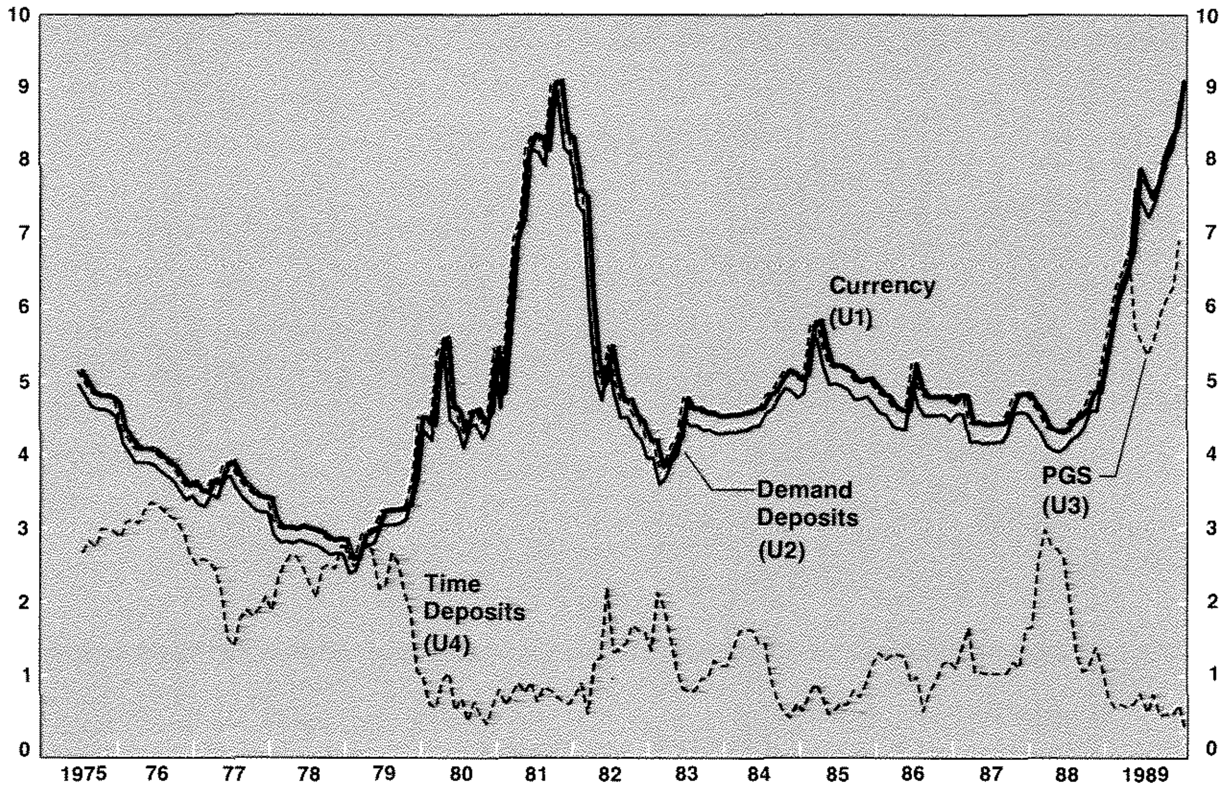



Figure 4
**Inflation and M2 and Divisia M2 Growth**



# Figure 5
## User Costs of Currency, Demand Deposits, PGS, and Time Deposits

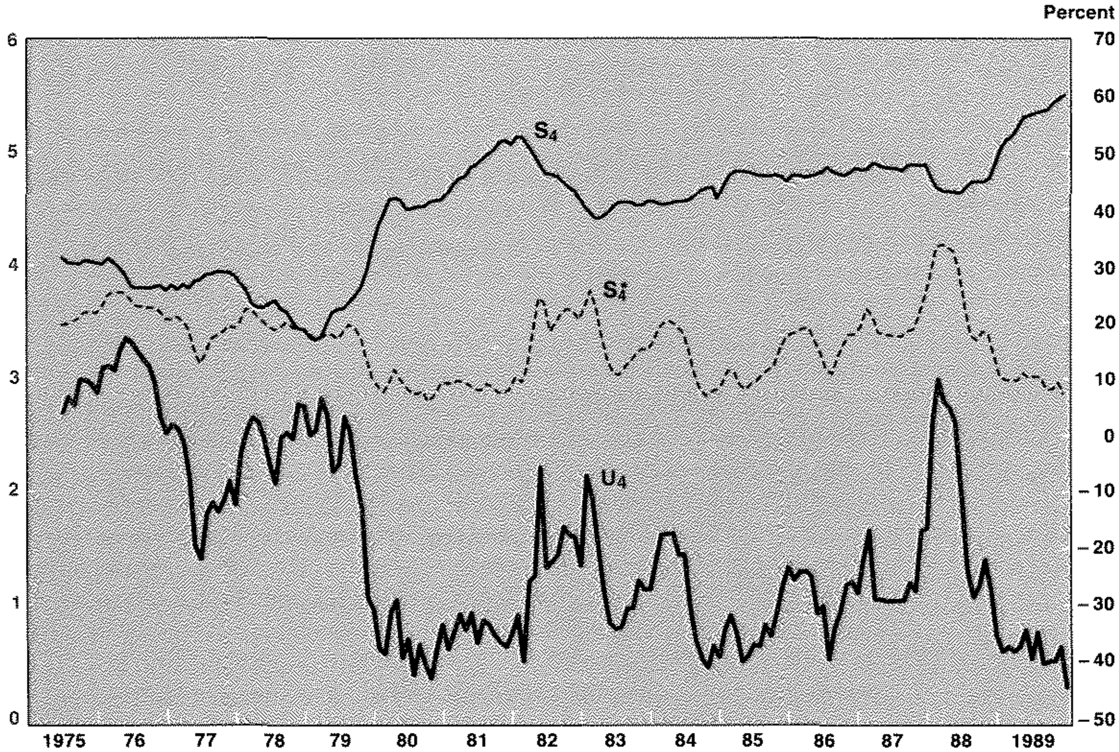



similar movements from 1975 through 1989, especially for the user costs of currency and demand deposits with banks. Thus, the *relative* user costs for the Divisia M1 components are nearly constant, making simple-sum M1 as useful as Divisia M1 over this period.[10]

Although the expenditure and quantity shares were similar for the M1 components, lower user costs for time deposits in M2 explain the divergent patterns shown earlier between simple-sum and Divisia M2. We can illustrate the importance of changes in the economic environment on the weights used by examining the different behavior of Divisia and simple-sum M2 over these time periods: January 1979 - December 1981; January 1982 - November 1987; December 1987 - December 1989. At the beginning of each period, there was a significant change in Swiss monetary policy as measured by sharp movements in the Swiss monetary base. During these periods, changes in the economic environment were reflected in the levels of short-term and long-term interest rates. As noted earlier (in figure 2), we used the three-month Euro-Swiss Franc rate as the short-term rate, the Swiss government bond yield as the long-term rate and the benchmark rate was equal or close to the higher of these two rates in any specific period. The growth rate of the Swiss monetary base over these periods was previously shown in figure 1.

[10]This result is consistent with Hicks' (Hicks, 1946) conclusion that "when the relative prices of a group of commodities can be assumed to remain unchanged, they can be treated as a single commodity."

Figure 6
**Simple-Sum Share $S_4$ and Divisia Share $S_4^*$ of Time Deposits and User Cost $U_4$**




### *The First Period: January 1979 to December 1981*

During this period, the SNB's response to rising Swiss inflation was sharply slower growth in the Swiss monetary base (resulting in lower inflation in 1983-84). The abrupt rise in short-term Swiss interest rates produced an inverted yield curve for the next two years. The dramatic increase in interest rates on time deposits reduced their user costs ($U_4$) to nearly zero as their interest rates approached the benchmark rate (see figures 2 and 5).

How did this interest rate movement affect the monetary aggregates? Asset holders shifted from lower yielding securities into time deposits (TD) causing the quantity of time deposits to increase dramatically and the quantity of demand deposits with banks (DB) to decrease substantially. Furthermore, asset holders also shifted funds into time deposits from other financial assets not included in M2. This sharp rise in the quantity of time deposits is indicated by the surge in their share in simple-sum M2, $S_4$ (shown in figure 6).

These changes produced quite different results in the Divisia M2 measure, however. As interest rates on time deposits increased relative to other interest rates, time deposits had lower opportunity costs and the monetary service flows from a given quantity of time deposits naturally fell. Thus, despite the large increase in time deposits, the expenditure share of the monetary service flows from time deposits actually declined during this period (see $S_4^*$ in figure 6), as did the growth of Divisia M2 (see figure 4).

### *The Second Period: January 1982 to November 1987*

During this period, the rate of inflation declined to lower levels and an extended period of expansionary growth in the monetary base began in January 1982. The term structure of Swiss interest rates resumed its normal shape, with short-term interest rates below long-term interest rates. Figure 5 shows that the user costs of currency, demand deposits and demand deposits with the giro system ($U_1$, $U_2$, $U_3$) began to fall in 1982. This reflects the fact that the difference between their interest rates and the benchmark rate was declining, while the user cost of time deposits ($U_4$) increased as its interest rate fell relative to the benchmark rate.

As noted previously, the contributions of each component to the Divisia and simple-sum M2 aggregates are determined by their shares. We only display the quantity and expenditure shares for time deposits ($S_4^*$ and $S_4$) in figure 6 for illustration. In 1982, the quantity share of time deposits ($S_4$) fell substantially, while its expenditure share ($S_4^*$) rose sharply. This resulted in the positive growth of Divisia M2 and negative growth of simple-sum M2 shown in figure 4 for 1982. Divergent movements in Divisia and simple-sum M2 occurred again in 1985 when the simple-sum M2 growth was positive, while Divisia M2 growth was almost zero. During the rest of this period, Divisia and simple-sum M2 moved similarly.

### *The Third Period: December 1987 to December 1989*

Swiss inflation rose from 2 percent throughout most of 1988 to nearly 5 percent by the end of 1989. While both short- and long-term interest rates rose over this period, short-term rates rose relative to long-term rates. Moreover, the major institutional changes that took place reduced demand for the monetary base.[11] In response to these events, user costs of the first two components ($U_1$ and $U_2$) rose, while the user cost of time deposits ($U_4$) fell (figure 5); these movements were similar to those in the first period. However, as mentioned earlier, the user cost of demand deposits in the postal giro system ($U_3$) fell in May 1989 when the interest rate jumped from zero to two percent. Consequently, the Divisia and simple-sum M2 measures moved in opposite directions; simple-sum M2 rose sharply, while Divisia M2 fell substantially (figure 4).

These three episodes suggest that, at least for a monetary aggregate as broad as Swiss M2, different aggregation procedures produce monetary measures that can move quite differently and generate very distinct interpretations for the stance of policy and the likely course of economic conditions. Therefore, it is important to know which of the potential broader monetary aggregate measures are more closely related to key economic conditions.

## COMPARISON OF THE PERFORMANCE OF THE DIVISIA AND SIMPLE-SUM AGGREGATES

To determine whether a monetary aggregate can be used as a monetary policy target, two questions must be answered. First, is there a satisfactory relationship between the monetary aggregate and some key economic variable, such as inflation or nominal GDP or GNP? Second, is the monetary aggregate strongly related to something that is directly controllable by the monetary authority? We examine both these questions in this section.

### *Inflation and Monetary Aggregates*

To evaluate the first question, the relationship between selected Swiss monetary aggregates and inflation are compared. Specifically, quarterly Swiss inflation rates were regressed on distributed lags of selected Divisia and non-Divisia monetary aggregates. Because the sample is relatively small and because we would like to include enough lags to capture the significant effect of money growth on inflation, the Polynomial Distributed Lag (PDL) estimation technique was used.[12]

Ideally, it is desirable to use one of the commonly used lag-length selection methods for choosing both the lag length and the degree of the polynominal. However, for two of the monetary aggregates, simple-sum M1 and Divisia M1, the equations exhibited significant serial correlation. This complicates the application of these procedures for these aggregates. Because of this, when these aggregates were used, several specifications of both lag length and polynominal

[11]See the data description in appendix 2.

[12]See Batten and Thornton (1983); Thornton and Batten (1985).

## Table 1
## PDL Regressions of Inflation on Money Growth

| | Growth Rate of Simple-sum | | Growth Rate of Divisia | |
|---|---|---|---|---|
| | M1 | M2 | M1 | M2 |
| PDL order | 1 | 1 | 1 | 1 |
| Lag | Coefficients of Distributed Lags | | | |
| 0 | 0.00898 | 0.02740 | 0.00917 | −0.01316 |
| 1 | 0.01232 | 0.02721 | 0.01257 | −0.00653 |
| 2 | 0.01566 | 0.02702 | 0.01597 | 0.00010 |
| 3 | 0.01900 | 0.02683 | 0.01938 | 0.00672 |
| 4 | 0.02233 | 0.02664 | 0.02278 | 0.01335 |
| 5 | 0.02567 | 0.02646 | 0.02618 | 0.01998 |
| 6 | 0.02901 | 0.02627 | 0.02958 | 0.02661 |
| 7 | 0.03235 | 0.02608 | 0.03298 | 0.03323 |
| 8 | 0.03569 | 0.02589 | 0.03639 | 0.03986 |
| 9 | 0.03903 | 0.02570 | 0.03979 | 0.04649 |
| 10 | 0.04237 | 0.02552 | 0.04319 | 0.05311 |
| 11 | 0.04571 | 0.02533 | 0.04659 | 0.05974 |
| 12 | 0.04905 | 0.02514 | 0.04999 | 0.06637 |
| 13 | 0.05238 | 0.02495 | 0.05339 | 0.07299 |
| 14 | 0.05572 | 0.02476 | 0.05680 | 0.07962 |
| 15 | 0.05906 | 0.02458 | 0.06020 | 0.08625 |
| 16 | 0.06240 | 0.02439 | 0.06360 | 0.09287 |
| 17 | 0.06574 | 0.02420 | 0.06700 | 0.09950 |
| 18 | 0.06908 | 0.02401 | 0.07040 | 0.10613 |
| Sum | 0.74154 | 0.48838 | 0.75596 | 0.88322 |
| t-Stat[1] | (3.1168) | (8.1203) | (3.1877) | (6.0924) |
| AR(1) | 0.4673 | 0.0763 | 0.4596 | 0.2253 |
| S.E. | 0.00697 | 0.00611 | 0.00695 | 0.00625 |
| Adj-$R^2$ | 0.5751 | 0.6729 | 0.5776 | 0.6579 |
| D-W | 1.9811 | 1.9409 | 1.9773 | 1.9249 |

S.E. is the standard error of the regression.

[1] The critical t-statistic value at the 5 percent significance level is 1.645.

degree were estimated. Specifications with relatively long lags and relatively low polynominal degrees produced the highest adjusted R-square. To keep the specifications comparable with those of simple-sum and Divisia M2 (which were chosen using the FPE criteria), results with lag lengths of 18 and first-degree polynominals are presented.[13]

To compare the long-run relationship of the monetary aggregates on inflation, we estimated the selected PDL models and computed the sum of coefficients of the distributed lags to test whether the sum of the lagged money growth coefficients was significantly different from *zero*. The estimated coefficients and respective statistics are shown in table 1.

The results in table 1 show that monetary aggregates influenced Swiss inflation over periods of up to four or more years. With the exception of simple-sum M2, the monetary aggregates have roughly similar values for the sum of the coefficients on their distributed lags. The hypothesis that the sum of the lag coefficients is

[13]The identical polynominal degree was obtained for M2 and Divisia M2 by the Pagano-Hartley technique if a T-statistic of 2.0 is used for the critical value.

Table 2
**F-Statistics for PDL Models[1]**

| Growth rates | Divisia M2 and M1 | Divisia M2 and Divisia M1 | M2 and M1 | M2 and Divisia M1 |
|---|---|---|---|---|
| F-Stat. | | | | |
| $H_1$ | 0.0605 | 0.0726 | 1.8349 | 1.8349 |
| $H_2$ | 4.0645 | 3.9585 | 7.3115 | 7.1715 |

[1]At the 5 percent significance level, the critical F value is 3.29.

zero was rejected in all cases at the 5 percent significance level.[14]

Because M1 and Divisia M1 are included in their respective M2 counterparts, we investigated whether the non-M1 components of M2 themselves added significant explanatory power in the inflation equation. Thus, we defined the *unrestricted* model as regressions of inflation on both the M2 and M1 PDLs; the *restricted* models were those with regressions of inflation on the M2 or M1 PDLs, respectively. The actual F-statistics and their 5 percent significance level critical values are shown in table 2. $H_1$ is the hypothesis that inflation can be explained by Divisia M2 or M2 alone; $H_2$ is the hypothesis that inflation can be explained by M1 aggregates alone. These hypotheses are tested against the corresponding unrestricted PDL model that inflation is explained jointly by simple-sum and Divisia M2 PDL *and* the M1 aggregates PDL.[15]

The results in table 2 show that the data failed to reject $H_1$, but did reject $H_2$. This result suggests that the broader aggregates M2 and Divisia M2 better explain Swiss inflation than does M1 or Divisia M1 alone.

## *Controllability*

As noted earlier, the practical use of a monetary aggregate as an intermediate target depends on its controllability. Even if some monetary aggregate shares a close relationship with inflation or nominal GDP, it would be of little use as a monetary *target* if its growth can not be controlled by monetary authorities. Since the central bank controls the monetary base, the relationships between it and the broader Swiss monetary aggregates are examined.

Because the cross correlations between the growth rates of monetary aggregates and the growth rate of the monetary base show a long-lag pattern, we used the PDL models to estimate their relationships. Again, because of significant serial correlation, various specifications of lag length and polynominal degree were estimated. However, they share the same qualitative properties. Table 3 displays the estimates of the 16-lag and first-degree PDL models.

Results show that the growth rates of M1, Divisia M1 and Divisia M2 are statistically significant in relation to the growth rate of the monetary base. However, a significant long-term relationship between the growth rate of the monetary base and simple-sum M2 is rejected at the 5 percent level of significance.

In addition, the contemporaneous growth rate of the monetary base is positively and significantly correlated to the growth rates of both M1 aggregates and the Divisia M2 aggregate. For simple-sum M2 growth, however, the contemporaneous and initial lagged growth rates of the monetary base have negative effects on its

[14]The hypothesis that the sum of the lag coefficients was unity failed to be rejected in all cases except for simple-sum M2. Thus, except for simple-sum M2, the results did not reject a one-to-one long-run relationship between the growth of the monetary aggregate and the rate of inflation.

The results for the monetary base are similar to those of the Swiss monetary aggregates; its adjusted $R^2$ (0.4880) was lower than those displayed in table 1. As shown in the first part of this paper, the relationship between inflation and growth of the monetary base slipped considerably during 1986-89 (the end of the period examined); earlier, however, there had been a close link between Swiss inflation and long-run growth in the monetary base. Because the estimation period covers 1975-89, the recent "breakdown" in the monetary base growth-inflation relationship does not dominate the results.

[15]For both M2 and M1 aggregates, we take the same number of lags, 18, in the PDL models.

Table 3

**PDL Regressions of Growth Rates for Monetary Aggregates on Growth Rate of Monetary Base**

| | Growth Rate of Simple-sum | | Growth Rate of Divisia | |
|---|---|---|---|---|
| | M1 | M2 | M1 | M2 |
| PDL order | 1 | 1 | 1 | 1 |
| Lag | Coefficients of Distributed Lag for the Growth Rate of the Monetary Base | | | |
| 0 | 0.39216 | −.07127 | 0.38461 | 0.20584 |
| 1 | 0.36648 | −.05610 | 0.35937 | 0.19467 |
| 2 | 0.34079 | −.04092 | 0.33414 | 0.18351 |
| 3 | 0.31511 | −.02574 | 0.30890 | 0.17235 |
| 4 | 0.28942 | −0.01057 | 0.28367 | 0.16118 |
| 5 | 0.26374 | 0.00461 | 0.25844 | 0.15002 |
| 6 | 0.23805 | 0.01979 | 0.23320 | 0.13886 |
| 7 | 0.21237 | 0.03496 | 0.20797 | 0.12769 |
| 8 | 0.18668 | 0.05014 | 0.18273 | 0.11653 |
| 9 | 0.16100 | 0.06532 | 0.15750 | 0.10537 |
| 10 | 0.13531 | 0.08049 | 0.13227 | 0.09420 |
| 11 | 0.10963 | 0.09567 | 0.10703 | 0.08304 |
| 12 | 0.08394 | 0.11085 | 0.08180 | 0.07188 |
| 13 | 0.05826 | 0.12602 | 0.05656 | 0.06071 |
| 14 | 0.03257 | 0.14120 | 0.03133 | 0.04955 |
| 15 | 0.00689 | 0.15637 | 0.00610 | 0.03839 |
| 16 | −0.01880 | 0.17155 | −0.01914 | 0.02722 |
| Sum | 3.17360 | 0.85237 | 3.10648 | 1.98099 |
| t-Stat | (2.3518) | (0.5770) | (2.3538) | (3.3068) |
| AR(1) | 0.57811 | 0.55397 | 0.57459 | 0.40863 |
| S.E. | 0.01852 | 0.02317 | 0.01821 | 0.01137 |
| Adj-$R^2$ | 0.42888 | 0.48930 | 0.42632 | 0.40400 |
| D-W | 1.97733 | 1.98227 | 1.98631 | 2.12645 |

S.E. is the standard error of the regression. The critical t-statistic for the 5 percent significance level is 1.645.

growth. Indeed, significant positive correlation shows up only three years after the changes in the monetary base.

These results suggest that the Swiss National Bank can significantly influence the growth of M1, Divisia M1 and Divisia M2 through changes in the growth of the monetary base. Long-term simple-sum M2 growth, however, does not appear to be influenced by growth of the monetary base.

## CONCLUSION

The relationship between the Swiss monetary base and inflation in Switzerland has become more uncertain in recent years. This phenomenon has generated considerable interest in using broader monetary aggregates as monetary policy targets.

This paper examined the potential usefulness of Swiss M1 and M2 monetary aggregates compared with Swiss Divisia M1 and M2 aggregates derived from economic aggregation theory. We showed that M1 and Divisia M1 generally displayed similar movements over time and were related similarly both to Swiss inflation (which justifies their potential usefulness as a target) and to the monetary base (which means that their growth was potentially controllable by the Swiss National Bank).

M2 and Divisia M2, however, displayed substantially different behavior over time and, at certain key times, yielded substantially different signals about the stance of monetary policy.

More importantly, M2 growth was statistically unrelated to the growth of the monetary base.

The results suggest that M1, Divisia M1 and Divisia M2 would be suitable for further study if the Swiss National Bank is interested in the possibility of using broader monetary aggregates to replace monetary base targeting. However, these results indicate that M2 is unlikely to provide an adequate substitute for monetary policy purposes.

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# Appendix 1 Divisia Indexes

There are two types of Divisia index numbers: the continuous-time version and the discrete-time version. Continuous-time Divisia index numbers are derived from microeconomic theory; discrete-time Divisia index numbers are approximations of the continuous-time version.

To understand how continuous-time Divisia index numbers are derived, consider the case where economic agents want a measure that aggregates a group of *n* commodities in the economy. The quantities of the goods are expressed by the vector $q=(q_1, q_2, \ldots, q_n)$; their corresponding prices are denoted by the vector $p=(p_1, p_2, \ldots, p_n)$. Economic aggregation theory states that the aggregator function is a utility function g(q) to be maximized subject to the budget constraint,

$$(1)\ \sum_{i=1}^{n} q_i p_i = g(q)f(p) = E,$$

where f(p) is the price aggregator function and E is the total expenditure on the specific goods. The first-order necessary condition for utility maximization is

$$(2)\ dg(q)/dq_i = \lambda\, p_i,$$

where $\lambda$ is the Lagrange multiplier. Because the aggregator function is linear homogeneous, Euler's equation is satisfied such that

$$(3)\ \sum_{i=1}^{n} (dg/dq_i)q_i = g(q).$$

Substituting equation 2 into equation 3 yields

$$\lambda \sum_{i=1}^{n} q_i p_i = g(q) \text{ and}$$

$$\lambda\, E = g(q).$$

Hence, $\lambda = g(q)/E$ and

$$(4)\ dg(q)/dq_i = p_i g(q)/E.$$

Taking the total differential of the aggregator function g(q) yields

$$(5)\ dg(q) = \sum_{i=1}^{n} (dg/dq_i)dq_i$$

Thus, substituting equation 4 into 5 yields

$$(6)\ dg(q) = \sum_{i=1}^{n} p_i dq_i g(q)/E \text{ and}$$

$$dg(q)/g(q) = \sum_{i=1}^{n} p_i q_i dq_i/Eq_i.$$

If we set $S_i = p_i q_i/E$ and call it the i-th good's value share in the total expenditure, equation 6 can be transformed into

$$(7)\ d(\ln(g(q))) = \sum_{i=1}^{n} S_i d(\ln(q_i)).$$

Solving equation 7 for g(t) yields

$$(8)\ g(t) = \text{EXP}\int\left(\sum_{i=1}^{n} S_i(t)d[\ln(q_i(t))]\right) dt.$$

Equation 8 is the continuous-time Divisia index.

Because economic variables are observed and measured in discrete time rather than continuous time, the continuous-time Divisia index must be transformed into a discrete-time version to make it useful. The discrete time approximation of equation 7 is

$$(9)\ \ln(g(t)) - \ln(g(t\text{-}1)) = \sum_{i=1}^{n} S_{it}^{*}[\ln(q_i(t)) - \ln(q_i(t\text{-}1))]$$

or

$$(10)\ g(t) = g(t\text{-}1)\text{EXP}\left(\sum_{i=1}^{n} S_{it}^{*}[\ln(q_i(t)) - \ln(q_i(t\text{-}1))]\right),$$

where $S_{it}^{*} = (S_{it} + S_{it\text{-}1})/2$,

$S_{it} = p_i q_i/E = p_i q_i/\left(\sum_{i=1}^{n} p_i q_i\right)$,

and $S_{it}^{*}$ is the average expenditure share in the two adjacent time periods. Equations 9 and 10 are the discrete-time Divisia index equations used in calculating the Swiss Divisia M1 and M2 monetary aggregates.

# Appendix 2
# Data

To calculate the Swiss Divisia M1 and M2 monetary services indexes, we used the seasonally adjusted monthly Swiss M1 and M2 series and their components consistent with the definitions established in 1975 and incorporating the revision that occurred in 1985 (for more details, see *Schweizerische Nationalbank*, 1985).

The monetary aggregates consist of the following assets held by individuals and non-bank institutions:

M1: Currency in circulation (C)
Demand deposits with banks (DB)
Demand deposits with the postal giro system (DP)

M2: M1 plus time-deposits (TD)

MB: Seasonally adjusted monetary base, defined as the sum of banks reserves and banks notes in circulation.

## *Interest Rates*

To compute the user costs of monetary assets, we need the assets' own rates of return, the benchmark rate of return and the cost-of-living index.

## *Own Rates*

C Zero
DB 0.25 percent
DP 1975:06 - 1989:04: Zero
1989:05 - 1989:12: 2 percent
TD three-month rate on time-deposits with large banks (monthly average)

## *Cost-of-living Index*

Monthly Swiss Consumer Price Index (CPI) calculated by the Federal Statistical Office (Bundesamt fuer Statistik).

## *Benchmark Rate*

The highest rate in each period from the following interest rates: the secondary market yield on cantonal bonds, interest rates on cash certificates with the cantonal or large banks and short-term Euromarket-Swiss franc interest rates. Short-term rates became the benchmark rates during 1979:12 - 1982:04 and 1988:12 - 1989:12, when the Swiss yield curve was inverted.