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The sensitivity of policy elasticities to the time period examined in the St. Louis equation and other tests.

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THE SENSITIVITY OF POLICY ELASTICITIES TO THE TIME PERIOD EXAMINED IN THE ST. LOUIS EQUATION AND OTHER TESTS

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ABSTRACT

Using the reduced form equation of the St. Louis Fed's monetarist macroeconomic model, we examine the sensitivity of monetary and fiscal policy elasticity estimates to the empirical estimation technique, to the assumed lengths of policy lags, and to the time period studied. The empirical results are not very sensitive to the first two factors, but the results are quite sensitive to the time period examined. Two plausible explanations for the divergent results are considered and examined and the implications of the divergent results for the usefulness of the St. Louis model is discussed.

1. Introduction

Using what has become known as the St. Louis equation, Andersen and Jordan [1] argued that the steady state effect of monetary policy is positive and significant while the steady state effect of fiscal policy is approximately zero and insignificant. These important policy conclusions have withstood criticism on several grounds including the assertion that the equation is a reduced form equation [2, 6, 12], the assumption that the measures of monetary and fiscal policy are exogenous [5, 11, 16, 17], and, more recently, that the results are independent of functional form [4, 9, 21].

The results generated by tests of St. Louis type equations have also been questioned concerning a number of other issues. These include the potential bias associated with the polynomial distributed lag (PDL) technique usually employed in empirical estimation. The PDL technique requires prespecification of the length of the policy lags and, in addition, places restrictions on the pattern of the lagged coefficients. These restrictions involve the requirement that the lagged coefficients lie on a polynomial of a given degree and, at times, constraining either one or both endpoints to equal zero. Econometric theory clearly establishes that misspecification of any of these parameters results in biased and inconsistent estimators [10, 13, 18], raising doubts concerning conclusions drawn from the empirical tests.

The basic purpose of this study is to examine the sensitivity of monetary and fiscal elasticities estimated from St. Louis type equations to the assumed lengths of the policy lags, to the potential bias inherent in the PDL

technique, and to the time period studied.[1] Another tangential issue to be explored deals with the stability of the relationship over time.

The analysis begins with a review of the nature of the PDL technique, the problems associated with it, and procedures used to circumvent the problems. This is followed by a description of the model and a presentation of the empirical results. The final section presents a summary of major conclusions.

2. Problems in Lag Estimation

Distributed lag models do not, in and of themselves, require sophisticated estimation techniques; ordinary least squares (OLS) procedures produce best linear unbiased estimators. However, the lagged values of a variable are likely to be highly collinear. This collinearity results in large standard errors for the individual coefficients and this, in turn, distorts the usual significance tests.

In order to circumvent the imprecision of the OLS estimators *at the individual coefficient level,* the PDL technique assumes "new information." This new information takes the form of a prespecification of the length of the lag, a prespecification that the individual coefficients lie on a polynomial of suitable degree, and, at times, a further prespecification that the coefficient of the first and/or last period of the distributed lag be equal to zero. The advantage of the PDL technique is that it yields estimators with standard errors that are usually sufficiently small to accommodate significance tests for the individual coefficients. The problem with the PDL technique is that

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[1]Andersen and Jordan [1] originally addresssed the question of the relative speed, strenth, and predictability of monetary and fiscal actions. Our focus is narrower in that we are only concerned with the relative strength of policies. The current study is more rigorous, however, in that we test these strengths over a broader range of lag structures, over alternative estimation techniques, and over several time periods.

if any of these key parameters, singularly or in combination, is misspecified then there is a specification error and the resulting estimators are inconsistent. Such misspecification is likely for there is no theoretical or empirical basis for determining, *a priori,* the correct value for each of the parameters.

The primary issue of St. Louis studies concerns the strengths of the policy elasticities, not the size of individual coefficients. The assumptions imposed by the PDL technique are designed to assess the impact of individual coefficients, but they are not necessary to examine the total effect of policy actions. A major question considered by this study is the sensitivity of past St. Louis results to the assumptions of the PDL. OLS estimators yield sufficiently precise estimates of the strengths of total policy actions without this potential bias. Thus, comparisons of PDL and OLS estimators allows an assessment of this question.

St. Louis equations are usually estimated using a second or fourth degree polynomial. We choose to use a second degree polynomial because it places more severe restrictions on the pattern of lagged coefficients thus enhancing the comparison of PDL produced elasticities with the OLS elasticities which, of course, do not restrict the pattern of lagged coefficients.

With respect to the "true" lengths of policy lags, the highly collinear data precludes a rigorous assessment of this issue. Multicollinearity is a problem associated with the data, not the estimation technique. Numerous variations in estimation technique have, not surprisingly, failed to satisfactorily ameliorate this problem. We choose to accept this uncertainty concerning the "true" lag structure and estimate policy elasticities over a range

of possible lag structures.[2] This procedure, of course, does not allow an identification of the "true" lags and "true" elasticities, but it does provide information regarding the sensitivity of the estimated elasticities to alternative assumptions regarding the lengths of the policy lags.[3]

The need to consider the sensitivity of St. Louis results to the time period examined is based on the possibility of structural shifts in the economy or, perhaps more honestly, the unfortunate fact that econometric evidence often yields divergent results over alternative time frames. Recent research also suggests that time period may be an important factor influencing results with the St. Louis equation [9, 13, 19, 21].

3. The Model and the Empirical Results

In their investigation, Andersen and Jordan [1] tested a number of different measures for both monetary and fiscal policy. They also used two different functional forms: variables were expressed as first differences and in rate of change form. They concluded that their results were independent of the variables used to measure the policies and of function form. For

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[2]In a recent article, Harper and Fry [13] use an empirical technique to estimate lag length and then proceed to apply a series of specification error tests to evaluate the reliability of the empirical results. Their initial procedure is to begin with a fourth degree polynomial and a ten period lag and apply "t-tests to determine if parameters have been overestimated." By their own admission, this porcedure is not rigorous. Compared to the Harper-Fry study, the current investigation examines a broader range of lag structures and explores specifically the impact of alternative assumptions regarding lag lengths on estimated elasticities. In addition, the current study investigates the sensitivity of results to the time period studied.

[3]At least one researcher found a correlation between assumed lag length and the size of resulting multipliers. In a simulation study, Frost [10] found that the mean value of the estimated multiplier calculated with the PDL technique over a range of parameter prespecifications increased monotonically with the length of lag. Frost's results are, of course, based on his particular model and are not necessarily general. They do, however, raise concern over the sensitivity of St. Louis results to the usual assumption of relatively short lag lengths.

comparability with more recent research, this study uses high employment Federal Budget expenditures as the measure of fiscal policy and M1B as the measure of monetary policy[4] with the equation stated in rate of change form.[5] Thus the general specification is:

$$\dot{Y}_t = a_t + \sum_{i=0}^{n} b_i \dot{M}_{t-i} + \sum_{j=0}^{q} c_j \dot{HEB}_{t-j} + e_t$$

where $\dot{Y}$ = rate of change in current dollar Gross National Product;

$\dot{M}$ = rate of change in M1B;

$\dot{HEB}$ = rate of change in high employment Federal budget expenditures; and

e = stochastic error term.

The data are derived from seasonally adjusted, quarterly observations.

The time periods include the overall period 1953I - 79IV and the two subperiods 1953I - 69IV and 1970I - 79IV. The monetary and fiscal policy lags

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[4]The high employment expenditures data for 1955I-79IV are from the new estimates [7] with prior data obtained from the old series. The rate of change of M1B is used after 1960I with prior data taken from old M1. We tested the St. Louis equation for all combinations of old and new high employment expenditures and M1 and M1B. There were no significant differences.

[5]In response to an article by Friedman [9], Carlson [4] argues that "the estimation of the St. Louis equation in arithmetic first difference form no longer appears to be acceptable because there is evidence of nonconstant error variance" and, therefore, Friedman's conclusion regarding the effectiveness of fiscal policy is inappropriate. Carlson then argues that the rate of change form is to be preferred to the first difference form because it satisfies the least-squares assumption of a constant error variance. Vrooman [21], commenting on both Friedman and Carlson, argues that Carlson's response to Friedman is inappropriate. According to Vrooman, Carlson should have employed a "weighted least-square estimation" of the first difference form. Using such a procedure, there is some support for Friedman's original conclusion. Our opinion on this debate, which is consistent with Vrooman's work, is that the inclusion of more recent years in tests of St. Louis type equations opens the broader view that the economic environment has changed. Either the size of policy elasticities vary with the state of the economy or relevant variables -- perhaps aggregate supply variables -- are excluded from the St. Louis equation.

are allowed to vary independently from 4 to 10 quarters in increments of two.[6] Thus, there are 16 different lag combinations considered for each time period. Each lag combination in each time period is estimated with both OLS and PDL techniques yielding a total of 96 pairs of monetary and fiscal policy elasticity estimates. Finally, the PDL results assume a second degree polynomial with no constraints on the endpoints.

The empirical results can be examined to determine the sensitivity of the policy elasticities to the following influences: the lag structure assumed, the estimation technique employed, and the time period studied. These are discussed in order.

(i) Sensitivity of Elasticities to Lag Structure

When the St. Louis equation is estimated in rate of change form the general monetarist conclusions are best stated along the lines of the quantity theory of money: the steady state impact of monetary policy on national income is significant and approximately one while the steady state impact of fiscal policy is approximately zero and insignificant. These conclusions are not sensitive to the assumed lengths of the policy lags. For example, every OLS and PDL derived monetary elasticity for the 1953I - 79IV period is at least four times its standard error and within one standard deviation of one, while the corresponding fiscal elasticities are always smaller than their standard errors (see Table 1).

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[6]We examined all lag combinations through 12 quarters for monetary and fiscal policy. Because the additional regressions did not produce any significant changes we chose to limit the recorded output to lags through 10 quarters.

TABLE 1
ELASTICITY ESTIMATES 1953I - 1979IV
Standard Errors in Parentheses

Ordinary Least Squares

Length of Monetary Lag	Type of policy	Length of Fiscal Lag 4	6	8	10
4	Monetary	1.15	1.16	1.16	1.17
		(.16)	(.16)	(.16)	(.15)
	Fiscal	-.01	-.01	-.02	-.09
		(.07)	(.07)	(.07)	(.08)
6	Monetary	1.02	1.01	1.00	1.04
		(.16)	(.17)	(.17)	(.16)
	Fiscal	.00	.02	.02	-.06
		(.07)	(.07)	(.07)	(.08)
8	Monetary	.94	.93	.93	.99
		(.18)	(.18)	(.18)	(.17)
	Fiscal	.01	.03	.03	-.05
		(.07)	(.07)	(.07)	(.08)
10	Monetary	.91	.90	.89	.98
		(.19)	(.19)	(.19)	(.18)
	Fiscal	.01	.03	.03	-.05
		(.07)	(.07)	(.07)	(.08)

Polynominal Distributed Lag*

Length of Monetary Lag	Type of policy	Length of Fiscal Lag 4	6	8	10
4	Monetary	1.15	1.15	1.13	1.14
		(.16)	(.16)	(.16)	(.16)
	Fiscal	-.01	-.01	-.01	-.07
		(.07)	(.07)	(.07)	(.08)
6	Monetary	1.01	.99	1.00	1.03
		(.16)	(.17)	(.17)	(.17)
	Fiscal	.01	.02	.01	-.04
		(.07)	(.07)	(.07)	(.08)
8	Monetary	.93	.92	.91	.98
		(.18)	(.18)	(.18)	(.18)
	Fiscal	.02	.02	.02	-.03
		(.07)	(.07)	(.07)	(.08)
10	Monetary	.90	.89	.89	.96
		(.19)	(.19)	(.19)	(.19)
	Fiscal	.02	.02	.02	-.03
		(.07)	(.07)	(.07)	(.08)

*Estimated with a second degree polynominal and with no endpoint constraints.

As for the size of the monetary elasticities, the assumed lengths of the policy lags have some impact; the OLS estimates for the 1953I - 79IV period range from a high of 1.17 to a low of 0.89 while the PDL estimates vary from 1.14 to 0.89. The size of the monetary elasticities generally move inversely with the length of the monetary lag and directly with the length of the fiscal lag. The fiscal elasticities, though never approaching statistical significance, tend to rise with the length of the monetary lag and decrease with the length of the fiscal policy.

The results for the 1953I - 69IV period (see Table 2) present a similar pattern with monetary policy always significant at the five percent level and never more than 1.19 standard deviations from one, while fiscal policy is insignificant. The size of the monetary and fiscal elasticities vary in a similar pattern to the 1953I - 79IV period.

The 1970I - 79IV results are slightly more sensitive to the assumed lengths of policy lags. The monetary elasticities are about one and significant or approaching significannce for four to eight quarter monetary lags, but substantially below one and insignificant for ten quarter monetary lags. The monetary elasticities, however, are never statistically different from one and are seldom more than one standard deviation from one. The size of the fiscal elasticities are significant or approaching significance throughout the lag structures tested, and tend to increase with the length of the fiscal lag. Although the 1970I - 79IV results are substantially different from results of earlier periods, a point to be discussed below, the fact that the monetary elasticities are never statistically different from one while the fiscal elasticities are always significant or approaching significance suggests that the quantity theory conclusions are not greatly sensitive to alternative specifications of the lag structure.

TABLE 2
ELASTICITY ESTIMATES 1953I - 69IV
Standard Errors in Parentheses

Ordinary Least Squares

Length of Monetary Lag	Type of policy	Length of Fiscal Lag 4	6	8	10
4	Monetary	1.16	1.15	1.17	1.20
		(.23)	(.23)	(.24)	(.22)
	Fiscal	-.06	-.06	-.07	-.15
		(.07)	(.07)	(.08)	(.08)
6	Monetary	.97	.90	.90	.97
		(.25)	(.25)	(.25)	(.24)
	Fiscal	-.06	-.04	-.04	-.12
		(.07)	(.07)	(.07)	(.08)
8	Monetary	.79	.71	.76	.87
		(.28)	(.28)	(.29)	(.28)
	Fiscal	-.06	-.03	-.03	-.11
		(.07)	(.07)	(.07)	(.08)
10	Monetary	.75	.63	.65	.82
		(.30)	(.31)	(.32)	(.32)
	Fiscal	-.06	-.03	-.03	-.11
		(.07)	(.07)	(.08)	(.08)

Polynominal Distributed Lag*

Length of Monetary Lag	Type of policy	Length of Fiscal Lag 4	6	8	10
4	Monetary	1.15	1.12	1.10	1.18
		(.22)	(.23)	(.25)	(.25)
	Fiscal	-.06	-.04	-.05	-.11
		(.07)	(.07)	(.08)	(.09)
6	Monetary	.95	.91	.91	.99
		(.24)	(.25)	(.27)	(.28)
	Fiscal	-.06	-.02	-.03	-.09
		(.07)	(.07)	(.08)	(.09)
8	Monetary	.83	.76	.73	.87
		(.27)	(.28)	(.30)	(.31)
	Fiscal	-.06	-.03	-.03	-.08
		(.07)	(.07)	(.08)	(.09)
10	Monetary	.78	.69	.71	.92
		(.29)	(.31)	(.33)	(.35)
	Fiscal	-.06	-.03	-.03	-.09
		(.07)	(.07)	(.08)	(.09)

*Estimated with a second degree polynominal and with no endpoint constraints.

To summarize these results, for a given time period the realization of quantity theory results is not affected by alternative specifications of the lengths of the lags. However, for a given time period the size of the estimated elasticities are somewhat sensitive to alternative assumptions regarding lag lengths.

(ii) The Sensitivity of Elasticities to the Estimation Technique

The size, sign, and significance of the policy elasticities derived from the PDL technique (with a second degree polynomial and without endpoint constraints) are very similar to the results obtained with OLS. In fact, for the 1953I - 79IV period (see Table 1), the differences between the OLS and PDL monetary elasticities never exceed 0.04 while the fiscal elasticities never exceed 0.02. The results from the two subperiods are also remarkably similar.

Thus, it would appear that in the current analysis, results from St. Louis studies cannot be attributed to the fact that the PDL technique restricts the flexibility of the individual lagged coefficients. Although it is unlikely that the "true" coefficients lie on the assumed second degree polynomial, any bias introduced by this assumption into the individual coefficients apparently cancels out to a large extent upon aggregation. Of course, the PDL technique, especially with a low degree polynomial, may still impose a substaintial bias in the estimates of the individual coefficients and, therefore, the timing of the policy actions.

(iii) The Sensitivity of Elasticities to the Time Periods Studied

The size and significance of the fiscal policy elasticities appear to be sensitive to the time period studied. The fiscal elasticities for the 1970I - 79IV period average 0.52 compared with a miniscule 0.00 and - 0.01 for the full and other subperiod. Furthermore they are either significant or

TABLE 3
ELASTICITY ESTIMATES 1970I - 79IV
Standard Errors in Parentheses

Ordinary Least Squares

Length of Monetary Lag	Type of policy	Length of Fiscal Lag 4	6	8	10
4	Monetary	1.16	1.18	1.24	1.08
		(.36)	(.37)	(.41)	(.43)
	Fiscal	.37	.45	.70	.51
		(.19)	(.24)	(.29)	(.32)
6	Monetary	1.09	1.11	1.06	.98
		(.42)	(.44)	(.47)	(.50)
	Fiscal	.36	.44	.67	.52
		(.20)	(.25)	(.30)	(.34)
8	Monetary	1.04	1.08	.89	.90
		(.53)	(.57)	(.59)	(.63)
	Fiscal	.37	.45	.70	.54
		(.22)	(.26)	(.32)	(.36)
10	Monetary	.32	.36	.36	.56
		(.56)	(.62)	(.65)	(.75)
	Fiscal	.46	.47	.65	.49
		(.20)	(.24)	(.29)	(.35)

Polynominal Distributed Lag*

Length of Monetary Lag	Type of policy	Length of Fiscal Lag 4	6	8	10
4	Monetary	1.18	1.22	1.22	1.18
		(.39)	(.39)	(.38)	(.39)
	Fiscal	.38	.48	.65	.55
		(.21)	(.24)	(.27)	(.29)
6	Monetary	1.07	1.03	1.05	1.05
		(.44)	(.43)	(.42)	(.42)
	Fiscal	.38	.47	.65	.57
		(.21)	(.24)	(.26)	(.29)
8	Monetary	.91	.96	.96	.94
		(.52)	(.53)	(.52)	(.51)
	Fiscal	.41	.48	.65	.56
		(.21)	(.24)	(.26)	(.29)
10	Monetary	.23	.40	.43	.43
		(.59)	(.63)	(.61)	(.61)
	Fiscal	.53	.51	.63	.56
		(.21)	(.23)	(.26)	(.28)

*Estimated with a second degree polynominal and with no endpoint constraints.

approaching significance at the five percent level in both OLS and PDL regressions.[7,8] The monetary elasticities for 1970I - 79IV are positive and close to one for short (eight quarters or less) monetary lags but substantially less than one and insignificant for 10 quarter monetary lags. This compares with a much narrower range of monetary elasticities centered around one for the other time periods. The monetary standard errors for 1970I - 79IV are approximately twice as large as the corresponding standard errors for the other time periods, thus preventing an accurate asessment of the impact of monetary actions during the 1970's. In fact, half of the monetary elasticities are insignificantly different from the theoretical extreme values -- zero and one -- at the five percent level.

There are at least two plausible explanations for the variation in policy elasticities witnessed among time periods. First, the reason for the divergent results may be found by considering the impact of the 1970 and 1974-75 recessions on the size of the policy elasticities. Macroeconomic theory has long suggested that the impact of monetary and fiscal actions may depend on the state of the economy, the impact of monetary actions being lower in times of high unemployment while the fiscal impact is increasing during such periods. If the size of the fiscal and/or monetary elasticities vary considerably with the state of the economy, then the St. Louis equation is not valid. The lagged coefficients would not be constant as presently assumed but, rather, would vary with some proxy(ies) for the state of the economy.

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[7]The estimated standard errors from the PDL regressions will be biased downward if the degree of polynomial is underspecified. Thus PDL significance tests should be interpreted with a note of caution.

[8]Our results for this later period concerning the effectiveness of fiscal policy are consistent with the results of Friedman [9], Harper-Fry [13], and Vrooman [21]. Fiscal policy appears to be more effective in the 1970's than in previous periods.

This interpretation of the 1970I - 79IV results receives support from tests on the stability of the St. Louis relationship. F-tests formed from the OLS regressions often reveal at the five percent level a statistically different relationship between the two subperiods (see Table 4).[9]

TABLE 4

F-TEST FOR DIFFERENCES IN THE RELATIONSHIP BETWEEN 1953I - 69IV AND 1970I - 79IV PERIODS

Length of Monetary Lag	Length of Fiscal Lag			
	4	6	8	10
4	2.17*	2.24*	2.16*	1.88*
6	1.63*	1.86*	1.81*	1.58
8	1.26	1.68	1.62	1.43
10	1.86*	1.92*	1.86*	1.76*

*indicates a significant difference at the five percent level.

A second possible explanation for the time period differences in elasticities could be the impact of "outside" factors affecting the level of aggregate supply. Both monetary and fiscal policy are designed to affect income through their influence on aggregate demand. It is obviously desirable when measuring the relative efficacy of money and fiscal actions as aggregate demand policies to remove or otherwise account for movements in aggregate supply.

It is not difficult to find examples of major disruptions in aggregate supply in the 1970s. The quadrupling of foreign oil prices in 1973 and subsequent price increases had a major impact during much of this period. Labor

[9]See J. Johnston [15, pp. 192-207] for a discussion of the test.

management disputes, including the major auto strike during 1970IV -71IV, also had a substantial impact on income. More directly, the assumption of constancy of aggregate supply is less plausible for the 1970I - 79IV period and this, in turn, may alter elasticity estimates. This explanation is also compatible with the stability tests discussed above.

Pursuing this line of reasoning, the authors examined two versions of the St. Louis equation expanded to include energy and labor strike supply side disruptions [3]. Although both variables generally proved significant, their inclusion did not alter the St. Louis equation's sensitivity to the time period studied. Of course these results do not rule out the possibility that other methods of representing aggregate supply shifts may account for the nonmonetarist results of the later period.[10]

4. Conclusions

During the past decade, tests using the St. Louis equation have been used to support the argument that monetary actions have a steady state impact on national income while fiscal policy does not. But these studies have, in a general sense, failed to consider the influence of the assumed lengths of the lags, the estimation technique employed, and the time period studied on these estimated elasticities. This study provides information regarding the sensitivity of elasticity estimates to each of these three elements.

The evidence presented here indicates that estimates of monetary and fiscal policy elasticities are somewhat sensitive to the assumed lengths of lags. This sensitivity is not, however, large enough to alter conclusions regarding

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[10]John Tatum [20] also expanded the St. Louis equation using similar proxies for energy and labor. However he only presents results for the 1955I - 78III period and does not consider the consistency of the St. Louis equation over different time periods.

the efficacy of monetary or fiscal actions. The evidence also indicates that the elasticities are not sensitive to the estimation technique employed. The fiscal elasticities are insignificant and approximately zero for every lag structure tested for both the 1953I - 1979IV and 1953I - 1969IV periods. This result prevails in both PDL and OLS estimations. The monetary policy elasticities are close to one and significant for these periods.

The elasticities, however, are sensitive to the time period studied. The fiscal elasticities for the 1970I - 79IV period are positive and often significant while the standard errors of the monetary elasticities are too large to accurately assess the impact of monetary policy in the 1970s. In fact, monetary elasticities are often insignificant in this period. The reasons for the divergent results are not clear. The existence of monetary and fiscal elasticities that vary with the state of the economy or the model's failure to consider changes in aggregate supply may account for the nonmonetarist results. Regardless of the reasons, the apparent inability of the St. Louis equation to produce consistent estimates of policy elasticities over different time periods must be viewed as a serious shortcoming of the equation.

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