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Money balances in the production function: Nonlinear tests of model stability and measurement issues – two sides of the same coin? ☆

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ABSTRACT

Past empirical attempts to test the role of money in the production function following the Sinai and Stokes (1972) preliminary Cobb–Douglas model specification estimated in 1929–1967, using yearly data, have focused on estimating alternative production function models, such as CES and Translog, and experimenting with alternative specifications of the monetary variable. Most research in the United States on this topic has involved four basic datasets: annual data in the period 1929–1967, nonfinancial quarterly data in the period 1953:1 to 1977:3, annual data in the period 1930–1978 and annual data in the period 1959–1985. The current research uses MARS modeling, general additive modeling, flexible least squares and VAR methods to assess whether there is evidence of nonlinearity and/or model structural change that is impacted by whether a monetary variable has been added to the model specification or a different period is under study. VAR modeling is used with the nonfinancial quarterly dataset to assess whether shocks in the financial sector, as measured by log real M2, can impact the real sector. Since a significant impact is found on log capital, log labor and log real output, the implication is that the real sector is not isolated from the financial sector. One way to think of this is that shocks to the financial sector can have dynamic effects on the real sector.

1. Introduction

Past empirical attempts to further test the role of the financial sector in the production function, following the Sinai and Stokes (1972) preliminary Cobb–Douglas model specification in the period 1929–1967, using the Christensen and Jorgenson (1969, 1970) annual data, have focused on estimating alternative production function models, such as the Boyes–Kavanaugh (1981) CES model and Short (1979) and Simos (1981) experiments with a translog production function model. In addition, there have been a number of experiments with alternative specifications of the monetary variable, including Sinai and Stokes (1989), using interest rates as a possible shift parameter. Most research in the United States on this topic has involved four basic datasets: annual data in the period 1929–1967 discussed in Sinai and Stokes (1972), nonfinancial quarterly data in the period 1953:1 to 1977:3 obtained from DRI and discussed in Sinai and Stokes (1981b), annual data in the period 1930–1978, discussed in Nguyen (1986) and Sinai and Stokes (1989), and annual data in the period 1959–1985, discussed by Benzing (1989). As noted by Sinai and Stokes (1972) and mentioned by Fisher (1974), measured increasing returns to scale were a concern whether or not a financial variable was in the specification of the production function. In an alternative and related

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line of research, Neuburger and Stokes (1974, 1975) investigated the effect of a measure of financial market efficiency unique to Germany and Japan on real output in a test of the Gerschenkron (1962) hypothesis. Measured increasing returns to scale were less of a problem in these papers. This research will not be treated further in this paper, which is focused on the role of real balances in an aggregate production function but should be thought of as an alternative way to model the financial sector's effect on real output. Sinai and Stokes (1989) reported results using the 1929–1967 data but modeled the financial sector using an interest rate shifter with and without real balances in the equation. This formulation did not correct the estimated increasing returns to scale found in Sinai and Stokes (1972) and is not investigated further here.

The theoretical arguments for a role for real monetary balances in the production function have been developed by Bailey (1962), Nadiri (1969, 1970) and others. The seminal survey paper by Fisher (1974) summarized some of this material and urged caution. In Fisher's view the measured increasing returns to scale obtained by Sinai and Stokes (1972) for their Cobb–Douglas production function were not credible. Sinai and Stokes (1975, Table 1) noted that the finding of increasing returns to scale was not just confined to models containing real balances. Sinai and Stokes (1972, p. 294) noted that "the Cobb–Douglas functions we estimate exhibit increasing returns to scale, a result that is consistent with Bodkin and Klein's (1967) estimates of the Cobb–Douglas for the period 1909–1949." The persistence of findings of increasing returns to scale in production function research of this kind suggests this finding appears to be inherent to the data and/or model specification and sets the stage for further analysis, which is one of the motivations for the current paper. As an example, the sum of the coefficients on labor and capital in a Cobb–Douglas model estimated with an OLS model not containing TIME is 1.835. If time is added, then the sum falls to 1.634. If LnM1 is added to a model without TIME, the sum is 1.767. As TIME is added the sum falls to 1.674. While the measured increasing returns to scale appear to be inherent to the Christensen and Jorgenson (1969, 1970) data itself, it is still an open question whether this is the case for Cobb–Douglas models using other datasets and for other periods?

Whether the estimated returns to scale found is caused by measurement error in the inputs to the production function or whether it is due to an incorrect functional form of the production function is at issue. The functional form of the estimated model could be inappropriate because it has shifted over time or is inherently wrong for any period. The Cobb–Douglas function is

$$Y = Ae^{\lambda t}L^{\alpha}K^{\beta}M^{\gamma}e \tag{1.1}$$

which can be estimated in log form as

$$\ln(y) = \ln(A) + \lambda t + \alpha \ln(L) + \beta \ln(K) + \gamma \ln(M) + \ln(e) \tag{1.2}$$

where Y, L, K and M are output, labor, capital and a real monetary variable such as M1 or M2. In Sinai and Stokes (1972, footnote 5) the reported Kmenta (1967, pp. 180–181) test suggested that the Cobb–Douglas function was more appropriate than the CES function for the Christensen and Jorgenson (1969, 1970) data, although others argued for CES and translog functions. To control for the effect of the functional form, in an initial test, only the Cobb–Douglas form of the model, with and without TIME and with and without a real balances variable, is used to calculate the returns to scale for different datasets in different periods in results presented in Table 1. Only OLS results are shown to isolate the effects on the point estimates of the coefficients. Dataset A was first studied by Sinai and Stokes (1972) in models estimated using second-order GLS over the period 1929–1967. Consult this paper for data sources. Dataset B is the original dataset estimated from 1930–1967. It should be compared with dataset D, which is the Nguyen (1986) dataset estimated for the same period where the measured returns to scale appear lower than in dataset B but still show increasing returns to scale. Dataset C is the Nguyen data for the period 1930–1978, where for model 16 containing LnM1 and TIME, the returns to scale were 1.12395. Model 14, the Nguyen dataset estimated with only TIME, where the returns to scale were 1.0721, makes little sense since the capital coefficient was negative. Dataset E, studied by Benzing (1989), covers a later period, 1959–1985, and still finds increasing returns to scale in all specifications. The Sinai and Stokes (1981a, 1981b) disaggregate quarterly dataset that is for the non-financial sector was estimated in the period 1953:1–1977:3 also finds increasing returns to scale. The implication from the results reported in Table 1 is that the finding of increasing returns to scale that troubles Fisher (1974) is not unique to the Sinai and Stokes (1972) dataset nor to the use of annual data nor the period of estimation nor to models containing or not containing real balances, nor whether the whole economy is modeled or just the nonfinancial sector. What is not tested in this table is whether the increasing returns found is due to the restrictive assumptions of the Cobb–Douglas functional form of the model.

Fisher (1974, pp. 530–531) raises a number of further issues, paraphrased below, that warrant further investigation:

> First, a production function containing real balances is based on given exchange arrangements that may change with the variables that enter the production function. The aggregation that is required to have a production function for the whole economy may ignore these changes.
>
> Second, one has to ask whether the measure of real balances used is an adequate and stable index of resources freed from transactions.
>
> Third, over time, unless the measure of technical progress is adequately modeled, real money balances will not continue to reflect the resources freed from transactions.