THE MONEY-INCOME RELATIONSHIP:

HAS IT BROKEN DOWN?

by

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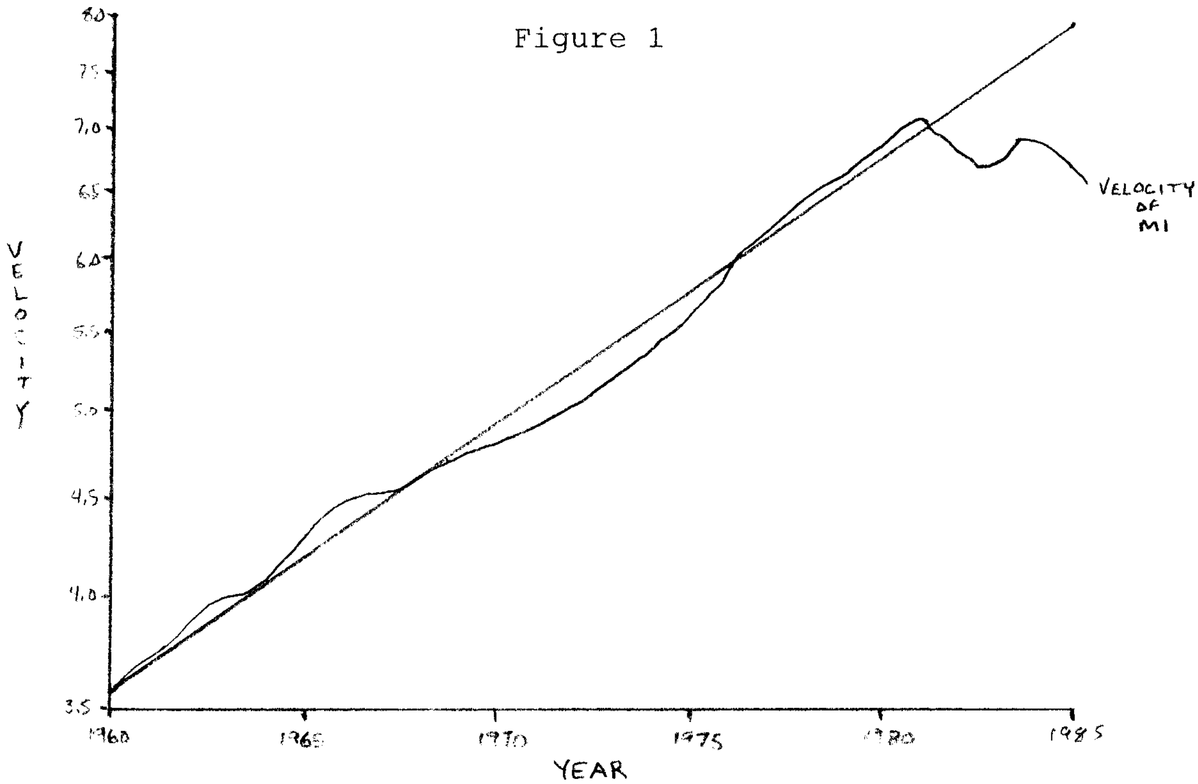
Effective monetary policy requires a stable and predictable relationship between the supply of money and the level of income. Recent shifts in the growth rate of velocity, the ratio of nominal income to money supply, have caused concern over the stability of the money-income relationship. Changes in velocity do not necessarily imply that the relationship between income and lagged money supply has broken down. Nominal income as measured by GNP contains components which cannot be expected to respond to changes in the money supply and which, if they fluctuate, will distort the perceived money-income relationship. The purpose of this paper is to examine the St. Louis equation as a model for the relationship between money and income as measured by GNP, gross domestic purchases, final demand, and domestic final demand (GNP net of both changes in inventories and net exports).

While the growth rate of velocity often fluctuates sharply from one quarter to the next, it has, until recently, averaged out to around three percent over longer periods. The following graph charts velocity since 1960. The straight line represents a 3.2 percent growth rate. It is clear from this chart why there has been concern that the relationship between money and income has shifted since 1980.

Figure 1



The St. Louis Equation

The St. Louis equation was introduced in 1968 by Leonall Anderson and Jerry Jordan of the Federal Reserve Bank of St. Louis[1]. In the original specification,

$$\Delta Y = \sum_{i=0}^{3} \alpha_i \Delta E_{t-i} + \sum_{j=0}^{3} \beta_j \Delta R_{t-j} + \sum_{k=0}^{3} \gamma_k \Delta M_{t-k} + \sum \Delta Z \quad \text{where:}$$

ΔY is change in total spending,
ΔE is change in government expenditures,
ΔR is change in government revenues, and
ΔZ is change in all other variables affecting spending.

Three lag periods (quarters) were used and their coefficients were constrained to lie on a fourth degree polynomial for which the fourth lag coefficient is zero.

The purpose of the St. Louis model was to test the proposition, commonly held at that time, that fiscal policy actions were more effective, more predictable and faster than monetary actions in their effect on the economy. Testing led to rejection of all three hypotheses. Because of the political implications of the study, it attracted a great deal of attention and criticism. Subsequent studies have confirmed the original conclusions regarding the relative effectiveness of fiscal and monetary policy and have led to new specifications which are both simpler and statistically stronger. Research by Dallas Batten and Daniel Thornton, also of the St. Louis Federal Reserve Bank has resulted in the current specification[2],

$$\dot{Y} = \sum_{i=0}^{10} \alpha_i \dot{M}_{t-i} + \sum_{j=0}^{9} \beta_j \dot{G}_{t-j} \text{ where:}$$

$\dot{Y}$ is the growth rate of nominal income,
$\dot{M}$ is the growth rate of M1, and
$\dot{G}$ is the growth rate of high-employment government expenditures (estimated by FRBSL).

Annual rates of change are used in place of first differences because it was found that errors in the original specification were heteroscedastic. Using rates of change or first differences in logarithms results in homoscedastic errors. Lag lengths are ten quarters for $\dot{M}$ and nine quarters for $\dot{G}$. Polynomial degrees are six and seven, respectively, and no endpoint constraints are used. This is the specification I used.

The method of polynomial distributed (or Almon[3]) lags solves the problem of multicollinearity in distributed lag models and, if properly applied, produces unbiased estimators of the true lag coefficients. It is based on the fact that for any n real numbers $X_1 \ldots X_n$, a polynomial P(z) of degree <= n can be specified for which $P(z) = X_z$ for all $z <= n$. Thus in the current specification of the St. Louis model, the estimated coefficients of the eleven values of $\dot{M}1$ (current plus ten preceding quarters) are constrained to lie on some sixth degree polynomial.

In order to produce unbiased estimators, the polynomial degree must not be "too small". If the degree is too large, the technique will produce estimates which are unbiased but poorer estimates of the actual coefficients. Batten and Thornton used the Pagano-Hartley methodology for determining the appropriate lag lengths and polynomial degree and found that the resulting specifications also produced the highest coefficient of determination[4].

Defining Income

If a reduced form model like the St. Louis equation is to be useful it should estimate income levels with a fair degree of accuracy and consistency. The current specification uses rates of change in the aggregates; so, in many cases, a small revision in the magnitude of the aggregate can make a big difference in the rate of change. It is therefore important that the aggregates used not contain large components which fluctuate for reasons outside the theory behind the model. Using GNP as a proxy for income may degrade the model if it contains such components, just as using a broad monetary aggregate could degrade the model if a large part of what was being counted as money was actually savings.

Changes in inventories and net exports are two components of GNP which can be expected to fluctuate independently of monetary or fiscal changes. GNP net of net exports is called gross domestic purchases. Without changes in inventories it is called final demand. GNP with both components removed will be called domestic final demand in this paper.

Seasonal Adjustment

Income, money supply and government spending are all subject to seasonal variations. Agricultural income is highest at harvest time, retail sales peak during the Christmas shopping season, and the construction industry is most active in the summer. The public demands more money at Christmas time, tax time and vacation time. Many government activities such as highway construction are seasonal and government purchases are often made at the end of the fiscal year. The process of seasonal adjustment is designed to remove seasonal fluctuations and leave only trend and cycle variations in the data.

Seasonal adjustment presents a problem in the analysis of the money-income relationship. Seasonal fluctuations in both the dependent and independent variables should be removed to see the true relationship. The problem arises in the adjustment of money supply data[5]. Monetary authorities seek to accomodate seasonal variations in the demand for money holdings and minimize seasonal fluctuations in interest rates. If some past fluctuation is identified by the procedure as "seasonal", then the authorities will adjust present money supply levels to accomodate it and it will be a self-perpetuating "seasonal variation", even though it may have nothing to do with seasonal variations in the demand for money.

While it is possible that the sophisticated adjustment procedures used on monetary aggregates suppress some non-seasonal variations which shouldn't be suppressed, they also suppress many of the purely random disturbances present in the data.

The Data

The data I used were all obtained from publications of various federal agencies. M1 and seasonally adjusted M1 figures were obtained from Business Statistics 1984, published by the Commerce Department. All the monthly figures had been recalculated to match the current (1984) definition of M1. Monthly data were averaged by quarter and annualized rates of change in the quarterly averages were calculated. Measures of change in nominal GNP, final sales and gross domestic purchases were obtained from the February 1986 Survey of Current Business[6], also published by the Commerce Department, as were money supply data for 1985. These are the most recent revisions of all National Income and Product Accounts data. Domestic final demand was calculated directly from these figures. All NIPA data is seasonally adjusted. High employment government expenditures are estimated by the Federal Reserve Bank of St. Louis and published in various issues of Monetary Trends. Statistical analysis was performed with the aid of the SAS statistical package[7].

Preliminary runs were made to test the specifications of the

St. Louis model found to be best by Batten and Thornton in 1983. In all cases the specification of polynomial degrees of six and seven on money lags and government spending lags respectively produced the highest coefficients of determination. Using shorter lag lengths resulted in significantly worse coefficients of determination. Longer lags produced slightly worse results, so I used what is now the current specification. These runs all used seasonally adjusted M1.

The next set of regressions used unadjusted M1 with and without dummy variables for quarters. Unadjusted M1 failed to produce any results for which the hypothesis that all coefficients were zero could be rejected. The introduction of dummy variables for quarters produced better results, but not as good as the published seasonally adjusted data. The coefficients assigned to the dummy variables were significant at the five percent level for the second (a positive coefficient) and fourth (negative) quarters. Despite the problems associated with seasonally adjusted money supply data, it appears that the process removes "noise" along with seasonal variations and the resulting values are better for predicting future economic activity.

Testing Hypotheses

Using the current specification of the St. Louis equation and seasonally adjusted money supply figures, I tested five hypotheses about the apparent breakdown of the money-income relationship in the 1980's. The first three are based on the problem of defining income. They are that the St. Louis model will better predict gross domestic purchases, final demand and domestic final demand than GNP. These were tested by substituting the various independent variables in the model and examining the coefficients of determination for regressions with data from before 1981, after 1980, before and after combined and before and after combined with a dummy variable to represent an intercept shift in 1981. The other two hypotheses tested concerned the nature of the breakdown. They tested for a change in slope and for a change in the intercept in 1981.

If net exports and changes in inventories are not determined by lagged money supply the way income is, then removing them from the definition of income should result in an improvement in the fit of the St. Louis model to the actual data. If the reason (or part of the reason) for the apparent breakdown in the money-income relationship in the 1980's is that net exports and/or inventories fluctuated significantly, then removing these components from income should strengthen the relationship. The following table shows the coefficients of determination (goodness of fit) for the various definitions of income when regressed over data from 1968 to 1980, 1981 to 1985, and 1968 to 1985:

Table 1

COEFFICIENTS OF DETERMINATION

ADJUSTED R^2	GNP	DOMESTIC PURCHASES	FINAL DEMAND	DOMESTIC FINAL DEMAND
BEFORE 1981	.317	.366	.496	.578
AFTER 1980	.353	.172	.565	.327
ALL	.160	.182	.308	.330
ALL W/ DUMMY FOR AFTER 1980	.200	.188	.400	.375

The significance of the relationship can be tested with the F-ratio from the analysis of variance. The probability that the dependent variables are unaffected by the independent variables is shown in parentheses under each F-value.

Table 2

TEST OF HYPOTHESIS THAT COEFFICIENTS ARE ZERO

F-RATIO (PROBABILITY > F)	GNP	DOMESTIC PURCHASES	FINAL DEMAND	DOMESTIC FINAL DEMAND
BEFORE 1981	**2.267** (.03)	**2.579** (.02)	**3.694** (.002)	**4.744** (.0003)
AFTER 1980	1.763 (.25)	1.290 (.40)	2.821 (.10)	1.681 (.27)
ALL	1.772 (.07)	**1.904** (.05)	**2.808** (.004)	**3.001** (.002)
ALL W/ DUMMY FOR AFTER 1980	**1.952** (.04)	**1.882** (.05)	**3.545** (.0004)	**3.282** (.0009)

As would be expected, the fit improved with the removal of net exports and final demand, and improved considerably when both were removed for the years before 1981. After 1980, the St. Louis model did a poorer job of estimating gross domestic purchases than it did GNP. This is surprising as it was after 1980 when balance of trade deficits became significant. Final demand produced considerably better results than GNP. Domestic final demand, which produced the best fit before 1981, did worse than GNP after 1980, apparently because of removing net exports. When all the data was combined, the pattern was the same as before 1981, but the fit was much poorer. There were twenty quarters after 1980 and fifty two before 1981, so it could be expected that the relationship existing before 1981 would dominate the combined results. When a dummy variable which was one after 1980 and zero otherwise was introduced, the pattern with combined data changed to resemble the after 1980 series and the fit improved.

It appears that although defining income as final demand improves the ability of the St. Louis model to accurately estimate changes in the growth rate of income from changes in the growth rate of money and government spending, fluctuations in inventories do not explain why the model worked better before 1981 than after. Final demand was a better proxy for income before 1981 also. Fluctuations in net exports since 1980 certainly don't account for the breakdown in the 1980's since removing them from the model made things worse. It seems that there was a fundamental shift in the money-income relationship in the early 1980's corresponding to the shift in the growth rate of velocity observed at that time.

A drop in the growth rate of velocity would result in a drop in the intercept in the St. Louis model, all else the same. This can be seen by assuming that the growth rates of money and government spending are both zero over the entire lag period. In that case, lowering the growth rate of velocity would imply lowering the growth rate of income. The growth rate of income when the independent variables are zero is the intercept. The dummy variable for after 1980 represents this shift in the intercept and its coefficient is -3.30 (when final demand is the dependent variable) indicating that the intercept did indeed fall. The estimated intercept is 3.02, so it appears the intercept went from positive to negative in the early 1980's. The separate regressions on data from before and after 1981 confirm this. The estimated intercept was 1.23 before and -21.60 after (with final demand). The T-statistics for the estimated coefficients of the dummy variable and the probability that the actual coefficient is zero are shown below:

Table 3

TEST OF HYPOTHESIS THAT INTERCEPT IS THE SAME BEFORE 1981 AND AFTER 1980

	GNP	DOMESTIC	FINAL	DOMESTIC FINAL
|T|	1.819	1.159	**2.847**	**2.069**
PROB > |T|	(.076)	(.253)	(.007)	(.044)

It is possible that the intercept was not the only part of the relationship to shift. A test of the hypothesis that the coefficients are the same in the two subperiods examines the ratio of the difference between the sum of the squared errors over the whole period and the sum of the squared errors over the two subperiods to the sum of the squared errors over the two subperiods. This ratio, adjusted for degrees of freedom, has an F distribution[8]. The results of this test on the St. Louis model are shown below:

Table 4

TEST OF HYPOTHESIS THAT COEFFICIENTS ARE SAME BEFORE 1981 AND AFTER 1980

	GNP	GROSS DOMESTIC PURCHASES	FINAL DEMAND	DOMESTIC FINAL DEMAND
F-RATIO	1.77	1.60	**2.28**	**2.15**

F > 1.97 is significant at 5% level.

The results of this test indicate that there has been a significant shift in both the intercept and the lag coefficients of the St. Louis model. Although the relationship between money and income does appear to have shifted, it is hard to say that it has broken down. When properly specified, the reduced-form model still produces strong coefficients of determination. The original conclusions of the St. Louis model also seem to remain valid. The effects of monetary policy are still stronger, faster and more predictable than those of fiscal policy. The distributions of the lag coefficients show pretty much the same pattern before and after 1981, but the values are higher after. The sum of all monetary lag coefficients is still significantly larger than the sum of the fiscal lag coefficients, indicating that monetary policy is more effective in influencing the growth path of income. The sum of the first few lags shows even more disparity, indicating that the effects of monetary policy will be felt faster.

Table 5

ESTIMATED LAG DISTRIBUTION
Dependent variable: FINAL DEMAND

BEFORE 1981

PARAMETER	ESTIMATE	STANDARD ERROR	0 — 1
INTERCEPT	1.232	3.510	
M(0)	0.757	0.171	***************
M(1)	0.395	0.164	********
M(2)	0.121	0.133	**
M(3)	-0.033	0.124	*
M(4)	-0.080	0.114	**
M(5)	-0.050	0.140	*
M(6)	0.015	0.121	*
M(7)	0.074	0.167	**
M(8)	0.073	0.141	**
M(9)	-0.069	0.261	*
M(10)	-0.485	0.267	**********
G(0)	0.113	0.057	**
G(1)	0.022	0.059	*
G(2)	0.012	0.055	*
G(3)	0.097	0.053	**
G(4)	0.089	0.053	**
G(5)	0.029	0.050	*
G(6)	0.041	0.048	*
G(7)	0.065	0.051	*
G(8)	-0.098	0.053	**
G(9)	0.035	0.055	*

Table 6

ESTIMATED LAG DISTRIBUTION
Dependent variable: FINAL DEMAND

AFTER 1980

PARAMETER	ESTIMATE	STANDARD ERROR		0 … 1
INTERCEPT	-21.602	22.653		
M(0)	0.226	0.233		*****
M(1)	0.383	0.210		********
M(2)	0.223	0.158		****
M(3)	0.236	0.115		*****
M(4)	0.377	0.156		********
M(5)	0.460	0.208		*********
M(6)	0.397	0.270		********
M(7)	0.265	0.330		*****
M(8)	0.219	0.368		****
M(9)	0.246	0.373		*****
M(10)	-0.249	0.275	*****	
G(0)	0.201	0.136		****
G(1)	0.136	0.199		***
G(2)	0.229	0.127		*****
G(3)	0.234	0.071		*****
G(4)	0.176	0.097		****
G(5)	0.106	0.142		**
G(6)	0.030	0.161		*
G(7)	-0.059	0.151	*	
G(8)	-0.121	0.132	**	
G(9)	-0.059	0.120	*	

Conclusions

One clear conclusion of this study is that final demand is a better proxy for income than GNP. If policymakers want to estimate the impact of a change in money supply growth rates on GNP growth they should estimate the impact on final demand and then add in a separately obtained estimate of changes in inventories. While the net exports component of GNP could be expected to fluctuate independently of money or government expenditure, removing it from the definition of income produced poorer results than leaving it in. Evidence of a shift in the early 1980's in the relationship between money and domestic purchases is much weaker than for GNP or final demand. Before 1981 domestic purchases performed better than GNP. The reasons for this are unclear.

It seems that there was in fact a substantial change in the relationship between money and income in the early 1980's. When this relationship is modeled by the St. Louis equation, both the slope and intercept change. Although the relationship does appear to have shifted, there is still a relationship. Claims that the relationship has broken down and that therefore monetary policy can no longer be considered effective or predictable appear to be exaggerated. In fact, the coefficients of lagged money supply growth rates are significantly higher than they were before 1981, indicating that monetary policy has even more power than before. What is different is the level of income growth resulting from a constant money supply and no change in government expenditures. This has fallen as a result of a drop in the growth rate of velocity. So while at low levels it takes higher money supply growth rates to produce the same income growth rate as before, there should be a point where, after the drop in the intercept has been compensated for, the paths should cross and the marginal impact of increasing the growth rate of money should be greater than before the shift occurred.

The implications for policymakers are that monetary aggregates are still valid intermediate targets, but that when estimating the effect of a monetary aggregate on income, changes in inventories should be estimated separately. Even when no effort is made to compensate for the shift in the early 1980's, the ability of the model to predict final demand is impressive. An adjusted R^2 of .308 for a simple reduced form equation explaining something as complicated as the U.S. economy over the last seventeen years indicates a relationship which, although imperfect and changing over time, has not suffered a serious breakdown.

NOTES

1. Andersen, Leonall and Jordan, Jerry. "Monetary and Fiscal Actions: A Test of Their Relative Importance in Economic Stabilization," Federal Reserve Bank of St. Louis Review (November 1968), p. 16.

2. Batten, Dallas and Thornton, Daniel. "How Robust Are the Policy Conclusions of the St. Louis Equation?: Some Further Evidence," Federal Reserve Bank of St. Louis Review (June/July 1984). In addition to specifying the optimal lag length and polynomial degree, the authors conclude that the policy conclusions of the St. Louis model hold up ouer a wide range of alternative specifications.

3. The method of polynomial distributed lags was first described by Shirley Almon in "The Distributed Lag Between Capital Appropriations and Expenditures," Econometrica, Vol. 33 pp.178-196. The best explanation I could find of how to actually apply the method is in Basic Econometrics by Damodar Gujarati (1978), pp. 255-286.

4. Batten, Dallas and Thornton, Daniel. "Polynomial Distributed Lags and the Estimation of the St. Louis Equation," Federal Reserve Bank of St. Louis Review, (April 1983) pp. 20-23. The authors describe the Pagano-Hartley methodology in the appendix to this article.

5. Cook, Timothy. "The 1983 M1 Seasonal Factor Revisions: An Illustration of Problems That May Arise in Using Seasonally Adjusted Data for Policy Purposes," Federal Reserve Bank of Richmond Economic Review (March/April 1984) pp. 22-33.

6. The National Income and Product Accounts were extensively revised and the results were published in the February 1986 Survey of Current Business for 1929 to 1985. However, all of the numbers reported for "percent change from preceding period for gross domestic purchases" are wrong. They are the same in every case as those for GNP. I found no correction in subsequent (up to June 1986) isues, so I calculated my own rates of change.

7. SAS is a product of the SAS Institute in Cary, North Carolina and has a procedure called PDLREG which calculates polynomial distributed lag regressions.

8. This is a traditional method of analyzing covariance. Hamburger (1977) and Siegel (1986) both used this method to find evidence of a shift during the 1970s. Neither found a shift in the 1970s, but Siegel did find strong evidence of a shift in the early 1980s.

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