Credit, Money and Production: Empirical Evidence

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of the instability in real exchange rates. This result suggests that exchange rate volatility is not necessarily a purely exogenous source of macroeconomic instability.

III. Concluding Remarks

This paper characterizes the dynamic relationship between US bilateral trade flows and a measure of exchange rate volatility using VAR techniques. Overall, the evidence from the general time series models for the countries in our sample suggests a weak relationship between these two variables. However, the impact of volatility on imports increases from the fixed exchange rate regime to the flexible rate regime. Furthermore, permanent shocks to volatility tend to depress imports.

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CREDIT, MONEY AND PRODUCTION: EMPIRICAL EVIDENCE

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Abstract—Our main contribution in this paper is the development and implementation of a simple but critical test of the role of financial variables in production. The test is based on a restricted cost function. Implementation was carried out in terms of a translog functional form estimated by nonlinear three stage least squares. The main data base was constructed by augmenting the manufacturing sector data developed by Berndt and Wood with information on the financial variables from the Federal Reserve Flow of Funds series. The results demonstrate that credit and money affect the costs of producing manufacturing output but that they cannot be treated as inputs.

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Introduction

Do financial variables play a role in the production process? If so, which ones—money, credit or both? Moreover, is this role the same as that of an input or a more general role as a facilitating factor but one which cannot be reduced to that of an input? The object of this paper is to provide empirical evidence on each of these three questions.

In a classic article Fischer (1974) showed that, under some restrictive assumptions, money can be treated as one of the firm's inputs; under more general assumptions, however, he argued that money's ability to economize on transaction costs facilitated production but it was not sufficient to treat it as an input. Other theoretical studies of the firm's demand for money also emphasize money's role as a means of economizing on transaction costs, e.g., all the studies surveyed in Bernstein (1978). On the empirical side, most studies simply introduce money as an input, e.g., Sinai and Stokes (1972), Short (1979), Simos (1981), and Dennis and Smith (1978). One quasi exception is the recent work of Nguyen (1986), who introduces money as an input in a Cobb-Douglas production function as well as the interaction of its rate of change with a time trend to capture other aspects. A heuristic interpretation of patterns of results leads Nguyen to conclude that money is not an input.

Recently, Betancourt and Kiguel (1988) have generalized Fischer's model by introducing credit into the analysis while allowing money to economize on transaction costs. This generalization uncovers additional restrictions that must hold for money to be treated as an input as well as new restrictions that must hold if credit is to be treated as an input. The more general result, however, is that both credit and money play a role in the production process at the firm level but that neither one of them can be treated as an input.

At the macro level interest on the role of these variables is evidenced by a question raised in the title of a session of the recent (1987) AEA convention "Is It Credit or Money or Both or Neither?" Research activity in this strand of the macro literature has been stimulated by, among other things, the work of Stiglitz and Weiss (1981) on credit rationing. In the application of some of its implications to an aggregate framework, Blinder and Stiglitz (1983) suggest the desirability of separating "credit theory" from "money theory." We present some empirical evidence that bears on this issue.

Our argument proceeds in the following manner. In section I, we present the theoretical model underlying the empirical investigation and we discuss its properties. In section II, we take up issues associated with empirical implementation: that is, the data sources, the specific functional form employed, the estimation procedure and one of the principal tests to be employed. In section III, the main results are presented and interpreted. Finally, a brief conclusion highlights the implications of our research.

I. The Model

We put forth the model described below as a flexible way of incorporating financial variables in the productive process. In particular, the model allows the data to decide whether financial variables enter the productive process as inputs or as state of nature variables that affect production.

As the starting point of our analysis, we postulate a neoclassical cost function of the following form:

$$TC = C(P_K, P_L, Q, F; T) \tag{1}$$

where TC are the total costs due to capital and labor services; P_K and P_L represent the prices of these services, respectively; Q denotes the level of output; F is the real quantity of one or more financial variables; and T captures technological change.

If C is to be interpreted as a neoclassical cost function, it must have the following properties: linear homogeneous, increasing and concave in prices, and increasing in output. In addition, if the financial variables are to be interpreted as inputs into the production process, then C must be decreasing (or at least non-increasing) in these variables and it must be viewed as a restricted cost function. If C is increasing in the financial variables, however, it is still a well-defined cost function but it cannot be viewed as a *restricted* cost function and the financial variables cannot be interpreted as inputs into the productive process. This feature of (1) provides the basis for a critical test of the substantive hypothesis that financial variables play the role of inputs into the production process. The variable T merely provides a control that prevents the financial variables from acting as a surrogate for changes in productivity due to nonfinancial factors.

One very important practical advantage of the specification in (1) is that it allows for a general specification of the structure of production without requiring either the definition or the empirical measurement of the price of financial variables in general and real money balances in particular. Empirical studies that employ a general approach to the structure of production and include real money balances employ different prices for real money balances, e.g., Short (1979), Simos (1981), and Dennis and Smith (1978). Alternatively, those empirical studies that avoid the need to measure the price of money impose restrictive Cobb-Douglas specifications on the production technology, e.g., Sinai and Stokes (1972) and Nguyen (1986). Indeed, the idea for the formulation in (1) was originally suggested to us by the work of Halvorsen and Smith (1986) on natural resources. They employed the specification in (1) (with natural resources in place of financial variables) because of their difficulties in measuring the price of natural resources. Incidentally, the use of the decreasing in the fixed input property of the cost function as a critical test of whether a variable can be treated as an input is somewhat obvious but new insofar as we know.

II. Empirical Implementation

As an approximation to the cost function in (1), we employ the translog functional form which has been used extensively in the analysis of production structures. The properties of symmetry of the second partials and linear homogeneity are imposed prior to estimation. The properties of monotonicity and concavity are used to check the basic consistency of the model with the data. The resulting equation is given in (2)

$$\begin{aligned}\ln TC^* = {} & \alpha_0 + \alpha_K \ln P_K^* + \alpha_Q \ln Q + \alpha_{CR} \ln CR \\ & + \alpha_M \ln M + \alpha_T T \\ & + \gamma_{KK}(\ln P_K^*)^2/2 + \gamma_{QQ}(\ln Q)^2/2 \\ & + \gamma_{CRCR}(\ln CR)^2/2 + \gamma_{TT}(T)^2/2 \\ & + \gamma_{MM}(\ln M)^2/2 + \gamma_{KQ}[\ln P_K^* \cdot \ln Q] \\ & + \gamma_{KCR}[\ln P_K^* \cdot \ln CR] \\ & + \gamma_{KM}[\ln P_K^* \cdot \ln M] + \gamma_{QCR}[\ln Q \cdot \ln CR] \\ & + \gamma_{QM}[\ln Q \cdot \ln M] \\ & + \gamma_{CRM}[\ln CR \cdot \ln M] + \gamma_{KT}[\ln P_K^* \cdot T] \\ & + \gamma_{QT}[\ln Q \cdot T] \\ & + \gamma_{CRT}[\ln CR \cdot T] + \gamma_{MT}[\ln M \cdot T] \quad (2)\end{aligned}$$

where the asterisk over a variable indicates that it has been normalized by the price of labor services, i.e., $\ln TC^* = \ln TC - \ln P_L$, $\ln P_K^* = \ln P_K - \ln P_L$. Note that the specification in (2) includes two different financial variables, credit (CR) and money (M), and a time trend (T).

Necessary conditions for the financial variables to be interpreted as inputs in the translog case, or for (2) to be interpreted as a restricted cost function, are the following:

$$\begin{aligned}\partial \ln TC^*/\partial \ln CR = {} & \alpha_{CR} + \gamma_{CRCR} \ln CR \\ & + \gamma_{KCR} \ln P_K^* + \gamma_{QCR} \ln Q \\ & + \gamma_{CRT} T + \gamma_{CRM} \ln M \leq 0,\end{aligned} \quad (3a)$$

and

$$\begin{aligned}\partial \ln TC^*/\partial \ln M = {} & \alpha_M + \gamma_{MM} \ln M + \gamma_{KM} \ln P_K^* \\ & + \gamma_{QM} \ln Q + \gamma_{MT} T \\ & + \gamma_{MCR} \ln CR \leq 0. \end{aligned} \quad (3b)$$

An interesting aspect of these conditions is that they can be tested at every data point in the sample. Since the null hypothesis that a financial variable can be treated as an input may be rejected at any data point, these conditions come as close to a critical test of a hypothesis as one is likely to find in economics.

Estimation of translog functions in similar contexts is usually undertaken jointly with the estimation of input shares in costs, which are obtained from the cost function via Shephard's Lemma, e.g., Betancourt and Edwards (1987). We follow the literature in this procedure as well as in deleting one of the share equations. The equation for the share of capital is omitted to conserve space; the share equation for labor was the one deleted in the estimation, as implied by the form in which (2) is presented above.

There are theoretical and practical reasons for treating some of the right hand side variables as endogenous. For instance, profit maximization implies that output is endogenous. Moreover, the analysis in Betancourt and Kiguel (1988) suggests, for example, that under a certain type of credit restriction money balances are endogenous while credit is exogenous. More generally, as pointed out by a referee, the use of aggregate data suggests that credit and money are endogenous. Therefore, nonlinear three stage least squares (NL3S), e.g., Amemiya (1985, ch. 8), was relied upon as the estimation method for the empirical results presented in the next section.

Our primary data set focuses on the U.S. manufacturing sector and relies on the information developed by Berndt and Wood (1985) as its starting point.[1] Data on the prices and quantities of labor and capital services as well as on output for the U.S. manufacturing sector were taken from the appendix in Berndt and Wood's study. This information was supplemented with the construction of three financial variables. Firms' holdings of real money balances (M) were constructed by taking currency plus checking deposits of nonfinancial corporate business and converting them to 1972 dollars with the GNP deflator. Two definitions of credit were used: A narrow one ($CR1$) which consists of loans and short-term paper issued by nonfinancial corporate business, also converted to 1972 dollars using the GNP deflator; and a broad one ($CR2$) which includes trade credit in addition to the above two items. All three financial variables were normalized to take the value of unity in 1972; the raw data for these variables were obtained from the Federal Reserve Flow of Funds series. The period of analysis was determined by the availability of the financial data and the Berndt and Wood data: It runs from 1952 to 1981. Incidentally, the time trend variable was constructed by setting the value $T = 0$ at the year of normalization.

III. Results

Since analyses of the structure of production based on translog forms are fairly common, our presentation of the results emphasizes the unique aspect of our

[1] A second set of data was made available to us by Jorgenson in printouts. It is an economy-wide data set, which corresponds more closely to the type of data used in most previous empirical studies of the role of money in production; indeed, it is an updated version of Nguyen's data. Since the results were similar to those obtained with the manufacturing data set, which is arguably the more appropriate one because of our development of the theory in terms of the demand for money by firms, they are not presented here.

TABLE 1.—QUASI-LIKELIHOOD RATIO TESTS FOR COEFFICIENTS OF FINANCIAL VARIABLES: U.S. MANUFACTURING

Model	Observed Value	Critical Value (0.01: 0.05)
$\alpha_M = \gamma_{Mi} = 0, \forall\, i(CR1)$	16.77	16.81 ; 12.59
$\alpha_M = \gamma_{Mi} = 0, \forall\, i(CR2)$	13.77	16.81 ; 12.59
$\alpha_{CR} = \gamma_{CRi} = 0, \forall\, i(CR1)$	11.05	16.81 ; 12.59
$\alpha_{CR} = \gamma_{CRi} = 0, \forall\, i(CR2)$	10.35	16.81 ; 12.59
$\alpha_M = \alpha_{CR} = \gamma_{CRi} = \gamma_{Mi} = 0, \forall\, i(CR1)$	32.78	24.73 ; 19.68
$\alpha_M = \alpha_{CR} = \gamma_{CRi} = \gamma_{Mi} = 0, \forall\, i(CR2)$	52.51	24.73 ; 19.68

study: namely, the role of the financial variables in production. A brief comparison to the usual results, however, is provided at the end of this section.

In estimating the model by nonlinear three stage least squares (NL3S), output, money balances and credit were treated as endogenous and third degree polynomials in the remaining exogenous variables ($\log P_K$, $\log P_L$ and T) were used as instruments. In order to see the robustness of the results vis-à-vis the instrument matrix, the model was also estimated by treating output and money balances as endogenous and using as instruments second degree polynomials in the augmented set of exogenous variables, i.e., $\log P_K$, $\log P_L$, T and $\log CR1$ *or* $\log CR2$. This second set of results is reported in an appendix (available upon request).

Turning to the actual results, table 1 contains the information necessary for performing a quasi-likelihood ratio test on the null hypothesis that financial variables do not affect costs in the U.S. manufacturing sector. The observed value of the test statistic in column (2) is the difference between the criterion function with the restrictions indicated in column (1) and the criterion function without these restrictions, given that the weighting matrix for the more general model is used to calculate the criterion function in both cases. Gallant and Jorgenson (1979) show that, asymptotically, it has a Chi-squared distribution with degrees of freedom equal to the number of restrictions. The critical values of the Chi-squared distribution for the relevant number of degrees of freedom are presented in column 3. The results are conclusive. The null hypothesis that money balances and credit do not affect costs is rejected at the 1% level of significance with both definitions of credit. Given that credit is included, the hypothesis that money balances do not affect costs is rejected at the 5% level of significance. Finally, given that money balances are included, the hypothesis that credit does not affect costs is accepted at the 5% level of significance for both definitions of credit. It is worth noting that the results in the appendix (table 1A) are quite similar. Indeed, the main difference is that, given that credit is included, the hypothesis that money balances do not affect costs is rejected at the 1% level of significance rather than at the 5% level of significance.

In table 2 we present the estimates of the elasticity of costs with respect to both financial variables. Just as the results of table 1, these estimates arise from estimating equation (2) and the associated equation for the capital share by NL3S with output, credit and money balances treated as endogenous. They represent the numerical values associated with equations (3a) and (3b) of the previous section for each of the two specifications of the credit variable. The sign of the elasticity of costs with respect to the financial variable is inconsistent with the financial variable being an input for at least half of the observations in each of the four columns of table 2. Using a t-ratio of 2 as a critical value, the null hypothesis that money is an input ($\partial \ln TC/\partial \ln M \leq 0$) is rejected at one data point for the broad definition of credit. Similarly, the null hypothesis that credit is an input ($\partial \ln TC/\partial \ln CR) \leq 0$) is rejected at three data points for the narrow definition of credit and at one data point for the broad definition of credit. Finally, the effects of money and credit on costs differ with respect to sign in about a third of the observations and the effect of money on costs varies with the definition of credit.[2]

For completeness, it is desirable to report briefly on a number of additional characteristics of the empirical results. First, it should be stressed that all the results presented here are based on the full translog model with no restrictions. The reason is that, as in most applications of the translog, homotheticity and homogeneity restrictions are rejected by the data. In our case, the quasi-likelihood ratio tests rejected both sets of restrictions at the 1% level of significance for both definitions of credit. Second, it should be stressed that concavity and monotonicity restrictions are satisfied at every data

[2] Once again, the results in the appendix (table 2A) are quite similar to the ones in the text.

TABLE 2.—ELASTICITY OF COSTS WITH RESPECT TO FINANCIAL VARIABLES: U.S. MANUFACTURING

	I		II	
	M	*CR*1	*M*	*CR*2
1952	0.51	−0.24	0.34	−0.52
1953	0.51	−0.08	0.13	−0.36
1954	0.08	0.00	0.25	0.71
1955	0.22	0.57	0.17	0.66
1956	0.37	0.02	0.18	0.01
1957	0.34	−0.07	0.16	−0.03
1958	0.11	0.20	0.13	0.42
1959	0.13	0.33	−0.03	0.62[a]
1960	0.20	0.07	−0.04	0.27
1961	0.09	0.22	0.06	0.43
1962	0.06	0.52[a]	0.14	0.74
1963	0.06	0.53[a]	−0.02	0.89
1964	0.09	0.46[a]	−0.09	0.75
1965	0.24	0.21	−0.00	0.35
1966	0.35	−0.09	0.02	−0.26
1967	0.36	−0.10	0.08	−0.12
1968	0.34	0.06	0.18	0.22
1969	0.42	−0.04	0.57	0.02
1970	0.37	−0.26	0.59[a]	−0.05
1971	0.20	0.04	0.24	0.68
1972	0.18	0.24	0.11	0.80
1973	0.37	−0.16	0.16	−0.08
1974	0.44	−0.59	0.31	−1.00
1975	0.12	−0.19	0.42	−0.40
1976	−0.04	0.40	0.19	0.30
1977	0.00	0.38	0.04	0.13
1978	0.07	0.22	0.01	−0.15
1979	0.13	−0.15	−0.18	−0.72
1980	0.01	−0.15	−0.27	−0.02
1981	−0.05	−0.13	−0.45	−0.02

[a] *t*-ratio greater than the absolute value of 2.

point with both definitions of credit. Finally, in table 3 we present estimates of the Allen-Uzawa partial elasticities of substitution, at the point of normalization, for both definitions of credit and for a base model that excludes the financial variables and is estimated by NL3S with the same instrument matrix as the other two models. We also present the values of the Durbin-Watson statistic for the two equations estimated, i.e., the cost function (C) and the share of capital equations (S_K). Inclusion of the financial variables raises the absolute value of the elasticities as well as their probability values.[3] In addition, it leads to D-W statistics close to two. This last result can be interpreted as an indication that including the financial variables eliminates the presence of omitted variables from the residuals in each equation. Just as with our previous results, the results in the appendix (table 3A) are quite similar to the ones in the text.

[3] Incidentally, in the base model concavity is violated for 6 out of 30 observations.

TABLE 3.—ALLEN-UZAWA ELASTICITIES OF SUBSTITUTION

	ϵ_{KK}	ϵ_{KL}	ϵ_{LL}	D-W(C)	D-W(S_K)
*CR*1	−0.667	0.167	−0.041	2.34	1.43
	(0.459)	(0.114)	(0.028)		
*CR*2	−0.765	0.190	−0.047	2.23	1.53
	(0.472)	(0.117)	(0.029)		
BASE	−0.426	0.106	−0.026	1.14	1.07
	(0.389)	(0.097)	(0.024)		

Note: Standard errors in parentheses below the coefficient estimates.

IV. Implications

Undoubtedly, the most robust conclusion to emerge from our analysis is that both financial variables together, credit and money, are statistically important in the determination of the costs of producing output. This result holds true for both definitions of credit and with all instruments matrices; therefore, it provides strong empirical support for the recent theoretical interest in linking financial and real variables at both the micro and the macro levels.

A somewhat less robust conclusion to emerge from our analysis is that neither money nor credit should be viewed as an input in the production process. The sign of the elasticity of costs with respect to money or credit is inconsistent with either variable being an input for at least *fourteen* or *seventeen* data points, respectively, in *each* of the four cases considered. Moreover, in *three* out of the possible *four* cases, the null hypothesis that credit is an input is rejected (using a critical value of 2) for at least one data point. With respect to money, however, the results are slightly weaker. Namely, in *two* out of *four* cases the null hypothesis that money is an input is rejected for at least one data point. Interestingly enough, both cases occur with the broad definition of credit ($CR2$).

Given the sensitivity of the results on the role of money to the definition of credit, a noteworthy implication of our analysis is that attempts to discriminate empirically between "credit theory" and "money theory" may have to pay special attention to the empirical definition of credit implied by a particular model. In the present context, it must also be pointed out that Betancourt and Kiguel (1988) generate the demand for credit by the firm out of the need for working capital, which suggests that the broad definition of credit, i.e., the one that includes trade credit, is the appropriate one. This view is also consistent with the macroeconomic argument by Brunner and Meltzer (1988) that loan rationing is not the only mechanism in the propagation of monetary impulses and that one should include a spectrum of assets and liabilities. Nonetheless we must conclude by noting that the empirical results do not provide compelling evidence on which to choose between the two definitions of credit.

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