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THE IMPORTANCE OF HUMAN CAPITAL AND FINANCIAL DEVELOPMENT IN ECONOMIC GROWTH: NEW EVIDENCE USING THE TRANSLOG PRODUCTION FUNCTION

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ABSTRACT

In this paper we evaluate the contributions of human capital and financial development to economic growth in a panel of 82 countries covering 21 years. The main innovations in the paper stem from the fact that we use a translog production function as a framework for estimating the relationships among economic growth and factor inputs. The factor inputs considered are: labour, physical capital, human capital, and a monetary factor (money or credit): human capital deriving from endogenous growth theory, and the monetary deriving from the theory of money in the production function. The translog production function enables a richer specification of the relationships among growth and factor inputs, than the more commonly used Cobb-Douglas approach, as it allows for interactions among factor inputs. We find significant evidence of such interactions, suggesting that studies using the Cobb-Douglas, or those which otherwise ignore such interactions are likely to be misleading. Our results suggest that financial development is at least as important as human capital in the growth process, but that some predictions of endogenous growth models are not rejected by the data.

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1. Introduction

The subject of economic growth has enjoyed a renaissance in the last 2 decades. The theoretical and empirical literature on the subject is vast; and a list of survey papers on its own would constitute a substantial bibliography. In this introduction, we do not attempt a comprehensive literature survey, but refer the reader instead to recent surveys. Examples include the texts by Barro and Sala-i-Martin (1995) and by Aghion and Howitt (1998), Temple's (1999) paper, and the detailed survey contained in Evans (1997).

The starting point for thinking about economic growth is invariably Solow's model in which the key determinants of growth are exogenous variables. In this model, sustained growth in output per head is only possible as a result of exogenous technical change. However, the resurgence of interest in growth theory over the last two decades has been inspired largely by the Romer-Lucas paradigm of endogenous growth, in which the key determinants of output growth may be endogenous variables. In this paradigm, output per head can grow over time because of endogenous forces within the economy, particularly human capital and the knowledge base. A third tradition in the literature, stemming from Goldsmith's work, emphasizes the importance of financial markets in the growth process. Financial markets facilitate growth by enabling efficient intertemporal allocation of resources, although there remains some debate as to whether financial development causes economic growth or *vice-versa*.[1]

All these theories of growth have been subject to considerable empirical testing. Probably the oldest and still frequently-used approach is that based on growth accounting. This essentially involves differentiating a Cobb-Douglas production function with respect to time, and using the resulting equation to model the the rate of economic growth as a function of the change in factor inputs. Originally, this type of model was estimated in cross-sectional regressions using cross-country data, with a limited or negligible time dimension. Fischer (1993) is a recent contributor to this strand of the literature. Endogenous growth theory stimulated extensions to this approach, which typically involved cross-section regressions of national growth rates on a wider range of variables, intended to capture cross-sectional variations in growth, including in particular indicators of human capital and the knowledge base. Such regressions were often not derived explicitly from a production function, but included instead a more-or-less ad hoc list of plausible explanatory variables. Such regressions are often called "Barro regressions" following Barro (1991) and Barro and Lee (1994). This methodology was subjected to numerous criticisms, and more recent papers have attempted to improve on it in a variety of ways. The first approach, originated by Mankiw, Romer and Weil (1992; hereafter: MRW) is to make more explicit the equilibrium conditions and dynamics implied by the underlying growth model, mainly the Solow model, and to include human capital explicitly as a third factor of production. The second approach employs panel data to make better use of the time domain, in order to test the convergence hypothesis implicit in Solow's original contribution. Knight, Loayza, and Villanueva (1993), Knowles and Owen (1995), and Islam (1995) are examples of this approach. Still a third approach is to develop completely different methodologies, such as Quah (1993, 1997), who has focussed on describing income distribution dynamics.

The vast majority of this empirical research has been concerned with characterizing stylized facts about growth, or with testing a single theory of growth, independently of other competing theories. Relatively few papers have attempted to integrate, or at least compare, rival theories, particularly those emphasizing human capital and those emphasizing finance. Exceptions include King and Levine (1993a, 1993b) and De Gregorio and Guidotti (1992).

This paper falls most nearly into the second category set out above, in that we utilize an international panel: of 82 countries covering 21 years (1972-93). Also, our methodology builds on the growth accounting/production function approach. However, we depart from previous research in two main ways. The first main contribution of the paper is that we utilize as our theoretical framework the translog production function. This enables us to set up precisely the relationship between output and factor inputs in a relatively parsimonious manner, and to compare the contributions of different factor inputs to the growth process. The translog production function enables a substantially richer specification of the relationships among growth and factor inputs than does the Cobb-Douglas approach or any linear approximations. In particular, it enables the testing of interactions among factor inputs within a well-specified framework. This has the advantage that it enables us to meet some of the criticisms of the Cobb-Douglas approach without resorting to the estimation of separate parameters for each country, as advocated by Lee Pesaran and Smith (1997; hereafter: LPS).

The second main contribution of this paper is that we make a more systematic attempt to evaluate the relative importance of finance and human capital in the growth process, first in the specification of the model, and second in the testing and diagnostic procedures. Specifically, we consider a production function with 4 factors: labour, physical capital, human capital, and a monetary factor, represented by money or credit. Labour and physical capital are derived from the basic Solow-Swan growth model; human capital is derived from endogenous growth theory, and the monetary factor is derived from the theory of money in the production function. To enable comparability with previous studies, we test for convergence in the usual way, by including initial income as one of the regressors[2], and we compare our results with those obtainable from the simpler Cobb-Douglas approach.

The rest of the paper is organized as follows. In section 2 we set out the translog methodology. Section 3 recapitulates some important arguments for the use of panel data and summarizes the data that we, in fact, employ. In section 4 we set out the estimation and testing procedure procedure. Care is taken to compare the translog with the Cobb-Douglas, and to evaluate different empirical definitions of the concepts of "human capital" and of "money" using several diagnostic and encompassing tests. Section 5 contains the empirical results. Section 6 contains some concluding remarks. The emphasis in this paper is on a brief summary of methods and results. Further detail is contained in Evans (1997), especially chapters 5, 6, and 7.

2. The Translog Specification

An important innovation of this study is to estimate output growth with panel data and the translog functional form. It is conjectured that this specification is likely to represent the most rigorous examination of the underlying data as it considers both the total dataset and the interactive relationships between independent parameters. Clearly the translog offers more parameters than the Cobb-Douglas. However, it has a specific advantage in the modelling of human capital. Several researchers have argued that the Cobb-Douglas is inappropriate for modelling the productive contribution of education in particular and human capital in general. See, *inter alia*, Bowles (1970), Klees and Wells (1977), Lau (1979) and Psacharopoulos and Arriagada (1986). The point is that human capital is typically embodied in other factors of production; its effect therefore arises in large part through its interaction with these other factors, especially as factors are renewed: young workers enter the labour force, or old capital replaced. It is argued that it would be better to analyse these effects with a more flexible functional form than the Cobb-Douglas, but, as far as we are aware, ours is the first analysis of the determinants of growth to take this point on board.

Following Berndt and Christensen (1972), the general translog can be written:

$$q_{nt} = a_{0n} + \sum_i a_{in} v_{int} + 0.5 \sum_i \sum_j b_{ijn} v_{int} v_{jnt} \qquad \text{...1}$$

The notation in (1) allows for a panel of N (=82) countries, and I (=4) factor inputs, so that:

q_{nt} = log of aggregate output in country *n* (= 1,...,N) at time *t* (= 1,...,T),

v_{int} = log of the *i*'th (i = 1,...,I) factor input in country *n* at time t,

a_{in}, b_{ijn} are the parameters of the production function.

We begin by converting (1) into *per-capita* terms by subtracting the (log of the) labour input (which we take to be v_4) and defining:

y_{nt} = log of output per unit of labour in country *k* at time t,

f_{int} = log of the *i*'th factor input per unit of labour (i = 1,...,3) in country *n* at time t.

We can derive:

$$y_{nt} = a_{0n} + \sum_i a_{in} f_{\text{int}} + 0.5 \sum_i \sum_j b_{ijn} f_{\text{int}} f_{jnt} \qquad \text{...2}$$

on the assumptions that:

$$\sum_i a_{in} = 1; \qquad b_{44n} = \sum_{i=1}^{3} \sum_{j=1}^{3} b_{ijn}\ ; \ \ b_{4jn} = -\sum_{i=1}^{3} b_{ijn}\ ; \quad n = 1,...,\text{N}$$

which are sufficient for (1) to exhibit constant returns to scale. It will become evident that we impose these assumptions primarily to facilitate comparison with more traditional models, which are implicitly or explicitly based on the Cobb-Douglas approach. Although equation (2) is technically equivalent to constant returns to scale in (1)[3], we do not regard this as restrictive, because we explicitly include in the model produced factors other than physical capital, ie: human capital and money. Finally, we form a growth rate regression, by differentiating (2) with respect to time, and adding a disturbance term, to get:

$$\Delta y_{nt} = a_{0n} + \sum_i a_{in} \Delta f_{int} + \sum_i \sum_j b_{ijn} \Delta f_{int} f_{jnt} + e_{nt} \qquad \text{...3}$$

where: $\Delta y_{nt} = y_{nt} - y_{nt-1}$, etc.,

e_{nt} are the regression disturbances.

Six main variables form the basis of the production function which we estimate: aggregate income; the four factors of production: labour, physical capital, human capital, and money; and initial income. Some remarks are required to justify our inclusion of initial income. As Temple (1999) points out, direct differentiation of the production function eliminates initial conditions. This leaves the main problem as that of explaining the rate of technical change. MRW propose that this be done mainly by including human capital as a second produced factor. However, initial conditions do appear in MRW's model, because it is tied down by the inclusion of long-run equilibrium conditions. In our model, we include two produced factors: human capital and money; but we do not impose equilibrium conditions. Therefore, as long as each economy is operating on its production function, (3) could be estimated directly without reference to initial income. We nevertheless include initial income for two reasons. First, wherever possible, we are interested in comparing our model with previous studies which, irrespective of theoretical foundation, have invariably included initial conditions in order to examine the question of convergence. Second, although our specification includes, in principle, all relevant factors of production, given the difficulty, in practise, of measuring human capital and money, we would still anticipate that there may be variables omitted from the model. Indeed, one might argue that omitted variables are an endemic problem in testing growth theory. There is a broad consensus that initial conditions are important for growth, even if the precise reasons for their importance are less well agreed. See Evans (1997) and Temple (1999). Insofar as initial conditions are important, then they are correlated with changes in factor inputs. Thus, in our model, initial conditions serve two purposes: first, to check for convergence, and second to capture any omitted factors of production. Of course, initial income is not itself a factor of production, but in this paper, we have treated it symmetrically with the factors of production, so as to allow for the possibility of interactions between the initial conditions and the changes in factor inputs[4].

The equation we estimate can be written more fully as:

$$\begin{aligned}\Delta y_{nt} = {} & a_{0n} + a_{1n}\Delta k_{nt} + a_{2n}\Delta m_{nt} + a_{3n}\Delta h_{nt} + a_{4n} y72_n + \\ & b_{11n}\left(k_{nt}\Delta k_{nt}\right) + b_{12n}\left(k_{nt}\Delta m_{nt} + m_{nt}\Delta k_{nt}\right) + b_{13n}\left(k_{nt}\Delta h_{nt} + h_{nt}\Delta k_{nt}\right) + b_{14n}\left(y72_n \Delta k_{nt}\right) + \\ & b_{22n}\left(m_{nt}\Delta m_{nt}\right) + b_{23n}\left(m_{nt}\Delta h_{nt} + h_{nt}\Delta m_{nt}\right) + b_{24n}\left(y72_n \Delta m_{nt}\right) + \\ & b_{33n}\left(h_{nt}\Delta h_{nt}\right) + b_{34n}\left(y72_n \Delta h_{nt}\right) + e_{nt}\end{aligned} \qquad \ldots 4$$

where: k_{nt} = physical capital per unit of labour,

m_{nt} = real money balances per unit of labour,

h_{nt} = human capital per unit of labour,

$y72_n$ = initial income per unit of initial of labour (1972).

The exact empirical counterparts of these variables are defined in section 3. Equation (4) offers a relatively parsimonious parameterization of the data, with no more coefficients to estimate than is common in Barro regressions[5], and obviously fewer than in country-by-country estimations. At the same time, the quadratic terms give additional curvature to the function, and allow for a much richer range of production possibilities, including individual country differences arising from the interaction terms. Since initial income is also included in the model, these individual country effects may also depend on initial conditions. In addition, the use of panel data enables us to allow for further differences in the aggregate production function across countries in the form of unobservable individual country effects. See Islam (1995).

3. Data

The advantages of panel data over a cross-section scarcely need emphasizing. A panel allows us to control properly for the heterogeneity of individual countries, both through the estimation procedure, and through the model specification. See Baltagi (1995) and Moulton (1986, 1987). It gives more informative data, more variability, less collinearity among the variables, more degrees of freedom and more efficiency, particularly in diagnostic testing. With specific reference to this study, cross-section data neglect 95% of the total dataset. Moreover, virtually all empirical studies of money-in-the-production-function have been confined to individual country time-series data. See the seminal studies of Sinai and Stokes (1972, 1989) and the review in Evans (1997)[6]. The use of panel data to test the money-in-the-production-function hypothesis constitutes a further contribution of this paper[7].

The panel consists of data from 82 countries covering 21 years from 1972-1992. There is a trade-off between availability of data in the time domain and that in the cross-section. For some countries, data are long-standing and up-to-date. For others, the data are of more recent origin or are severely unreliable. The time period was chosen to cover a sufficiently long period as to be able to examine the convergence issue in a way comparable to earlier studies. The cross-section was selected so as to include a comprehensive sample of income groups and geographical spread. The majority of the data derives from The World Bank tables (WBT); but additional data were extracted from the Barro-Lee database, International Financial Statistics, UNESCO, and the Summers-Heston Penn World tables (PWT). Various adjustments were made to the data to ensure compatibility among the different sources. In addition, local currency data were converted to US dollars using the real exchange rate (RER)[8] calculated as:

$$RER = SP^* / P \qquad \text{...5}$$

where S is the spot exchange rate against dollars, P^* is the US price deflator, and P is the price deflator of the home country. See Evans (1997) for further details on these issues.

The traditional growth variables, output, capital and labour are relatively straightforward to measure. GDP and labour force are taken from the WBT, with initial GDP being that for 1972. Physical capital is estimated from gross investment (from the WBT) using the perpetual inventory method with a depreciation rate of 5%, following, for example, King and Levine (1994) and Romer (1989). Several possible empirical counterparts of "money" and human capital have been suggested in the literature. Given this ambiguity, we employ 2 different definitions of money, and 3 of human capital. We then estimated models with all 6 permutations of these definitions, and compared the results from each set of estimates, both informally and with a non-nested specification test. For money, we employ a monetary measure and a credit measure. The former is defined as the ratio of M2 to GDP, as in Hermes and Lensink (1993). The latter is defined as the ratio of domestic credit to GDP, following, for example, King and Levine (1993a). For human capital, it is generally agreed that rates of educational attainment provide a broad indicator of the skill-level of the workforce. Accordingly, our first two measures of human capital are primary and secondary school enrolment rates following numerous authors, for example: Barro (1991), and Roubini and Sala-i-Martin (1992). However, the enrolment rate has been subject to criticism in the literature, especially because it can be argued that it represents the flow of new capital rather than the stock of existing capital. See Psacharopoulos and Arriagada (1986). We therefore used as a third measure real public expenditure on education, following Landau (1986)[9]. Summary definitions of the variables used in the model and their mnemonics and sources, together with the countries chosen, are given in tables 1 and 2.

4. Estimation and Testing Procedures

The model to be estimated is given by equation 4, which can be written in more compact form as:

$$\Delta y_{nt} = a_{0n} + \sum_i a_{in} z_{int} + e_{nt}\,; \qquad n = 1,...,N \qquad ...6$$

where now, z_{int} (i = 1,...,13) are the explanatory variables in the regression. There are 6 versions of this model to estimate, corresponding to the 6 permutations of the definitions of money and human capital. The notation so far suggests that the production functions for each country have different slope and and intercept coefficients from one another. Indeed LPS (1997) argued that one should, from the start, allow for such differences. In this paper, we adopt a simpler approach for several reasons. First, our dataset has a significantly shorter time-span than that of LPS, mainly because of the inclusion in our data of measures of human capital. LPS are concerned exclusively with the Solow growth model. Our shorter time-span and greater number of coefficients render nugatory the estimation of single-country dynamics, and suggest the need to exploit any commonalities inherent in the panel. Second, LPS estimate Cobb-Douglas production functions. The (non-linear) interaction terms arising from our application of the translog imply that there may be heterogeneity among countries, even if the slope coefficients are equal across countries, simply because of different initial conditions[10].

However, we do not impose common coefficients at the outset. Instead, we estimate (6) directly by OLS, which is equivalent to OLS on each country separately, and then perform Chow (*F*-) tests for the "poolability" of the panel. The Chow tests are done in two steps: first we test for common slope coefficients, implying (6) can be written:

$$\Delta y_{nt} = a_{0n} + \sum_i a_i z_{\text{int}} + e_{nt}\,; \qquad n = 1,...,N \qquad ...7$$

Equation (7) (estimated by OLS) is equivalent to the fixed-effects model. Next we test for common intercepts and slopes by OLS on the pooled data:

$$\Delta y_{nt} = a_0 + \sum_i a_i z_{\text{int}} + e_{nt}\,; \qquad n = 1,...,N \qquad ...8$$

For completeness, we also check if there are common intercepts (α_0) and different slopes (α_{in}). Because of the large sample size, and correspondingly large number of degrees of freedom, we applied Leamer's (1978) correction to the critical value of the *F*-statistic used to evaluate the poolability tests[11]. See also Baltagi (1995) for details on these procedures[12].

It transpires that poolability is accepted for both slopes and intercepts. (See table 4, and the discussion in section 5.) However, the power of the Chow test in this setting is low if the country-specific effects are not in fact fixed, but random, implying that the disturbances of the model are heteroskedastic[13]. Therefore we also estimated the random effects model:

$$\Delta y_{nt} = a_0 + \sum_i a_i z_{\text{int}} + u_n + e_{\text{int}}\,; \qquad n = 1,...,N \qquad ...9$$

(where u_n is the country-specific disturbance) and carried out Hausman (1978) tests to check which of the fixed or random effects models was more acceptable. According to these tests (shown in tables 7 and 8), there is no evidence of correlation between the individual country effects and the other parameters in the model, implying that the random effects model is appropriate. We therefore report estimates of the random effects model using the standard GLS estimator. See Hsaio (1986).

The widely-used Cobb-Douglas is a special case of the translog. We therefore began our hypothesis tests with a test for the value added by the use of the translog. This involves an *F*-test for the significance of the quadratic terms in (3) to determine whether it can, in fact, be reduced to a Cobb-Douglas. The null hypothesis is that : $\beta_{ij} = 0,\ \ldots i,\ \ldots j$; with the alternative being that at least one β_{ij} ! 0. If, as indeed turns out to be the case, this hypothesis is rejected, we return to the general translog and seek a more parsimonious formulation by testing down where possible, using *t*- and *F*-tests. We report parameter estimates for the general translog and for the parsimonious version of the model. Some additional diagnostic tests were performed on both the general and parsimonious versions of the model; and these are reported with the parameter estimates in tables 7 and 8. Allowing for 6 permutations of money and human capital, as well as a general and a parsimonious version of the translog, we have 12 sets of estimates in all, and these are summarized in table 3.

The use of different empirical measures of a variable in different regressions raises important issues of interpretation, which are often dealt with in the literature by *ad hoc* comparisons. It is clearly important to be as rigorous as possible in evaluating which of the variables used to measure "money" or "human capital" are actually relevant to economic growth. Moreover, it is not simply a matter of which variable works best in the regression. The difference between money and credit in the production function reflects, to some extent, real economic differences of opinion and analysis as to the underlying causal mechanisms of growth. See the original contributions of McKinnon (1973) and Shaw (1973), as well as more recent work, such as King and Levine (1993b). Likewise, although human capital is quite simply hard to measure at all, differences among different definitions also reflect, to some extent, underlying differences of view as to the role of human capital in the growth process. See, *inter alia*, Psacharopoulos and Arriagada (1986).

Considerations of model size, interpretation, and estimation all preclude using all 5 money and human capital variables simultaneously in a general model, and then testing down. Instead, we used the J-test of Davidson and MacKinnon (1981) to examine more rigorously how far the different measures of money and human capital contain overlapping or independent information about the true underlying variables. As argued by Mizon (1984), J tests can be interpreted as (variance-) encompassing tests. Consider as an example, a comparison between money (*M2*) and credit (*CR*). We first estimate the model with *M2* ($H0^1$) and then test if *CR* increases the explanatory power of the model. We then estimate with *CR* ($H0^2$) and test if *M2* increases the explanatory power of the model. If $H0^1$ is accepted and $H0^2$ rejected, we would conclude that *M2* variance-encompasses *CR*. In that event, *CR* would be a redundant variable in the model; and the data would be consistent with a monetary interpretation rather than a credit interpretation of the production function. If however, $H0^2$ is accepted and $H0^1$ rejected, the data would be consistent with a credit interpretation. If both null hypotheses are accepted, or both rejected the outcome is less clear, as it would imply that the data are consistent with either or both variables (respectively) contributing to the production function. However, as Davidson and MacKinnon pointed out, this ambiguity is inherent in any non-nested testing procedure. We did pairwise J-tests on all the money and human capital variables: *M2-CR* with each of *PS*, *SS*, and *PE* in turn as the human capital variable; then *PS-SS*, *PS-PE*, *SS-PE*, with first *M2* and then *CR* as the money variable. This makes 9 such tests in all.

5. Empirical Results

Tests for poolability are reported in table 4. The results clearly suggest that the data is poolable. Slopes and intercepts are statistically equal across countries (columns 5 and 6); poolability of slopes, allowing for varying intercepts, is accepted (columns 1 and 2); likewise, the poolability of intercepts, allowing for varying slopes, is accepted (columns 3 and 4). As explained in section 4, this reduces the estimation problem to deciding among fixed effects, random effects, or pooled OLS. The choice between random effects and fixed effects is determined by the Hausman test, which tests for misspecification in the random effects model (see section 4). The results of the Hausman test (tables 7 and 8) suggest that the random effects model is the more appropriate, irrespective of data definitions, and this forms the basis of the coefficient estimates reported in tables 7 and 8.

We turn next to specification tests. General diagnostics are reported in tables 7 and 8. The RESET tests suggest that the general model specification is correct. There is no evidence of any remaining heteroskedasticity, nor, within the limitations of a relatively short time domain, is there any evidence of autocorrelation. Overall, these appear to be relatively well-specified estimates. Tests for the value added by the translog are given in table 5 (ie., that: $\beta_{ij} = 0, \ldots i, \ldots j$), and show clearly that the quadratic terms introduced by the translog, even in this restricted constant-returns-to-scale form, are collectively highly significant, irrespective of which variant of the model is estimated. This is a very strong finding, supporting our use of a more general production function than the Cobb-Douglas, and underpinning the arguments of those who have expressed doubts about the validity of the Cobb-Douglas as a framework for studying human capital in particular[14].

The final major set of specification tests concerns the J-tests, which are reported in table 6. All the tests are inconclusive in the sense that H0 is always rejected. For any pair of variables, this implies that neither one on its own can be interpreted as properly measuring the true underlying variable: either money-in-the-production function or human capital. This is perhaps disappointing, but not necessarily surprising, given the difficulties involved in measuring these concepts. Moreover, we have used variables which have been widely used in other studies. See Evans (1997). Hence, our results suggest that previous researchers may have over-estimated the importance of their own findings, except where they have peformed substantial diagnostics as to the robustness of the variable definitions used. However, the inconclusiveness of the J-tests may also be attributable to the fact that J-tests do not necessarily perform well in finite samples, particularly if the two competing models are very different. Although our sample is relatively large, and we have performed pairwise comparisons between just two variables, the quadratic terms in the production function imply that 5 out of 13 of the slope parameters are different as between the two sets of estimates in any J test. Under these circumstances, the J test statistic tends to be too large, possibly substantially so; see Davidson and MacKinnon (1993). This is not inconsistent with the results in table 6; and suggests that undue pessimism is not warranted.

We turn finally to the parameter estimates. Table 7 presents the translog specifications including *CR* as the real balances variable, with each human capital variable estimated in turn. Equations (2), (4), and (6) are the parsimonious regressions[15]. Table 8 gives analagous results with *M2* as the real balances variable, and equations (8), (10), and (12) as the parsimonious regressions. All the parameters associated with the linear (Cobb-Douglas) part of the model are significant; and, overall, only a few of the parameters associated with the quadratic terms are insignificant. This gives further confidence in the translog specification over the Cobb-Douglas.

As far as the coefficients are concerned, those for capital, money and credit are generally satisfactory. The marginally significant coefficients for capital are not a worry. De Gregorio and Guidotti (1992) and Coppin (1994) report similar results in a Cobb-Douglas specification; and, in our estimates, the quadratic terms involving capital are all highly significant. The results for money and credit are particularly interesting. The results for *M2* are consistent with those of Sinai and Stokes (1972), who used time-series data. It provides no support for the claim of De Gregorio and Guidotti (1992), that monetary aggregates are unsuitable measures of the financial system, and that *CR* should take precedence in measuring the impact of finance on growth. In our analysis, both money and credit are found to be meaningful and significant measures of the role of money and finance in the production process. Moreover, although the J-test results suggest that *M2* and *CR* may be measuring different functions of the financial system, the very similar sign patterns of the coefficients on *M2* and *CR* in the production functions would suggest that these functions nevertheless have a broadly comparable impact on the production process. In addition, we find that there are important complementarities between finance and capital in the production process, reflected in the positive coefficients on the interaction terms involving these variables (*K-CR* and *K-M2*). This provides interesting support for the original McKinnon-Shaw thesis, as it does suggest that there is an important relationship between financial development and economic growth[16].

In contrast, the human capital variables mostly have negative coefficients, particularly in the *CR* variant of the model (table 7). Even in Cobb-Douglas models, negative coefficients on human capital variables are not unusual, as, for example, in Lau *et al*. (1991) for a sub-sample of south-east Asian countries. The reasons advanced for such a finding include: the possibility of high fixed costs in the initial production of human capital, high opportunity cost in terms of output of educating child workers, and costs involved in the interaction of educated and non-educated workers. The translog formulation enables us to investigate some of these hypotheses more rigorously. The interactions between physical and human capital are uniformly negative, implying a surprising lack of complementarity between these factors, and providing evidence against the embodiment and learning-by-doing hypotheses. More interesting perhaps are the positive coefficients on the *M-H* interactions, providing evidence of complementarity between financial development and human capital, particularly in the credit version of the model. This would suggest that a developed financial system is an essential complement to a developed educational system in the growth process. The more ambiguous results for *M2* may help explain why credit versions of financial development have found more favour than money in the new growth literature. See De Gregorio and Guidotti (1992). Overall though, the human capital coefficients are not supportive of the primary role given to education within endogenous growth theory.

One might perhaps argue that the positive coefficients on the squared capital term are consistent with a key principle of endogenous growth, that is, an absence of diminishing returns to capital, taken by itself. There is a corresponding "absence of diminishing returns" to *M2*, supporting endogenous financial growth. However, the inclusion of human capital as an explicit factor of production, is usually thought of as capturing such effects directly. See MRW (1992). These results may therefore perhaps reflect the underlying limitations of the human capital variables.

We turn finally to the convergence indicators, represented by initial income *per capita*. At the outset, we emphasize that these are *ad hoc* variables in the current model, and their significance may be due in part to omitted variables. Nevertheless, the coefficients on the terms involving initial income are of some considerable interest. The coefficients on initial income itself are all positive, suggesting divergence[17], but the interaction terms vary in sign in an interesting and intuitive way. On the one hand, the negative interaction with physical capital implies that there may be convergence in respect of the productivity of physical capital. On the other hand, the positive interactions with credit and with money, and (mostly) with human capital suggest that there is divergence in respect of the productivity of both finance and human capital. This is substantially more consistent with endogenous growth theory; the difference in sign between the *K-Y72* interactions and the *M-Y72* and *H-Y72* interactions being particularly striking. For the finance variables, one possible explanation for these results is that financial development in poorer countries needs to be accompanied by the development of appropriate economic and legal frameworks, which are already in place in wealthier countries. See Levine (1992), Saint-Paul (1992) and King and Levine (1993a, 1993b). If, for example, the financial system expands within an inadequate regulatory environment (typical of lower income economies), it may have adverse effects on economic growth. See De Gregorio and Guidotti (1992). A similar argument could be applied to the human capital variables, where, eveidently, the quality of education is as important as the bare enrollment rates.

6. Summary of Conclusions

In this paper we specified and estimated the relationships among economic growth, financial development and human capital using as model the translog production function and estimating this on panel data. Evidence shows that the data are poolable, and specification tests favour the random effects estimation procedure. Comprehensive diagnostic testing suggests that the empirical results are correctly specified, and that the translog specification is substantially superior to the Cobb-Douglas model.

The main findings that emerge from the estimation of the model can be summarised as follows. First, we find that both money and human capital make a significant contribution to growth. Moreover, this is true irrespective of whether money or credit is employed as a measure of the monetary factor, and irrespective of the precise measure of human capital. Consequently, it seems clear that testing for the impact of human capital or of money in isolation is likely to produce misleading results. However, we cannot determine whether any one particular measure of money or human capital is superior to the others. This, in turn, suggests the need for further research at the micro and macro level to investigate the appropriate measures of these variables. Second, we find that there is substantial evidence of (mostly intuitively reasonable) interaction effects among factor inputs, all of which give another reason why Barro regressions may be misleading. The linearity assumption in most applications which implicitly use the Cobb-Douglas production function is simply inconsistent with the data. Third, as far as the underlying theories are concerned, we find only limited and indirect evidence to support endogenous growth theories, and rather more evidence to support the McKinnon-Shaw hypotheses. Finally, the estimates of the parameters associated with the initial income variable provides *ad hoc* evidence that convergence in factor productivities may itself be factor-dependent. We conjecture that the precise impact of human capital and financial development on growth may perhaps depend in part on the quality of the imput as much as on any single measure of its quantity.

Footnotes

* This paper is a revised version of chapter 7 of Dwyfor Evans' Ph.D. dissertation at Cardiff Business School. See Evans (1997). This dissertation research was funded by a University of Wales scholarship; and we thank the University of Wales for their financial support.

1. Key references include Solow (1956), Romer (1986), Lucas (1988), and Goldsmith (1969).

2. In this paper, we are concerned primarily with beta-convergence, ie. convergence to a common growth rate across countries. Clearly, if equilibrium growth rates differ, as LPS (1997) argue and indeed find, the concept of beta-convergence loses its meaning. However, the LPS study uses the Solow model as its framework for generating equilibrium growth. In our setup equilibrium growth is conditional on human capital and finance. A common trans-national long-run steady-state in this setting is quite consistent with (apparently) different long-run steady states in the Solow model.

3. It is therefore equivalent to Kmenta's (1967) proposed approximation to the CES.

4. The treatment of initial income is not precisely symmetric with other factors because, obviously, $\Delta y72_n = 0$ by definition! see equation (3).

5. Barro and Sala-i-Martin (1995) report regressions with 14 or more coefficients, compared with 14 in equation (4).

6. Those papers on finance and growth which do use panel data, such as King and Levine (1993a, 1993b), are concerned with financial markets in general, and not specifically with money in the production function.

7. A possible drawback with panel data is that they raise the problem of business cycles. Distinguishing growth effects from business cycle effects is difficult, as many of the determinants of long-run growth fluctuate over the business cycle. As short-run fluctuations and long-run growth are fundamentally different phenomena, business cycles

may distort panel data (see Mankiw, 1995; Islam, 1995). However, this problem is more than offset by the much richer database offered by a panel.

8. Many studies convert local currency data using PPP exchange rates, such as those in the PWT. Certainly, there is now considerable evidence in favour of long-run PPP. See Coakley and Fuertes (1997) for a recent contribution. However, there is less agreement about the time period over which real exchange rates may be expected to converge to their PPP levels. In the meantime, countries have to live with the actual real exchange rate which will affect the competitiveness of the economy and its growth performance. See for example Copeland (1989). Accordingly, while a PPP exchange rate may be suitable for cross-sections or very short panels, we would argue that it is unduly smoothed for use as a conversion factor in the relativel long panel which we are using; and we therefore prefer the real exchange rate.

9. Other variables which may estimate the stock of human capital, were not used, either because they were inappropriate, or because there were insufficient data for the sample countries. For example, there were insufficient data to construct the Barro-Lee (1992) estimate of mean years of schooling for the full panel.

10. For the same general reasons, we treat all those variables in the model which involve the sums and products of levels and differences as single (constructed) variables, which can therefore be entered directly in a linear regression.

11. Leamer (1978) argued that testing at a fixed significance level tends to distort the size of the test against accepting the null, as the sample size grows. Certainly, it can be difficult not to reject *any* null hypothesis in very large panels. Leamer proposed adjusting the 5% critical value of the *F*-test to: $F_{crit} = F(T^{r/T}-1)(T-k)/r$; and it is this critical value that it is used in the poolability tests. See table 3.

12. The regressions were all run in TSP.

13. Strictly speaking, the Chow test is generally invalid in the presence of heteroskedastic variances. However, Toyoda (1974) notes that the test is well behaved so long as the sample size is very large, as is the case with our sample.

14. We did however estimate the Cobb-Douglas directly and performed comparable diagnostics on the estimated equations. The results of these excercises are available in Evans (1997).

15. The parsimonious models are determined by conventional *F*-tests. Leamer's (1978) critical values for the *F*-test exceed the classical critical values. Accordingly, since the null is always accepted by the classical critical value, it is necessarily also accepted using Leamer's value.

16. Of course, this argument does depend on the precise interpretation given to the money and credit variables. For example, Morisset (1993) argues that a positive effect of credit on growth depends, in practise, on the allocation of credit, especially that the flow of domestic credit to the private sector is not pre-empted by the needs of the public sector.

17. Divergence is consistent with the results of Barro (1991), and Dowrick (1992), although Barro (1991) does find a convergence effect if the starting value of human capital is also included as an explanatory variable. Most other studies have found evidence of convergence only among sub-samples of economically "similar" nations, see Brander (1992) for a review.

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Table 1. Variable Definitions and Menmonics

	mnemonic	definition	Source
Income	Q	GDP	WBT
Labour force	L	Labour force	WBT
Physical Capital	K	Perpetual inventory method with 5% depreciation rate	WBT
Money	M-M2	M2 money = currency + demand deposits + time and savings deposits	WBT and IFS
	M-CR	Domestic Credit	IFS
Human Capital	H-PS	Primary school enrolment rate	UNESCO
	H-SS	Secondary school enrolment rate	UNESCO
	H-PE	Public expenditure on education	UNESCO
Exchange rates, prices, PPP			PWT

Table 2. Sample Countries

Low income	Middle (low) income	Middle (high) income	High income
Bangladesh	Bolivia	Algeria	Australia
Benin	Cote d'Ivoire	Argentina	Austria
Burkina Faso	Dominican Republic	Barbados	Belgium
Burundi	Ecuador	Chile	Canada
Cameroon	Egypt	Colombia	Denmark
Central African Republic	El Salvador	Costa Rica	Finland
Ethiopia	Guatemala	Fiji	France
The Gambia	Honduras	Gabon	Germany
Ghana	Morocco	Greece	Ireland
India	Nicaragua	Jamaica	Israel
Indonesia	Papua New Guinea	South Korea	Italy
Kenya	The Philippines	Malaysia	Japan
Madagascar	Senegal	Mexico	The Netherlands
Malawi	Swaziland	Oman	New Zealand
Mali	Zambia	Panama	Norway
Myanmar		Paraguay	Spain
Nepal		Peru	Sweden
Nigeria		Portugal	United Kingdom
Rwanda		South Africa	United States
Sierra Leone		Suriname	
Sri Lanka		Trinidad and Tobago	
Tanzania		Tunisia	
Togo		Turkey	
		Uruguay	
		Venezuela	

Table 3. Translog Estimations

Eq.	Human Capital	Real Balances	Restriction	Eq.	Human Capital	Real Balances	Restriction
1	PS	CR	Unrestricted	7	PS	M2	Unrestricted
2	PS	CR	Parsimonious	8	PS	M2	Parsimonious
3	SS	CR	Unrestricted	9	SS	M2	Unrestricted
4	SS	CR	Parsimonious	10	SS	M2	Parsimonious
5	PE	CR	Unrestricted	11	PE	M2	Unrestricted
6	PE	CR	Parsimonious	12	PE	M2	Parsimonious

Table 4. Chow Test for Data "Poolability"

	Hypotheses						
	Ai,B=Ai,Bi		A,B=Ai,B		A,B=Ai,Bi		
Eq.	df	F	df	F	df	F	RESULT
(1)	*F*(233,1312)	3.522	*F*(81,1545)	0.581	*F*(314,1312)	2.821	Accept equality
(2)	*F*(235,1312)	3.507	*F*(81,1547)	0.551	*F*(316,1312)	2.803	Accept equality
(3)	*F*(233,1312)	3.580	*F*(81,1545)	0.640	*F*(314,1312)	2.886	Accept equality
(4)	*F*(235,1312)	3.562	*F*(81,1547)	0.615	*F*(316,1312)	2.867	Accept equality
(5)	*F*(233,1312)	3.697	*F*(81,1545)	0.599	*F*(314,1312)	2.961	Accept equality
(6)	*F*(235,1312)	3.680	*F*(81,1547)	0.582	*F*(316,1312)	2.948	Accept equality
(7)	*F*(233,1312)	1.870	*F*(81,1545)	0.943	*F*(314,1312)	1.663	Accept equality
(8)	*F*(236,1312)	1.855	*F*(81,1548)	0.951	*F*(317,1312)	1.656	Accept equality
(9)	*F*(233,1312)	1.894	*F*(81,1545)	0.855	*F*(314,1312)	1.656	Accept equality
(10)	*F*(235,1312)	1.878	*F*(81,1547)	0.861	*F*(316,1312)	1.647	Accept equality
(11)	*F*(233,1312)	2.325	*F*(81,1545)	0.879	*F*(314,1312)	1.997	Accept equality
(12)	*F*(234,1312)	2.315	*F*(81,1546)	0.882	*F*(315,1312)	1.992	Accept equality

Notes: Critical values are presented at the 5% level.

The critical values of the *F*-tests (see Leamer, 1978) are:

F(314,1312) = 13.061; *F*(233,1312) = 10.487; *F*(81,1545) = 8.419; *F*(316,1312) = 13.134; *F*(235,1312) = 10.543; *F*(81,1547) =8.430; *F*(317, 1312) = 13.171; *F*(236,1312) = 10.571; *F*(81,1548) = 8.436; *F*(315,1312) = 13.098; *F*(234,1312) = 10.515; *F*(81,1546) = 8.427.

Table 5. Functional Form Test (Cobb-Douglas vs. Translog)

	F-TEST (at the 5% level)		
Explanatory Variables	**Calculated Value**	**Critical Value**	**Result**
CR and PS (9,1627)	23.425	1.884	REJECT NULL
CR and SS (9,1627)	17.477	1.884	REJECT NULL
CR and PE (9,1627)	23.962	1.884	REJECT NULL
M2 and PS (9,1627)	21.849	1.884	REJECT NULL
M2 and SS (9,1627)	20.506	1.884	REJECT NULL
M2 and PE (9,1627)	21.902	1.884	REJECT NULL

Notes: At *F*(9,1627) df., the critical values at the 1% and 10% levels are 2.421 and 1.633 respectively.

Table 6. Encompassing (J-)Tests for Human Capital and Real Balances

Hypotheses	J-Test value	Result[a]
M2, CR and PS		
H0: CR with predicted value of M2	23.022***	H0 not accepted and H1 Î H0
H1: M2 with predicted value of CR	9.519***	H1 not accepted and H0 Î H1
M2, CR and SS		
H0: CR with predicted value of M2	23.055***	H0 not accepted and H1 Î H0
H1: M2 with predicted value of CR	9.103***	H1 not accepted and H0 Î H1
M2, CR and PE		
H0: CR with predicted value of M2	22.568***	H0 not accepted and H1 Î H0
H1: M2 with predicted value of CR	9.539***	H1 not accepted and H0 Î H1
PS, SS and M2		
H0: SS with predicted value of PS	7.365***	H0 not accepted and H1 Î H0
H1: PS with predicted value of SS	6.326***	H1 not accepted and H0 Î H1
PS, SS and CR		
H0: SS with predicted value of PS	6.190***	H0 not accepted and H1 Î H0
H1: PS with predicted value of SS	3.538***	H1 not accepted and H0 Î H1
PS, PE and M2		
H0: PE with predicted value of PS	7.139***	H0 not accepted and H1 Î H0
H1: PS with predicted value of PE	7.104***	H1 not accepted and H0 Î H1
PS, PE and CR		
H0: PE with predicted value of PS	5.487***	H0 not accepted and H1 Î H0
H1: PS with predicted value of PE	6.658***	H1 not accepted and H0 Î H1
SS, PE and M2		
H0: PE with predicted value of SS	6.429***	H0 not accepted and H1 Î H0
H1: SS with predicted value of PE	6.806***	H1 not accepted and H0 Î H1
SS, PE and CR		
H0: PE with predicted value of SS	5.068***	H0 not accepted and H1 Î H0
H1: SS with predicted value of PE	7.573***	H1 not accepted and H0 Î H1
Human Capital and Real Balances		
H0: HC with predicted value of RB	34.516***	H0 not accepted and H1 Î H0
H1: RB with predicted value of HC	4.021***	H1 not accepted and H0 Î H1

Notes: *** significant at the 1% level.
Î denotes "encompasses".

Table 7. Human Capital and Real Balances Estimation (Translog): Credit in the Production function

Dependent variable: GDP growth per worker, 1972-1992 (82 economies)

Eq	Y72	K	CR	PS	K^2	DC^2	PS^2	KY72	KCR	KPS	CRY72	CRPS	PSY72	$\bar{R}^2$ SE	Haus[a]	RESET[b]	LM[c]	Auto[d]	*F*-stat[e]
(1)	.1E-06	0.159	0.587	-0.921	-0.007	-0.011	-0.072	-.1E-04	0.027	-0.017	.8E-05	0.054	.1E-05	.68	8.34	**2**: 1.53	1.57	**1**: 3.58	-
	3.50**	1.18	6.14**	-2.74**	-0.63	-4.93**	-2.44*	-6.24**	9.17**	-2.35*	4.61**	6.44**	0.14	0.099		**3**: 0.78		**2**: 4.75	-
(2)	.1E-05	0.089	0.599	-0.895	-	-0.011	-0.071	-.1E-04	0.026	-0.019	.9E-05	0.054	-	.68	2.73	**2**: 3.47	1.57	**1**: 3.66	*(2,1629)*
	3.61**	1.18	6.44**	-2.68**	-	-4.89**	-2.41*	-9.29**	10.02**	-2.82**	4.69**	6.62**	-	0.100		**3**: 2.60		**2**: 4.85	0.50
Eq	**Y72**	**K**	**CR**	**SS**	**K^2**	**DC^2**	**SS^2**	**KY72**	**KCR**	**KSS**	**CRY72**	**CRSS**	**SSY72**	**SE**	**Haus**	**RESET**	**LM**	**Auto**	***F*-stat**
(3)	.1E-05	0.256	0.348	-0.385	-0.006	-0.012	-0.021	-.1E-04	0.027	-0.007	.7E-05	0.027	.2E-06	.68	9.80	**2**: 0.01	1.60	**1**: 3.75	-
	3.36**	1.75†	4.37**	-2.16*	-0.52	-5.22**	-1.79†	-6.36**	8.98**	-1.03	3.64**	4.63**	0.04	0.100		**3**: 0.05		**2**: 4.62	-
(4)	-1E-05	0.193	0.358	-0.361	-	-0.012	-0.020	-.1E-04	0.026	-0.008	.7E-05	0.027	-	.68	4.97	**2**: 0.04	1.61	**1**: 3.79	*(2,1629)*
	3.39**	2.52*	4.75**	-2.15*	-	-5.19**	-1.78†	-9.06**	9.80**	-1.45	3.64**	4.89**	-	0.100		**3**: 0.08		**2**: 5.75	0.38
Eq	**Y72**	**K**	**CR**	**PE**	**K^2**	**DC^2**	**PE^2**	**KY72**	**KCR**	**KPE**	**CRY72**	**CRPE**	**PEY72**	**SE**	**Haus**	**RESET**	**LM**	**Auto**	***F*-stat**
(5)	.1E-05	0.137	0.441	-0.235	-0.004	-0.012	-0.009	-.1E-04	0.027	-0.012	.8E-05	0.030	-4E-05	.69	7.90	**2**: 0.46	1.66	**1**: 2.42	-
	3.40**	1.08	6.44**	1.72†	-0.36	-5.08**	-0.99	-6.79**	8.92**	-2.21*	4.53**	7.06**	-1.69†	0.099		**3**: 0.30		**2**: 2.50	-
(6)	.1E-05	0.099	0.449	-0.105	-	-0.011	-	-.1E-04	0.026	-0.013	.8E-05	0.031	-.4E-05	.69	3.05	**2**: 0.51	1.67	**1**: 2.38	*(2,1629)*
	3.41**	1.22	6.73**	-2.27*	-	-5.09**	-	-9.32**	10.07**	-2.42*	4.55**	7.16**	-1.58	0.099		**3**: 0.33		**2**: 2.50	0.70

Notes: A constant term is included in all regressions.

Figures in parentheses are *t*-statistics. ** significant at the 1% level; * significant at the 5% level; † significant at the 10% level.

a ***The Hausman test*** is distributed as a c^2 statistic and the 5% critical values at 11 df.=19.67; at 13 df.=22.36.

b ***Test of functional form***: RESET tests were carried out by including the square (2) and the cube (3) of the predicted values of each regression as additional explanatory variables. *F* values are reported above for the tests of the (joint) significance of the additional regressor(s). The critical value at the 5% level of the squared parameter (2)=3.75 and the cubed parameter (3)=3.00.

c ***Test for Heteroskedasticity***: The LM test is distributed as a c^2 statistic. The 5% critical value at 82 df=104.14.

d ***Test for Serial Correlation***: The Breusch-Godfrey LM test is distributed as a c^2 statistic. At the 5% level, the critical value at 1 df.=3.84; at 2 df.=5.99.

e ***F-Test:*** The critical value at the 5% level for *F*(2,1629) is 3.00.

Table 8. Human Capital and Real Balances Estimation (Translog): Money in the Production function

Dependent variable: GDP growth per worker, 1972-1992 (82 economies)

Eq.	Y72	K	M2	PS	K^2	$M2^2$	PS^2	KY72	KM2	KPS	M2Y72	M2PS	PSY72	$\bar{R}^2$ SE	Haus[a]	RESET[b]	LM[c]	Auto[d]	*F*-stat[e]
(7)	.1E-05	0.218	0.154	-0.428	0.026	0.012	0.014	-.1E-04	0.004	-.8E-08	.1E-04	-0.031	.9E-05	.74	15.43	**2**: 0.03	0.72	**1**: 1.38	-
	4.06**	1.83†	1.97**	-1.35	2.77**	4.92**	0.54	-5.65**	1.95†	-0.12	5.24**	-3.80**	1.19	0.090		**3**: 0.07		**2**: 2.37	-
(8)	.1E-05	0.228	0.175	-0.525	0.025	0.012	-	-.1E-04	0.004	-	.1E-04	-0.028	-	.74	14.27	**2**: 0.02	0.72	**1**: 1.60	*(3,1630)*
	3.91**	2.61**	2.36*	-3.81**	2.90**	5.12**	-	-6.04**	2.12*	-	5.51**	-4.11**	-	0.090		**3**: 0.03		**2**: 2.81	0.51
Eq.	**Y72**	**K**	**M2**	**SS**	**K^2**	**$M2^2$**	**SS^2**	**KY72**	**KM2**	**KSS**	**M2Y72**	**M2SS**	**SSY72**	**SE**	**Haus**	**RESET**	**LM**	**Auto**	***F*-stat**
(9)	.1E-05	0.080	0.332	0.029	0.031	0.008	0.004	-.1E-04	0.006	-0.013	.1E-04	-0.004	.7E-05	.74	13.04	**2**: 0.28	0.72	**1**: 3.24	-
	4.02**	0.62	4.76**	0.16	3.18**	3.62**	0.41	-6.13**	3.38**	-2.05*	5.59**	-0.93	1.73†	0.090		**3**: 0.19		**2**: 5.61	-
(10)	.1E-05	0.080	0.347	-	0.031	0.007	-	-.1E-04	0.006	-0.014	.1E-04	-0.003	.7E-05	.74	12.26	**2**: 0.23	0.73	**1**: 3.68	*(2,1629)*
	4.01**	0.70	6.11**	-	3.28**	3.65**	-	-6.18**	3.48**	-2.81**	5.60**	-1.64†	1.92†	0.090		**3**: 0.15		**2**: 5.43	0.06
Eq.	**Y72**	**K**	**M2**	**PE**	**K^2**	**$M2^2$**	**PE^2**	**KY72**	**KM2**	**KPE**	**M2Y72**	**M2PE**	**PSY72**	**SE**	**Haus**	**RESET**	**LM**	**Auto**	***F*-stat**
(11)	.1E-05	0.130	0.430	-1.152	0.022	0.006	-0.021	-.1E-04	0.007	-0.013	.1E-04	0.004	.1E-05	.74	12.25	**2**: 0.93	0.96	**1**: 1.58	-
	4.08**	1.15	7.33**	-1.20	2.47*	3.02**	-2.47*	-5.81**	3.69**	-2.51*	5.63**	1.69†	0.51	0.089		**3**: 0.94		**2**: 2.66	-
(12)	.1E-05	0.143	0.436	-0.159	0.021	0.006	-0.022	-.1E-04	0.007	-0.012	.1E-04	0.005	-	.74	12.26	**2**: 0.17	0.96	**1**: 2.01	*(1,1628)*
	4.05**	1.28	7.52**	-1.27	2.44*	3.03**	-2.61**	-5.78**	3.66**	-2.47*	5.74**	1.82†	-	0.090		**3**: 0.12		**2**: 3.69	0.20

Notes: A constant term is included in all regressions.

Figures in parentheses are *t*-statistics. ** significant at the 1% level; * significant at the 5% level; † significant at the 10% level.

a ***The Hausman test*** is distributed as a c^2 statistic and the critical values at 10 df.=18.31; at 11 df.=19.67; at 12 df.=21.03; at 13 df.=22.36.

b ***Test of functional form***: RESET tests were carried out by including the square (2) and the cube (3) of the predicted values of each regression as additional explanatory variables. F values are reported above for the tests of the (joint) significance of the additional regressor(s). The critical value at the 5% level of the squared parameter (2)=3.75 and the cubed parameter (3)=3.00.

c ***Test for Heteroskedasticity***: The LM test is distributed as a c^2 statistic. The critical value at 82 df=104.14.

d ***Test for Serial Correlation***: The Breusch-Godfrey LM test is distributed as a c^2 statistic. At the 5% level, the critical value at 1 df.=3.84; at 2 df.=5.99.

e ***F-Test***: The critical value at the 5% level for *F*(1,1628)=3.75; *F*(2,1629)=3.00; *F*(3,1630)=2.60.

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