E C O N O M I C S   B U L L E T I N

Is the Financial Development and Economic Growth Relationship Nonlinear?

Elena Ketteni
University of Cyprus

Theofanis Mamuneas
University of Cyprus

Andreas Savvides
Oklahoma State University

Thanasis Stengos
University of Guelph

Abstract

Using nonparametric estimation techniques we find that, in contrast to recent research, the finance-growth relationship is linear when the previously documented nonlinearity between initial per capita income, human capital and economic growth is taken into account.

Citation: Ketteni, Elena, Theofanis Mamuneas, Andreas Savvides, and Thanasis Stengos, (2007) "Is the Financial Development and Economic Growth Relationship Nonlinear?." *Economics Bulletin,* Vol. 15, No. 14 pp. 1-12
Submitted: April 27, 2007. **Accepted:** July 24, 2007.
URL: http://economicsbulletin.vanderbilt.edu/2007/volume15/EB-07O10010A.pdf

1 Introduction

In this paper we examine whether and how financial development (as measured by a number of indicators of financial intermediary development) influences economic growth. We use both parametric and nonparametric econometric techniques to establish whether financial development is a significant determinant of economic growth and whether the relationship is linear or nonlinear. We apply both techniques to investigate the consistency, under different frameworks, of the result that a significant positive relationship exists between financial development and growth, as well as to investigate the linear/nonlinear nature of the finance-growth relationship. A substantial literature demonstrates a strong positive link between financial development and economic growth and also that financial development is a good predictor of future economic growth, see King and Levine (1993a, 1993b), Levine, Loayza and Beck (2000), Beck, Levine and Loayza (2000), Benhabib and Spiegel (2000), Loayza and Ranciere (2005).

All the above studies rely on a framework that assumes a linear finance - growth relationship. More recent studies have challenged the linearity assumption and they seem to suggest that the relationhsip between financial development and economic growth is nonlinear. They examine the existence of a threshold in the finance-growth relationship either by imposing an exogenous threshold in an *ad hoc* fashion as in Rioja and Valev (2004a, 2004b), or an endogenous threshold technique as in Deidda and Fattouh (2002) but one, nonetheless, that imposes a specific (linear) functional form for the relationship above and below the threshold. In addition, some of the papers that find either a linear or nonlinear relationship between growth and financial development ignore previous research that has shown that a nonlinear relationship exists between economic growth and two of its determinants: initial income and human capital (as measured by mean years of schooling), see Kalaitzidakis *et al.* (2001) and Mamuneas *et al.* (2006).

In this paper we employ a general nonparametric framework that allows all three determinants of economic growth (per capita income, human capital and financial development) to be treated nonlinearly and provides specification tests for choosing amongst alternative models. Our findings reveal that the financial intermediary index has a *linear* effect on growth only when we account for the nonlinearity between initial income and human capital, on the one hand, and economic growth, on the other. On the contrary, if the nonlinearity of initial income and human capital is not taken into account, the finance-growth relationship appears to be nonlinear. Overall, our results predict that better functioning financial intermediaries accelerate economic growth.

The rest of the paper is organized as follows. The next section presents the methodology. Section 3 presents the results from the nonparametric framework as well as specification tests for the validity of alternative models. The correct specification is then estimated to establish whether financial intermediary development promotes growth.using a dynamic panel GMM.estimator.

2 The Model and Methodology

In order to provide tractability and to overcome the so-called "curse of dimensionality", nonparametric regression techniques typically impose some structure on the functional form to be estimated. Based on the literature on nonlinearities and economic growth, see Kalaitzidakis *et al.* (2001) and Liu and Stengos (1999), we employ a particular version of the semiparametric partially linear (PLR) model that allows for additive semiparametric components. In this way, one can obtain graphical representations of the nonparametric components. These graphs can shed light into nonlinearities and can be used as a guide to a more suitable parametric specification. Consider the following semiparametric PLR specification model (where time and country subscripts have been omitted for clarity of presentation):

$$y = x\beta + \theta(z) + \epsilon \tag{1}$$

where y is the rate of economic growth, x and z are the determinants, of dimension q and p respectively, of the rate of economic growth and β and θ are a parameter and an unknown functional form, respectively, to be estimated and $E(\epsilon/x, z) = 0$.

In this paper, we are interested in the determinants of economic growth that belong to the linear component, x, and those to the unknown nonlinear component, $\theta(z)$. Using a Kernel based approach, see Robinson (1988) we can obtain an estimate of β, call it $\hat{\beta}$ that has a parametric rate of convergence (*square-root-n)*. Once we obtain the estimate of β, then the redefined variable $y - x\widehat{\beta}$ can be regressed on z nonparametrically using kernel techniques to obtain an estimate of the unknown function $\theta(.)$. If one wants to uncover the shapes of the individual components of z (in order to investigate whether nonlinearities exist) it is necessary to impose more structure on the equation to be estimated by assuming an additive structure on the unknown components.

For the growth regression model in (1) we allow several variables ($z\prime s$) to enter nonlinearly including the variable of interest - financial development - as well as initial income and average years of schooling (a measure of human capital) to enter nonlinearly. In general, the additive semiparametric PLR model can be written as:

$$y_i = x_i\beta + \theta(z_{1i,}z_{2i,..,}z_{pi}) + \varepsilon_i = x_i\beta + \sum_{s=1}^{p}\theta_s(z_{si}) + \varepsilon_i \quad i = 1, .., n. \tag{2}$$

Linton and Nielsen (1995) use marginal integration to estimate the components of the additive semiparametric partially linear regression PLR) model in (2). Applying marginal integration to the additive semiparametric PLR model leads to the result that the asymptotic distribution of $(\widehat{\theta}_s(z) - \theta_s(z)$, $s = 1, .., p)$ is the same as if the other components $\theta_l(.)$ for $l \neq s$ and β were known.

3 Estimation and Empirical Results

We have obtained data from Levine *et al.* (2000) for a panel of 74 countries from 1961-1995 and the data are averaged over 5-year intervals, so that there is a maximum of seven observations per country.[1] Similar data have been used by Rioja and Valev, thus ensuring direct comparability of our results. The data include the following: the growth rate of real per capita gross domestic product (the dependent variable), initial income per capita ($Initial$), government size (Gov), openness to trade ($Trade$), inflation (Pi), human capital (Sec), the black market premium (Bmp) and three indicators of financial development. The three indicators are: (i) *Liquid Liabilities* (Lly): liquid liabilities of the financial system (currency plus demand and interest-bearing liabilities of banks and non bank financial intermediaries) divided by GDP as a measure of financial depth and the overall size of the financial intermediary sector; (ii) *Commercial-Central Bank* ($Btot$): the ratio of commercial bank assets divided by commercial plus central bank assets;

[1] Our data set differs slightly from Levine *et al.*: they include 359 observations and our data set includes 363.

(iii) *Private credit* (*Privo*): the value of credit by financial intermediaries to the private sector divided by GDP.

We begin our analysis by considering the additive semiparametric PLR model of equation (3) that allows three variables as nonlinear determinants of economic growth: the logarithm of initial per capita income (z_1), human capital (z_2) , and, the focus of our study, the logarithm of the financial intermediary index (z_3).[2] We use instrumental variables to compute the exogenous component of the financial development index to counter the possible endogeneity between financial development and growth. The instruments are the same as in Levine, Loayza and Beck. The other explanatory variables are included in the linear part of the model ($x_i\beta$). All the explanatory variables in the linear part of the model are in logarithmic form and we introduce time dummies for each of the periods 1971-75, 1976-80, 1981-85, 1986-90, 1991-95.

The model under consideration ca deal effectively with an unbalanced dataset because the estimation is taking place for each observation using Kernels. For estimation purposes we have used the Gaussian kernel. The choice of bandwidth is given by $c \times s_{Z_i} \times n^{-1/5}$, where s_{Z_i} $(i = 1, 2, 3)$ is the standard deviation of z_i, c is a constant, and n is the number of observations. We used cross-validation to select the value of c in the range 0.8 to 2.0.

Figure 1 shows the shapes of the relationship between economic growth and initial income (z_1), human capital (z_2), and private credit (z_3). In each graph, 95% confidence bands and the linear benchmark are also presented. The first graph shows that, in accordance with previous studies, the logarithm of initial income has a nonlinear effect on economic growth. In addition, the relationship between growth and average years of secondary schooling is nonlinear (second graph). Noting the linear benchmark and the confidence bands, nonlinearities in the relationship do appear in countries with relatively high levels of secondary schooling (high levels of human capital). The third graph shows that private credit has a positive effect on economic growth. The graph shows that the relationship between economic growth and private credit is linear because the linear benchmark falls entirely within the 95 percent confidence bands.

Based on our graphical analysis we conclude that the appropriate speci-

[2] To conserve space the results presented and discussed in this paper use private credit as the index of financial development. Similar results are obtained with the other two indices and are available from the authors.

fication of the growth model should be one where initial income and human capital have a nonlinear effect on economic growth, while the financial index has a linear (and positive) effect on growth. Previous studies have also established a nonlinear effect of initial income per capita and human capital, see, for instance, Kalaitzidakis *et al.* (2001) and claim that the nonlinear relationship between initial income and growth can be modelled as a fourth degree polynomial and the nonlinear relationship between human capital and growth as a third degree polynomial. We verify this assertion when we reestimate the model to include only initial income (z_1) and human capital (z_2) in the nonlinear part of equation (2). The estimated coefficients (along with t-statistics) of the linear part of this semiparametric PLR model are shown in the first two columns of Table 1. The graphs of the nonlinear component (initial income and human capital) are in Figure 2.

Semiparametric estimation shows that the financial index has a significant, positive, and linear effect on economic growth when we allow for possible nonlinear effects of initial income and human capital on economic growth. Previous research that claims to have found nonlinearities between financial development and growth, see Rioja and Valev (2004a, 2004b), have ignored nonlinearities between initial income/human capital and growth. To investigate further this point, we purposely misspesify the model to include in the nonlinear part of equation (2) only one variable, the financial index, considering the other two variables (initial income and human capital) as components of the linear part of the model. This result is in Figure 3. In this case the relationship between finance and growth appears to be nonlinear, except for a small range of observations in the middle of the distribution, the linear benchmark lies almost entirely outside the confidence intervals. The nonlinearities occur in countries with high and low levels of financial development. The positive effect of financial development on growth in the middle-region countries (based on level of financial development) is in accordance with the findings of Rioja and Valev (2004a).

3.1 Specification Tests

In order to verify the appropriate specification of the financial development-growth relationship we perform, first, a specification test proposed by Li and Wang (1998). It tests the null hypothesis of a linear regression model against a PLR alternative formulation, as in Robinson (1988). The value of the test statistic is 1.98 and therefore the null of a parametric specification is rejected. This implies that some nonlinearities do exist in the model and should be taken into account. We proceed to test for a partially linear specification conditioned on two variables, initial income and secondary schooling, and where financial development enters linearly, against a general nonparametric alternative. This test is used in order to establish whether this model is appropriate when compared to the more general one that conditions upon three explanatory variables i.e. one that includes nonlinearly the financial intermediary index as well initial income and secondary schooling. The valued of the test statistic is 0.78 giving support to the null hypothesis of a partially linear specification (semiparametric model conditioned on initial income and human capital) cannot be rejected against the alternative. Interaction terms between variables under investigation may play an important role in explaning economic growth and should be included in the nonparametric framework. We have included a product term between z_i and z_j as a regressor in the linear part of equation (2) to test for possible interactions among the z variables. The interaction term was insignificant in every case[3]. This provides further verification that the assumption of separability is valid.

The results from these specification tests are consistent with the graphical analysis: the appropriate specification for the financial development-economic growth relationship is one that considers human capital and initial income as the variables that affect economic growth in a nonlinear manner, while financial development enters linearly. Having established the appropriate specification of the model, we proceed to estimate the effects of financial development on economic growth using parametric techniques.

3.2 Parametric Results

We use the graphical representations of the two nonparametric components in Figure 2 as a guide to a more satisfactory parametric specification of the growth regression. Following Kalaitzidakis et al (2001) we have augmented the linear parametric growth equation in Levine, Loayza and Beck (2000) with a fourth degree polynomial in initial income and a cubic polynomial in mean years of schooling. The results are in Table 1.

[3] The t-statistics obtained when the product term between z_i and z_j was used as a regressor in the equation were 0.38 for $z_1 z_3$, -1.16 for $z_2 z_3$ and 1.05 for $z_1 z_2$.

For comparison purposes, in Table 1 we present results from two parametric models: the linear model of Levine, Loayza and Beck (2000) (columns 3 and 4) and the nonlinear model (columns 5 and 6). Both models are estimated using the GMM dynamic panel estimator of Arellano and Bond (1991). For both models the Sargan test for instrument adequacy and a serial correlation test are computed ($p-$values of all the tests are reported in Table 1). The tests show no evidence of second order serial correlation and also show that the instruments used are appropriate.

The nonlinear model shows that all the nonlinear coefficients for initial income and secondary schooling are significant. A Wald test (z_1, z_2 nonlinear vs linear) rejects the linear model in favor of the nonlinear one. Therefore, estimation results, both from parametric and nonparametric estimation, confirm a strong, significant, positive and linear relationship between financial development and economic growth; on the other hand, the relationship between growth and initial income and human capital is nonlinear. As a final check on our results we have tested the preferred nonlinear parametric specification against first a parametric model where initial income, human capital and the financial index enter nonlinearly (z_1, z_2, z_3 nonlinear vs z_1, z_2 nonlinear) and second a parametric model where only the financial index enters nonlinearly (z_1, z_2 nonlinear vs z_3 nonlinear). The p-values of the two Wald tests are reported in the last two rows of Table 1: clearly our preferred specification cannot be rejected against the alternatives.

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Table 1: Estimation Results

(Dependent variable: GDP growth; t-statistics in parenthesis)

	Semiparametric		*Parametric (GMM)*			
			Linear		Non-Linear	
Constant	1.111	(5.85)	4.723	(4.92)	412.17	(3.50)
Gov	-0.211	(-0.50)	-1.373	(-5.63)	-0.078	(-0.84)
Trade	0.042	(0.18)	0.212	(1.98)	0.854	(4.88)
Pi	-2.548	(-3.27)	-1.274	(-4.21)	-2.462	(-4.97)
Bmp	-1.046	(-3.20)	-0.741	(-8.54)	-0.460	(-3.10)
$D71-75$	-0.495	(-1.32)	-1.012	(-12.38)	-0.734	(-7.07)
$D76-80$	-0.670	(-1.63)	-1.152	(-7.83)	-0.785	(-4.27)
$D81-85$	-2.397	(-6.61)	-3.039	(-18.49)	-2.926	(-11.73)
$D86-90$	-1.430	(-4.07)	-2.182	(-15.90)	-1.889	(-8.15)
$D91-95$	-1.894	(-5.08)	-2.791	(-17.42)	-2.445	(-8.89)
Privo	0.811	(3.62)	1.608	(14.76)	1.493	(8.87)
Sec			0.127	(1.62)	1.383	(2.96)
$(Sec)^2$					-1.249	(-2.72)
$(Sec)^3$					0.261	(2.93)
Initial			-0.363	(-2.92)	-216.0	(-3.93)
$(Initial)^2$					40.63	(3.85)
$(Initial)^3$					-4.316	(-3.72)
$(Initial)^4$					0.134	(3.53)
Tests (p-value)						
Sargan				0.537		0.336
Serial Correlation				0.520		0.741
Wald test (z_1, z_2 nonlinear VS linear)						0.000
Wald test (z_1, z_2, z_3 nonlinear VS z_1, z_2 nonlinear)						0.531
Wald test (z_1, z_2 nonlinear VS z_3 nonlinear)						0.000

All variables are in logarithms except *Sec*. Also *Pi* and *Bmp* are defined as $ln(1+variable)$.

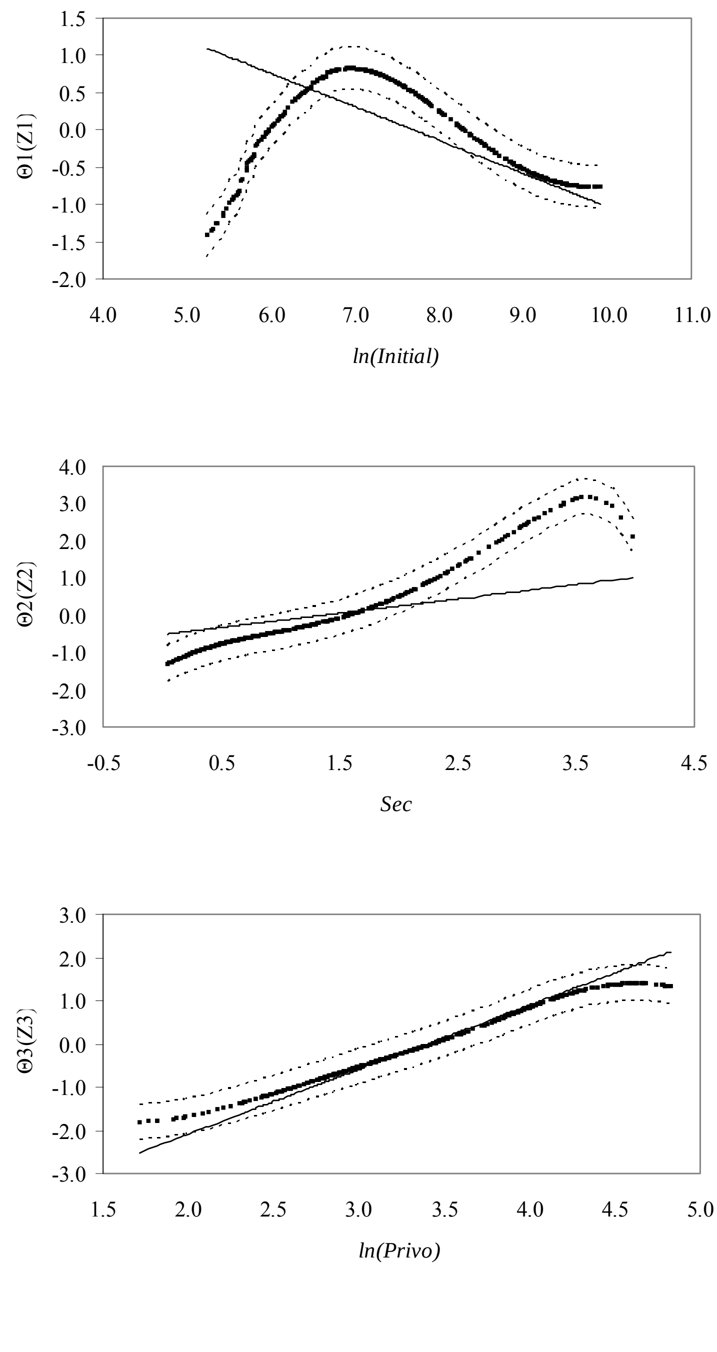

Figure 1: Model conditioned on initial income, human capital and private credit

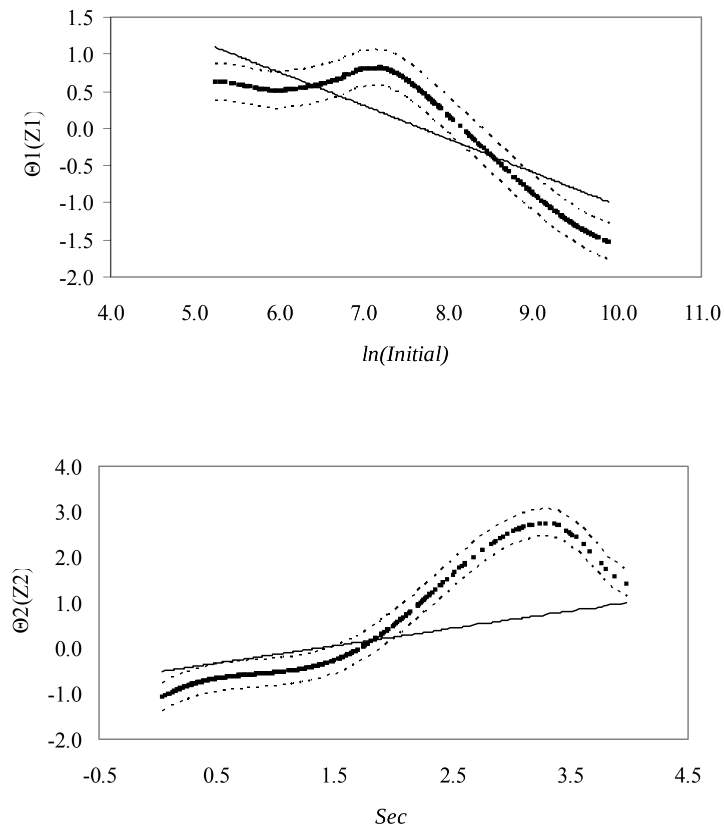

Figure 2: Model conditioned on initial income and human capital

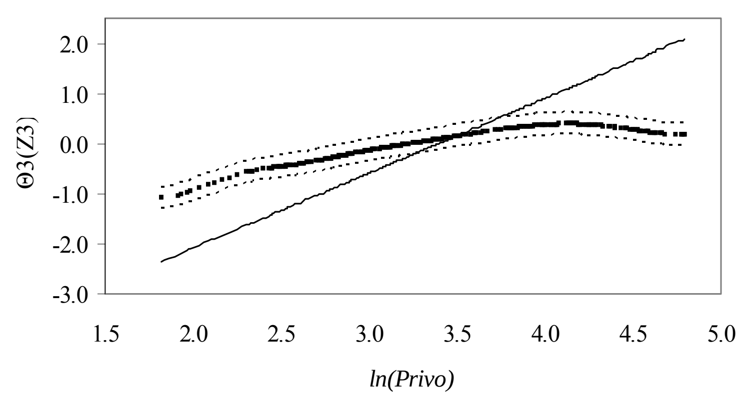

Figure 3: Model conditioned on private credit