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ANOTHER LOOK AT THE CREDIT-OUTPUT LINK

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1. Introduction

Among financial variables that transmit monetary policy to aggregate economic activity, the monetary aggregates receive the greatest attention. The most commonly accepted justification for this money-output relationship is that informational imperfections or nominal rigidities allow changes in nominal money balances to have a short-run impact on real output. But since the 1980s breakdown in the money-output relationship, economists are looking more carefully at the role of credit in transmitting monetary policy, and other financial sector shocks, to the real economy.[1]

In order for changes in money balances to have an impact on real output, it must be the case that no perfect substitute for money exists. One argument supporting the notion of a credit-output link is that there is no perfect substitute for bank credit. When banks reduce their lending in response to tighter monetary policy and the resultant higher interest rates, some firms are unable or unwilling to borrow. As a result, investment and economic activity are curtailed.[2]

As a practical matter, bank credit and bank deposits are highly correlated.[3] A contraction of reserves leads to a contraction of both loans

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[1] See Friedman (1988) for a discussion of the breakdown in the relationship between money and output. See Friedman (1982), Blinder and Stiglitz (1983), Bernanke and Gertler (1987), and Bernanke and Blinder (1988) for discussions of the links between credit and output. For a survey of recent work concerning the latter, see Gertler (1988).

[2] See Bernanke and Blinder (1988) for a discussion of this issue. Note that the relationship between credit and output is even stronger if, when interest rates rise, banks engage in nonprice discrimination of their loan applicants.

[3] In fact, the correlation between total bank loans and demand deposits over the period 1959:1-1987:4 is 0.91, although part of this correlation is a correlation between trends. The growth rates of these two aggregates have a much lower but still highly significant correlation.

and deposits, and makes it difficult to empirically distinguish between a credit channel and a money channel for the transmission of monetary policy. More generally, although shocks to the financial sector may first impinge upon the credit market, ultimately both money and output are affected. Thus, the credit-output link would also show up as a correlation between money and output. The most likely scenario is that the money and credit channels operate simultaneously so that both variables provide information about future economic activity. This possibility suggests that paying attention to both sides of the banking system's balance sheet could improve our information about future movements in output.

Previous empirical work on the credit-output and money-output links offers mixed evidence on the strength of the relationship between credit and economic activity. Based on both Granger causality and variance decomposition tests, King (1986) found that the link between credit, as measured by bank loans, and both real and nominal output was weaker than the link between demand deposits and output. Using the same empirical methods employed by King and broader measures of money and credit, Bernanke (1986) found that money was a stronger predictor of output than credit. Bernanke then estimated a structural vector autoregression model and found that money and credit explained equal percentages of the variation in output.

The King and Bernanke articles constitute the most recent evidence on the credit-output link. Since their work was published, however, a number of developments have altered the way in which empirical models are specified, raising doubts about the conclusions reached in the earlier work. At issue is how stationarity of variables is achieved and how the lag structure of variables is determined.

We know that in order to obtain the proper test statistics and draw the proper inferences, we must use data in stationary form. Only recently, however, has it become popular to employ unit root tests so that stationarity can be formally determined. Further, if two series are cointegrated, or move in similar ways over time, their long-run relationship can be exploited. Tests have recently been developed that determine if such a relationship exists.

Stock and Watson (1989) employ unit root and cointegration tests to examine the Granger-causal relationship between money and output. They find that M1 is characterized by one unit root and a time trend. When these characteristics are accounted for, money has a much stronger predictive link with output than previously found. The purpose of our work is to allow for this same specification of M1 and, if appropriate, credit when comparing the money-output link with the credit-output link.

Empirical findings can also be highly sensitive to lag-length specification. (See, for example, Thornton and Batten (1985)). To resolve this problem, formal statistical tests have been developed to insure that empirical work is less subject to criticisms of lag-length misspecification. The empirical work presented here incorporates such a procedure.

Our work differs from previous work in two additional ways. First, we allow the contemporaneous value of the independent variable to play a predictive role. The idea behind such an allowance is that a variable in one month could affect another variable in immediately succeeding months. With quarterly data, this temporal ordering shows up as a correlation between contemporaneous values, and this information is ignored when the contemporaneous value of the independent variables is excluded. Moreover, the independent variables used in this study are available on a monthly basis. For any given quarter, the data are available prior to the release of quarterly output data and this information could aid in our understanding of the money-output and credit-output links. Second, we emphasize Akaike's (1969, 1970) final prediction error criterion in determining the predictive strength of a variable. As we discuss below, this statistic is more in the spirit of Granger causality than the commonly used F-test.

The unit root test leads to a variable specification roughly equivalent to that used by King and Bernanke. But the inclusion of the contemporaneous values of the independent variables, together with statistically determining the lag-length of the variables, leads to an overturning of the King and Bernanke results. We must emphasize, however, that our work only overturns earlier conclusions about the <u>predictive</u> ability of money versus credit. Further work is necessary to understand the extent to which credit market activity <u>impacts</u> the real economy. The subsequent sections present the basis for our conclusion.

2. <u>The Test Procedure</u>

This study uses Granger causality tests to examine the money-output and credit-output links. The use of causality tests allows us to incorporate the techniques discussed in the previous section and to compare the results to the earlier work of King and Bernanke. It also allows us to explore the credit-output link in a manner that parallels the work on the money-output link reported by Stock and Watson.

Following earlier studies, we examine the predictive relationship between the independent, or policy, variables and both nominal and real gross national product. Real output is used to consider the extent to which nominal policy variables have real effects in the short run. Nominal output is used because the breakdown of a policy variable's effect between real economic activity and prices is often difficult to determine. Moreover, the high correlation of money with nominal output has been well documented. (See Friedman and Schwartz (1963, 678-86)). The output measures used in this study consist of quarterly data on the logarithmic values of nominal and real gross national product (NGNP and RGNP) for the years 1959-87.

The independent variables in this study consist of quarterly observations on the logarithmic values of seasonally adjusted nominal M1 (M1) and M2 (M2), the log of the sum of loans made by commercial banks, mortgages at savings and loans, and mortgages and other loans at mutual savings banks (C), and the 1-year Treasury bill rate (RTB). We employ the monetary aggregates, as opposed to the demand deposit variable used by King, since the aggregates are the focus of discussion in the implementation of monetary policy. The inclusion of loans made by savings and loans and mutual savings banks in our measure of credit allows us to more accurately measure the amount of credit available through the financial sector. This credit variable is also the broadest bank credit measure available.

The analysis first involves examining each of the series to determine whether or not they are stationary. The series are tested for up to two unit roots. The existence of a unit root indicates a nonstationary time series that must be differenced to achieve stationarity. As reported in Appendix A, each of the series contains one unit root. In addition, similar to the results obtained by Stock and Watson, the first difference of M1 exhibits evidence of a time trend. Thus, with the exception of M1, each of the series is used in first difference form. The first difference of M1 is detrended to eliminate its deterministic component.

The variables are also examined for cointegration, or their long-run equilibrium relationship, with output. The idea behind cointegration is that even though two individual series may be nonstationary, with no tendency to return to trend, they may move in similar ways over time. Such a long run relationship can be exploited in empirical work. Moreover, finding that a policy variable is cointegrated with output would lend support to the idea that the variable contains important information about future output movements.[4] As reported in the Appendix, however, only M2 shows evidence of being cointegrated with output, and allowing for this relationship does not improve our results.

Next, to determine the appropriate lag-length specification of the variables, we used Akaike's Final Prediction Error (FPE), where a maximum of eight lags is allowed for. The FPE statistic measures a regression's mean square prediction error, trading off bias from selecting lag lengths that are too short against inefficiency from selecting lag lengths that are too long.[5] Lagged values of the dependent variable and current and lagged values of the independent variable are included in an equation as long as their inclusion lowers the FPE. Given lagged values of the dependent variable, if the inclusion of a variable lowers an equation's FPE, the variable is said to have a predictive relationship with the dependent variable.

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[4] Pairs of the independent variables were also examined for cointegration, since a long-run relationship between independent variables can also be exploited. No such relationship was found, however.

[5] Employing Akaike's final prediction error in this way was first suggested by Hsiao (1981) and then used by McMillin and Fackler (1984) and by Chowdhury, Fackler, and McMillin (1986).

The FPE statistic also indicates the order in which the variables in trivariate and multivariate tests should be entered. Following Hsiao (1981), once the autoregressive lag length is established, we estimate bivariate equations, determining whether each of the independent variables lowers the FPE of output, and determining the appropriate lag length of each of the variables. Among the variables that lower an equation's FPE, the variable that produces the lowest FPE is said to have the strongest predictive relationship with output. Therefore, this variable is entered first in the trivariate case and has the same lag-length specification as in the bivariate case. The remaining variables are then added, one at a time, to this regression and examined for their appropriate lag length, conditional on the fixed lag length of the previously entered variable. The procedure is similar in moving from a trivariate to a multivariate test.

The use of the FPE statistic is consistent with the notion of Granger causality: a variable x is said to Granger cause another variable y if y can be better predicted by using its own lagged values and x than by using only its own lagged values. Yet much of the previous work using Granger causality tests has reported the marginal significance levels of subset F-tests that examine whether or not the coefficients of lagged values of a variable are significant. These tests are usually based upon arbitrarily chosen lag lengths, yet are conditional on the lag length being known. In the work presented here we report and focus on FPE statistics, although we also report the marginal significance levels of the subset F-tests. While the FPE statistic is the more appropriate measure of the predictive strength of an equation, and hence more in the spirit of Granger-causality, reporting the F-test results allows us to compare our work to that of previous researchers.

Recent work has shown that omitting variables in Granger causality tests can lead to spurious causal findings.[6] This result suggests that only conclusions based on regressions that include all the relevant variables are valid. Because of the sequential nature of the FPE procedure, however, we report all of our test results. Reporting all of our results also allows us to compare our work with the earlier work that involved only bivariate tests.

3. Bivariate Results

This section presents the results from examining the Granger-causal relationship between output and each of the four policy variables: M1, M2, the one-year Treasury bill rate and credit. The question is, does the policy variable have predictive content for output, once lagged values of output are accounted for?

Table 1 reports the bivariate test results. Over the period 1961:2-1987:4, given lagged values of the dependent variable, each of the independent variables have a predictive relationship with nominal and real output. The FPE statistics indicate that credit has the strongest predictive relationship with both nominal and real GNP. The interest rate, whose FPE we report because the interest rate is included in subsequent tests, has the second strongest predictive relationship with nominal and real output. M2 follows next in predicting nominal output, while M1 follows next in predicting real output. The marginal significance levels rank the variables in the same order

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[6] See Sims (1980). Sims found that when a short-term interest rate is added to a model that includes money, prices, and industrial production, the proportion of variance in output explained by innovations in money is greatly reduced. In contrast, Lütkepohl (1982) demonstrates that a variable may not be significant in a bivariate Granger causality test and yet be significant in a multivariate test.

of importance as the FPEs do.

The bivariate test results presented in Table 1 differ significantly from the results reported by King and by Bernanke. King found that the relationship between demand deposits and output is far stronger than the relationship between bank loans and output. Bernanke used M1 and the exact credit variable used in this paper and obtained results similar to those obtained by King. Although King employed narrower aggregates than those used here and did not include data from the 1980s, Bernanke used the same variables as we did and his time period extended into the 1980s. Therefore, the difference in results most likely can be attributed to either lag-length specification or to the inclusion of the contemporaneous value of the independent variables. We explore each of these possibilities in the remainder of this section.

Using the FPE procedure to determine lag-length specification of each of the regression variables generally produces a shorter lag specification than the four-lag assumption made by King and Bernanke. Perhaps more importantly, King's work indicates that money has stronger predictive content for output when quarterly data are used, while credit has stronger predictive content when monthly data are used. This result seems to be explained by the fact that King did not include the contemporaneous values of the independent variables in his analysis. As discussed previously, although such an assumption is probably appropriate for determining causality with monthly data, it is not necessarily appropriate with quarterly data.

In the regressions reported in this paper, we found the contemporaneous value of each of the independent variables to be significant.[7] This information, excluded from King's quarterly tests, seems to produce the result that credit dominates money in explaining output. Such a conclusion suggests that credit may have a more immediate predictive relationship with output than money.

To more carefully examine the hypothesis that the contemporaneous value of credit significantly affects output and greatly increases the overall significance of credit, we conducted two tests. First, we reexamined King's data. Using his 4-4 lag-length specification, we estimated his equations, with and without the contemporaneous value of the independent variables. Focusing on marginal significance levels, as King did, we found that including the contemporaneous value of credit greatly increased the significance of credit. In the case of demand deposits, including the contemporaneous value either has no effect or actually lowers the marginal significance of the causal relationship between deposits and output.[8] We then applied the FPE procedure to King's data and found that the significance of credit increased even further. For example, over the period 1950:1-1979:3, the significance level of credit becomes 0.013. The significance of deposits, at 0.000, is

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[7] Including the contemporaneous value of the independent variable is discussed in Granger (1969) and Singh and Sahni (1984). Granger notes that a model which excludes the current value of the independent variable may not be sufficient when using quarterly data, but would be sufficient for monthly data.

[8] Although we obtained King's data from the editorial office of the Journal of Money, Credit and Banking, we could not reproduce his results exactly. For example, King reported the marginal significance of credit in explaining nominal output as 0.302 over the period 1950:1-1979:3. We obtain a level of 0.560. When the contemporaneous value of credit is included, the significance level becomes 0.125. In the case of demand deposits, King reported a significance of 0.002. We obtain a 0.000 significance level, both with and without the inclusion of the contemporaneous value of deposits.

only slightly higher.

We then reestimated the relationships reported in our Table 1, using four lags of the dependent and independent variables, first excluding and then including the contemporaneous value of the independent variable. As Table 2 shows, the exclusion of the contemporaneous value of credit greatly increases the prediction error of credit. In fact, all of the variables have a higher FPE, and a lower marginal significance level, than they did in Table 1. Adding the contemporaneous value of the variables lowers the FPE statistics, except in the case of M2. In particular, the importance of credit rises significantly when its contemporaneous value is included. But even when contemporaneous values are included, as a comparison of Table 1 and Table 2 shows, the FPEs are still higher under the arbitrary specification of a 4-4 lag structure than when lag length is also determined by the FPE statistic.[9]

To summarize, the inclusion of the contemporaneous value of credit in Granger causality tests produces the result that credit has a highly significant causal relationship with output. Ignoring this information leads to a fairly large underestimation of the importance of credit in predicting economic activity.

4. Multivariate Test Results

This section extends the bivariate tests of credit and output by including, in turn, each of the remaining independent variables. Credit is

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[9] To further compare our results to King's, and to examine the period prior to deregulation, we also applied the FPE procedure to our data over the period 1961-79. We found that M1 produces a lower FPE and has a higher marginal significance in predicting nominal GNP than credit does. However, for real GNP, credit has a higher predictive content than either M1 or M2. The details of this work are presented in Appendix B.

entered first in these tests since it had the lowest FPE in the bivariate tests. The question is, does the additional variable have predictive content for output, once lagged values of output and credit are accounted for?

As indicated in Table 3, each of the variables improves the prediction of nominal GNP after credit is accounted for, while only M1 and the interest rate improve the prediction of real GNP. The model containing credit and the interest rate produces the lowest FPE in both the nominal and real GNP case. Such a result is not too surprising since these variables had the lowest FPEs in the previous tests. The marginal significance levels tell a similar story: credit continues to predict economic activity even after M1 or M2 is accounted for. M1 and M2 are significant in predicting nominal output at the 10-percent level, but only M1 is significant in predicting real output. The Treasury bill rate is highly significant in both cases.

Because the credit-interest rate model produces the lowest FPEs in predicting both nominal and real GNP, as a final step, each of the monetary aggregates is added, in turn, to this model. We would not expect M2 to have an effect in the multivariate case because it does not lower the FPE of real output in the trivariate case. Nevertheless, we add M2 to the regression in order to verify the trivariate result.

The results from the multivariate tests are presented in Table 4. As the FPEs indicate, including the monetary aggregates aids in predicting nominal GNP, but only M1 aids in predicting real GNP. According to the marginal significance levels, credit remains significant in predicting both nominal and real GNP. M2 is significant in predicting nominal GNP but is not significant in predicting real GNP. Finally, M1 has a higher significance level than credit with respect to real output, but credit has a higher significance level with respect to nominal output.[10]

Although M2 lowers the FPE of real output in a bivariate test, M2 becomes insignificant when additional variables are accounted for. Also noteworthy is the fact that the importance of a variable as determined by the FPE statistic is roughly similar to its importance as determined by its marginal significance level. For example, in the trivariate test of real GNP, credit, and M2, both the FPE and the marginal significance suggest that M2 does not contain additional information about real output once credit is accounted for. This result also holds true in the multivariate test.

The Treasury bill rate is second only to credit in lowering the FPE of both the nominal and real output regressions, and the interest rate has the highest marginal significance level in every case. While this latter result could be disconcerting for both money and credit, the FPE criterion is the more appropriate measure of predictive ability. The FPE criterion supports the existence of a strong relationship between credit and output; it offers weaker support for a relationship between money and output.

In sum, for the 1961-87 period, credit is highly significant in predicting both nominal and real GNP. In two separate cases, M1 and M2 have a higher marginal significance level than credit, but credit still remains fairly significant. In the two remaining cases, credit has a higher marginal significance level than either of the aggregates. The one-year Treasury bill rate is also highly significant in all cases, and in most instances has a higher marginal significance level than either money or credit. However,

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[10] The inclusion of an energy price variable in the real GNP regression does not alter our conclusions. Energy prices produce a fairly high FPE and do not aid in prediction after the other significant variables are included.

Akaike's Final Prediction Error is a more appropriate measure of predictive ability and is more in the spirit of Granger causality than significance levels based on subset F-tests. By the FPE criterion, credit has a stronger predictive relationship with real and nominal output than the other policy variables examined in this study.

5. Conclusion

This paper has employed recently developed statistical techniques to test and compare the credit-output and money-output relationships. Employing Akaike's Final Prediction Error to determine lag-length and predictive strength of the variables in Granger causality tests, along with the inclusion of contemporaneous values when using quarterly data, produces significantly different results from those obtained previously. In particular, we find that credit is highly significant in predicting both nominal and real output. This conclusion holds true even when the information content of a monetary aggregate and an interest rate are accounted for. In every instance according to the FPE criterion, and in almost every instance with respect to marginal significance levels, credit is a stronger predictor of output than is money.

Our results suggest that it makes sense to consider credit as an information variable that aids in the prediction of output. Our results also suggest that it would be worthwhile to examine the extent to which monetary policy operates through credit markets. However, this work _only_ overturns earlier conclusions about the _predictive_ ability of money versus credit. Further work is needed to understand the extent to which monetary policy operates through credit markets, and to understand the extent to which credit market activity affects the real economy.

Table 1

Bivariate Tests of Predictive Content for GNP
1961:2 - 1987:4

	NGNP				RGNP			
	FPE x 10^5	Marginal Sig. Level	Lag Length	BG	FPE x 10^5	Marginal Sig. Level	Lag Length	BG
C	8.338	.000	1*	.157	7.633	.000	2*	.916
M1	9.376	.066	0*	.036	8.615	.007	1*	.621
M2	8.929	.006	1*	.106	8.747	.015	1*	.983
RTB	8.406	.000	0*	.201	7.735	.000	5*	.572

NOTE: NGNP = nominal GNP, RGNP = real GNP, RTB = 1-year Treasury Bill, C = credit. One lagged value of NGNP and two lagged values of RGNP were included as lagged dependent variables. The Final Prediction Error of NGNP was 9.508 and that of RGNP was 9.155 when only their own lagged values were included in the regression.

BG = Breusch-Godfrey statistic. This statistic detects the presence of serial correlation. Because of the presence of lagged dependent variables, the Durbin-Watson statistic is invalid. The marginal significance level for the BG test is reported, indicating that none of the equations contains serially-correlated residuals.

* Indicates that the contemporary value of the independent variable was included in the regression. Given the time interval of the data, inclusion of the contemporaneous value of the independent variable does not rule out a temporal ordering.

Table 2

Bivariate Tests of Predictive Power for GNP
1961:2 - 1987:4

Excluding Contemporaneous Values

	NGNP				RGNP			
	FPE x 10^5	Marginal Sig. Level	Lag Length	BG	FPE x 10^5	Marginal Sig. Level	Lag Length	BG
C	10.267	.416	4	.067	9.806	.417	4	.385
M1	9.875	.101	4	.168	9.423	.097	4	.373
M2	9.525	.023	4	.648	9.444	.106	4	.810
RTB	9.410	.014	4	.874	8.437	.001	4	.077

Including Contemporaneous Values

	NGNP				RGNP			
	FPE x 10^5	Marginal Sig. Level	Lag Length	BG	FPE x 10^5	Marginal Sig. Level	Lag Length	BG
C	9.019	.003	4	.069	7.978	.000	4	.520
M1	9.838	.076	4	.145	9.124	.025	4	.246
M2	9.695	.044	4	.628	9.549	.136	4	.891
RTB	8.794	.001	4	.629	8.220	.000	4	.035

NOTE: Four lagged values of NGNP and RGNP were included as lagged dependent variables. The Final Prediction Error of NGNP was 10.685 and that of RGNP was 9.507 when only their own lagged values were included in the regression.

Table 3

Trivariate Tests of Predictive Content for GNP
1961:2 - 1987:4

	NGNP				RGNP			
	FPE x 10^5	Marginal Sig. Level	Lag Length	BG	FPE x 10^5	Marginal Sig. Level	Lag Length	BG
C	8.261	.000	1*	.535	7.517	.000	2*	.954
M1		.085	3			.064	3*	
C	8.180	.002	1*	.268	7.645	.001	2*	.974
M2		.057	1*			.192	1	
C	7.946	.007	1*	.642	7.195	.007	2*	.690
RTB		.013	1*			.011	5*	

NOTE: The number of lagged dependent variables included is the same as the number in the bivariate tests.

* Indicates that the contemporary value of the independent variable was included in the regression.

Table 4

Multivariate Tests of Predictive Content for GNP
1961:2 - 1987:4

	NGNP				RGNP			
	FPE x 10^5	Marginal Sig. Level	Lag Length	BG	FPE x 10^5	Marginal Sig. Level	Lag Length	BG
C		.015	1*			.056	2*	
M1	7.823	.064	3*	.846	6.726	.011	5*	.703
RTB		.006	1*			.001	5*	
C		.061	1*			.015	2*	
M2	7.301	.001	0*	.315	7.311	.595	0*	.762
RTB		.000	1*			.015	5*	

NOTE: The number of lagged dependent variables included is the same as the number in the bivariate tests.

* Indicates that the contemporary value of the independent variable was included in the regression.

Appendix A: Unit Root and Cointegration Tests

Table A.1 reports the results of the unit root tests. The first two columns report the ρ value and the Dickey-Fuller test statistic, T_{τ}, for a single unit root. The next two columns report the ρ value and T_{τ} value of the test for a second unit root. In all cases the null hypothesis of one unit root is accepted ($\rho = 1$), while in no case is the null hypothesis of a second unit root accepted.

Next, the first difference of each of the series is regressed against a constant, time and four of its own lags to determine whether each of the series contains a deterministic component. Similar to the results obtained by Stock and Watson, only M1 exhibits evidence of a time trend. Thus, with the exception of M1, each of the series appears to be stationary in first difference form. The first difference of M1 is stationary around a time trend.

Table A.2 reports the results from the cointegration tests. In no case are the policy variables cointegrated with real or nominal GNP at the 5-percent level. M2 and nominal GNP are cointegrated at the 10-percent level, a result consistent with Engle and Granger's (1987) findings. The error-correction term, resulting from this relationship between money and output, did not improve the bivariate money-output equation, however.

Table A.1

Unit Root Tests

1959:1 - 1987:4

	One unit root		Second unit root	
Series	$\hat{\rho}$	$\hat{T}_\tau$	$\hat{\rho}$	$\hat{T}_\tau$
C	.965	-2.420	.722	-3.579
M1	.992	-0.640	.071	-4.721
M2	.969	-2.061	.565	-3.498
RTB	.886	-2.451	.149	-4.168
RGNP	.939	-2.487	.274	-4.590
NGNP	.954	-2.314	.324	-4.350
Critical Value (5-percent level)		-3.45		-3.45

The test performed is the augmented Dickey-Fuller test allowing for drift.

The test statistic is the "*t* statistic" $\tilde{T}_\tau = \frac{\hat{\rho}-1}{\hat{\sigma}_\rho}$ for the null hypothesis that $\rho = 1$ in the regression

$$X_t = \alpha + \rho X_{t-1} + \beta_1(X_{t-1} - X_{t-2}) + \ldots + \beta_4(X_{t-4} - X_{t-5}) + \gamma T + \varepsilon_t,$$

where X_t is the logarithmic value of each of the variables in the test for one unit root, and the first difference of the variable in the test for a second unit root. T is the time trend variable.

Critical value for the $\hat{T}_\tau$ statistic is from Fuller (1976, 373).

Table A.2

Cointegration Tests
1959:1 - 1987:4

Variables	t statistics*
NGNP, C	-2.574/-2.752
RGNP, C	-1.953/-1.872
NGNP, M1	-0.627/-0.375
RGNP, M1	-1.766/-1.201
NGNP, M2	-3.032/-3.065
RGNP, M2	-1.871/-1.640
NGNP, RTB	-1.498/-2.528
RGNP, RTB	-1.866/-2.558
Critical Value (5-percent level)	-3.17

The test performed for cointegration has two stages. In the first stage, the cointegrating equation $Y_t = \alpha + \beta X_t + u_t$ is estimated. In the second stage, the residuals from the cointegrating equation are used. The test statistic is the t statistic for $\hat{\rho}$ for the null hypothesis that $\rho = 0$ in the following augmented Dickey-Fuller test:

$$\Delta\hat{u}_t = \alpha + \rho\hat{u}_{t-1} + \beta_1\Delta\hat{u}_{t-1} + \ . \ . \ . + \beta_4\Delta\hat{u}_{t-4} + \varepsilon_t .$$

Critical value for the t statistic for $\hat{\rho}$ is from Engle and Yoo (1987, 158).

* The first statistic has the first variable as the dependent variable.
  The second statistic has the second variable as the dependent variable.

Appendix B: 1961:3-1979:3

In order to compare the results from this study more directly with King's results, we present here Granger causality tests for the period 1961:3-1979:3. Examining this time period allows us to eliminate the years following the Federal Reserve's change in operating procedure, and it allows us to eliminate the years following the abolishment of interest rate ceilings. Credit rationing by banks, and the role of bank credit in determining economic activity, was possibly more important when interest rate ceilings led to deposit withdrawals, during times of rising interest rates. If this hypothesis is true, the credit-output link should be stronger when the 1980s are excluded from the analysis.

The steps are parallel to those reported in our paper. First, unit root tests are performed to obtain the proper stationary form for each of the series. As reported in Table B.1, with the exception of the Treasury bill rate, the null hypothesis of one unit root is accepted in all cases. The null hypothesis of a second unit root is accepted for credit, M1, and M2. Nominal GNP is stationary around a time trend. Thus, real GNP is the only variable that maintains the same stationarity properties from the longer time period. Because the independent and dependent variables do not have the same order of integration, the series are not examined for cointegration.

Table B.2 reports the bivariate test results over the 1961:3-1979:3 period. Lagged values of the dependent variable only appear in the real output regression. Given these lagged values, each of the independent variables improves the prediction of real output. As the table shows, M1 has a lower FPE than credit when predicting nominal output, while credit has a lower FPE when predicting real output. M2 has the highest FPE in both cases.

The marginal significance levels rank the variables in the same order as the FPEs. Thus, the bivariate test results presented here differ somewhat from the results obtained over the longer time period. M1 has a stronger predictive relationship with nominal economic activity over the earlier time period, while M2 has a weaker relationship with both nominal and real GNP. And credit has a weaker relationship with nominal output during the earlier time period than it does when 1980s data are included in the analysis.

Table B.3 reports the trivariate test results. Following the FPE procedure, M1 enters first in the nominal GNP equation. Neither credit nor the interest rate lowers the prediction error for nominal output further. The marginal significance levels of credit and the interest rate are also quite low. In the real GNP equation, the interest rate enters first. Only credit lowers the prediction error for this equation further. M1 and M2 do not add additional predictive power once the interest rate is accounted for.

The trivariate tests suggest that credit and the interest rate do not improve upon the predictive relationship between M1 and nominal output. Nevertheless, we examine the multivariate equation with M1, credit, the interest rate, and nominal output. As reported in Table B.4, this equation has a higher FPE than the bivariate M1-GNP equation. The marginal significance levels indicate that credit is significant at only the 10-percent level, while the interest rate is not significant.

The trivariate tests also suggest that only credit contains information about real output, once the interest rate has been accounted for. Nevertheless, we add each of the monetary aggregates to the interest rate, credit, real output equation. As reported in the Table, neither of the aggregates lowers the equation's FPE.[1,2]

A comparison of the three sets of tests over the 1961-79 period indicates that the inclusion of additional variables can alter the marginal significance levels of variables in bivariate Granger tests. For example, the interest rate is significant in the bivariate nominal GNP equation, but it becomes insignificant once M1 is accounted for. Similarly, the monetary aggregates are individually significant in predicting real GNP, but they become insignificant when included with other variables.

The results also indicate that the links between the independent variables and both real and nominal output differ somewhat between the 1961-87 period and the 1961-79 period. M1 contains more information about nominal GNP and less information about real GNP during the 1960s and 1970s, than during the 1980s. M2 contains more information about nominal GNP in the current decade than it did in the two previous decades, but M2 appears to have contained no information about real GNP prior to the 1980s. These results are consistent with the notion that the relationship between M1 and nominal output deteriorated during the 1980s, while the relationship between M2 and nominal output has strengthened. The predictive relationship between the interest rate and nominal GNP has also increased in the 1980s.

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[1] Over the subperiod, the inclusion of energy prices in the real GNP equation do not alter our results. However, energy prices do aid in predicting real output once the other significant variables are accounted for.

[2] Because the stationarity properties of the data for the 1959-79 period differ from and are less common than those for the entire period, we also performed the causality tests over the subperiod using the stationarity properties that characterize the data over the longer 1959-87 period. Under this alternative specification, M2 has the strongest relationship with nominal GNP, followed by credit. Their FPEs are higher than any of the FPEs reported in Table B.2, however. Both M1 and credit have strong relationships with real GNP under this alternative specification, and their FPEs are close to those reported in the table.

It is also the case that credit significantly predicts real output over both time periods. Because credit movements did not significantly predict movements in nominal output over the subperiod, we can conclude that credit movements did not contain more information about nominal output movements during the 1960s and 1970s than during the 1980s. Rather, credit has a predictive relationship with real output over both time periods, and it contains more information about movements of nominal output during the 1980s than previously.

Overall then, M1 did have a stronger predictive relationship with nominal output during the 1960s and 1970s than credit did. This conclusion is based on the FPE criterion, although it is consistent with the conclusions reported by King. Still, the marginal significance level of credit, while slightly lower than M1, was much stronger than indicated in the earlier work. Moreover, in contrast to the earlier work, we found that credit had a stronger predictive relationship with real output during the 1960s and 1970s than M1 did.

Table B.1

Unit Root Tests
1959:1 - 1979:3

Series	One unit root $\hat{\rho}$	One unit root $\hat{T}_\tau$	Second unit root $\hat{\rho}$	Second unit root $\hat{T}_\tau$
C	.936	-3.008	.748	-2.911
M1	.979	-1.156	.385	-3.344
M2	.986	-0.920	.640	-3.261
RTB	.725	-3.850	.240	-3.430
RGNP	.927	-2.061	.227	-3.865
NGNP	.981	-0.741	-.247	-4.887
Critical Value (5-percent level)		-3.50		-3.50

Critical value for the $\hat{T}_\tau$ statistic is from Fuller (1976, 373).

Table B.2

Bivariate Tests of Predictive Content for GNP
1961:3 - 1979:3

	NGNP				RGNP			
	FPE x 10^5	Marginal Sig. Level	Lag Length	BG	FPE x 10^5	Marginal Sig. Level	Lag Length	BG
C	7.622	.101	0*	.980	8.212	.002	0*	.507
M1	7.241	.016	6*	.376	8.486	.014	6*	.941
M2	7.749	.148	3	.835	9.061	.082	5	.373
RTB	7.393	.035	1*	.550	8.182	.004	1*	.661

NOTE: No lagged value of NGNP and two lagged values of RGNP were included as lagged dependent variables. The FPE of RGNP was 9.140 when only the lagged values of RGNP were included.

* Indicates that the contemporary value of the independent variable was included in the regression.

Table B.3

Trivariate Tests of Predictive Content for GNP
1961:3 - 1979:3

	NGNP				RGNP			
	FPE x 10^5	Marginal Sig. Level	Lag Length	BG	FPE x 10^5	Marginal Sig. Level	Lag Length	BG
C	7.245	.105	7	.437				
M1		.003	6*					
C					7.621	.010	0*	.644
RTB						.013	1*	
M1	7.362	.051	6*	.264	8.190	.031	1*	.249
RTB		.293	2			.103	5*	
M2					8.386	.663	1*	.845
RTB						.006	1	

NOTE: The number of lagged dependent variables included is the same as the number in the bivariate tests.

* Indicates that the contemporary value of the independent variable was included in the regression.

Table B.4

Multivariate Tests of Predictive Content for GNP
1961:3 - 1979:3

	NGNP				RGNP			
	FPE x 10^5	Marginal Sig. Level	Lag Length	BG	FPE x 10^5	Marginal Sig. Level	Lag Length	BG
C		.096	7			.017	0*	
M1	7.375	.011	6*	.394	7.756	.419	0*	.543
RTB		.430	1			.013	1*	
C						.011	0*	
M2					7.826	.804	0*	.681
RTB						.014	1*	

NOTE: The number of lagged dependent variables included is the same as the number in the bivariate tests.

* Indicates that the contemporary value of the independent variable was included in the regression.

Data Appendix

Data are seasonally adjusted for the period 1959-87. Real and Nominal Gross National Product (NGNP and RGNP) are from the National Income and Product Accounts. M1, M2, and the 1-year Treasury bill (RTB) rate are from the Federal Reserve data bank. The credit variable (C) is composed of total loans issued by commercial banks, mortgages held by savings and loans, mortgages held by mutual savings banks, and other loans held by mutual savings banks. For the total loans series, the 1959-70 data are from Banking and Monetary Statistics (BMS) Table 1.4, and the 1971-72 data are from the Annual Statistical Digest (ASD). The 1973-87 data can be obtained from the ASD, the Federal Reserve Bulletin or the Citibase Data Bank. The series for mortgages held by savings and loans, mortgages held by mutual savings banks, and other loans held by mutual savings banks are from the Federal Reserve Bulletin Table 1.37. The data for mortgages held by savings and loans for 1987 are from the Federal Home Loan Bank Board, Monthly Thrift Financial Report System, Report TA215S (Final).

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