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Threshold Effects in the Relationship Between Inflation and Growth: A New Panel-Data Approach*

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Abstract

In this paper we use a new approach to throw light on the old question of the super-neutrality of money. Recent theoretical results suggest a threshold model instead of super-neutrality. To ascertain whether or not there is a threshold level of inflation above which the effect of inflation on long-run growth changes, we apply new econometric methods for estimation and inference in non-dynamic, fixed-effects, panel-data models that may contain threshold effects.

In the full sample of 138 countries over the period 1950–2000, we find that there is one threshold that is well identified by the data; the estimated value of the threshold is 19.16%. For the industrialized sample, our results indicate that there are two threshold points at 2.57% and 12.61%. In the full sample, if the initial inflation rate is below 19.16%, increases in inflation do not have a statistically significant effect on growth. In contrast, when the initial inflation is above 19.16%, further increases in inflation will decrease long-run growth.

Keywords: threshold model, nonlinear model, empirical growth, super-neutrality, panel data
JEL Codes: C23, E31, O42, O57

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The recent theoretical literature has begun to ask an old question in a new way; is money super-neutral for all possible levels of initial inflation, or is there a threshold level of inflation, above which money is not super-neutral? Our application of new panel-data techniques to standard datasets provides evidence that the last question should be answered affirmatively.

Many of the theoretical models in the money and growth literature analyze the impact of inflation on long-run growth. There are four principal predictions in the literature regarding the impact of inflation on output and growth.

1. The prediction that there is no effect of inflation on growth (money is super-neutral) was first established by (Sidrauski 1967) when he showed that money is neutral and super-neutral in an optimal control framework with money in the utility function.
2. (Tobin 1965) assumed that money is a substitute for capital, causing inflation to have a positive effect on long-run growth.
3. (Stockman 1981) presented a cash in advance model in which money is complementary to capital, causing inflation to have a negative effect on long-run growth.
4. There is a new class of models in which inflation has a negative effect on long-run growth, but only if the level of inflation is above a threshold level. In this class of models, financial market efficiency is affected by various informational asymmetries, as in (Huybens and Smith 1998), for example. In these models, high rates of inflation typically exacerbate financial market frictions, interfere with the efficiency of the financial system, and thus inhibit growth.

In this paper we provide evidence that there is a threshold level of inflation above which the effect of inflation is negative and statistically significant, and we interpret this result as supporting prediction 4. We apply new econometric techniques due to (Hansen 1999) and (Gonzalo and Pitarakis 2002) to estimate the number of threshold points, their values and their coefficients and

perform inference about whether or not these effects could be attributed to sampling error. We overcome the limitation to balanced panels¹ by applying our own insight that we can use a cluster bootstrap to obtain the standard errors of the parameters in the model.

We use an unbalanced panel with data for 138 countries for the period 1950–2000. As is standard in the empirical growth literature, we use averaged data for half-decades that do not overlap.

The remainder of the paper is organized as follows. In Section I we briefly discuss previous empirical studies on inflation thresholds and on economic growth. In Section II we describe our empirical specification, our procedures for estimation and inference, and the dataset that we use. In Section III, we present our results. Finally, in Section IV we present the main conclusions of our study and discuss future extensions of this line of research.

I The Empirical Literature

In this section, we briefly discuss previous empirical studies that focus on inflation thresholds and on economic growth.

A The Empirical Literature on Inflation Thresholds

The seminal work by (Fischer 1993) is among the first to examine the possibility of nonlinearities in the relationship between economic growth and inflation in the long run. Using both cross section and panel data for a sample that includes both developing and industrialized countries, Fischer’s parameter estimates indicate a negative relationship between inflation and growth. Interestingly, by using (arbitrarily chosen) break points of 15% and 40% in spline regressions, Fischer shows not only the presence of nonlinearities in the relationship between inflation and growth, but also that

¹(Hansen 1999) uses a wild-bootstrap method for inference in balanced panels. The balanced panel assumption is not necessary in the cluster bootstrap.

the strength of this relationship weakens for inflation rates above 40%.² One weakness of Fischer's study is the arbitrary nature of the sample splitting, a weakness that our approach overcomes.

In the time-series literature, (Bullard and Keating 1995) use a structural vector autoregression to estimate the response of real output to permanent inflation shocks for each country in a sample of 16 countries. Looking at their results, from a cross-sectional point of view, indicates the the presence of the following nonlinear relationship. Increases in long-run inflation have a positive (negative) effect on long-run output for sufficiently low (high) initial levels of inflation.

Finally, closer to our line of work, (Khan and Senhadji 2001) estimate the threshold level of inflation by using a balanced panel that averages time-series data over nonoverlapping half decades. The authors estimate the threshold level of inflation, above which inflation significantly slows growth, to be between 0.89% and 1.11% for industrialized countries, and between 10.62% and 11.38% for developing countries. The negative and significant relationship between inflation and growth, for inflation rates above the threshold level, is quite robust with respect to the estimation method, perturbations in the location of the threshold level, the exclusion of high inflation observations, data frequency and alternative specifications. But their results are difficult to interpret because their specification does not fit into the class of models pioneered by (Hansen 1999, Hansen 2000).³ This implies that Hansen's methods of inference do not necessarily apply. Moreover, they do not use the model selection methods derived by (Gonzalo and Pitarakis 2002), which allow one to select the number of threshold points without incurring a multiple testing problem.

²See also (Sarel 1996), and (Ghosh and Phillips 1998). For higher frequency data see (Bruno and Easterly 1998), and (Faria and Carneiro 2001).

³(Khan and Senhadji 2001) use a functional form that is continuous at the threshold point, but this specification does not fit directly into the (Hansen 1999, Hansen 2000) framework.

B The Empirical Literature on Economic Growth

Traditional and augmented cross-sectional analyses focus on conditional convergence and suffer from a striking lack of attention to nonlinear alternatives to the neoclassical growth model. While this paper does not aim to study cross-country convergence, the results therein indicate that inflation may have a nonlinear effect on growth.

While the panel-data approach provides greater flexibility, thereby reducing potential misspecifications, it also complicates the interpretation in terms of conditional convergence. This change in interpretation is not a problem for this paper, because we do not aim to study cross-country convergence. Rather, we simply want to know whether or not, inflation has a nonlinear effect on growth, after removing cross-country heterogeneity,

As with all the papers in this literature that use nonoverlapping half-decade averages to approximate long-run behavior, our choice of bandwidth is driven by conventions in the literature. In an unpublished appendix, we report similar results that use four-year and six-year averages.

II Empirical Methodology

A The Empirical Specification and Econometric Methods

We estimate the coefficients and number of threshold points in the functional form specified in equation (1):

$$y_{it} = \mu_i + \nu_t + \sum_{p=0}^j \gamma_p d_{itp} \tilde{\pi}_{it} + x_{it} \beta + \epsilon_{it}, \quad (1)$$

where j is the number of threshold points, y_{it} denotes the percentage growth rate of country i at time t , μ_i denotes the level of country- i 's fixed-effect, ν_t is the level of time- t 's fixed-effect, γ_p is the coefficient on the semi-log transform of inflation of country i at time t ($\tilde{\pi}_{it}$) in region p , d_{itp} is the indicator variable for region p , x_{it} is a vector of other covariates, β is a vector of coefficients on

x_{it} , and ϵ_{it} is a zero mean, finite variance, i.i.d. disturbance that is orthogonal to the covariates and the threshold variable.⁴

When $j = 0$, equation (1) reduces to the well-known linear fixed effects (FE) model, but, when $j \geq 1$, this specification is nonlinear in the semi-log of inflation. To see these points, note that the threshold-region indicator variable is

$$d_{itp} = \begin{cases} 1 & \text{if } \tilde{\pi}_p^* < \tilde{\pi}_{it} \leq \tilde{\pi}_{p+1}^* \\ 0 & \text{otherwise} \end{cases} .$$

where $\tilde{\pi}_0^* = -\infty$, $\tilde{\pi}_{j+1}^* = \infty$ are the endpoints, and $\tilde{\pi}_p^*$, $p \in \{1, 2, \dots, j\}$, are the j threshold points.⁵

The fact that some observations have negative inflation rates prohibits using the log of inflation. For this reason, we use the semi-log transform of the inflation rate π_{it} given by

$$\tilde{\pi}_{it} = \begin{cases} \pi_{it} - 1 & \text{if } \pi_{it} \leq 1 \\ \ln(\pi_{it}) & \text{if } \pi_{it} > 1 \end{cases} .$$

A specification with j threshold points defines $j+1$ distinct regions over the inflation rate space and requires the estimation of and inference about the $j+1$ coefficients γ_p , and the j threshold points $\tilde{\pi}_q^*$.⁶ Treating the fixed effects as nuisance parameters implies that the parameters of interest are the number of threshold points j , the $j+1$ coefficients γ_p , the j thresholds $\tilde{\pi}_q^*$, and the vector β .

If the true number of threshold points and their values were known, equation (1) would be a linear panel-data model with two-way fixed effects, and all the standard methods would apply.⁷

⁴The orthogonality condition (ii) of Assumption A2 in (Gonzalo and Pitarakis 2002) is satisfied when each covariate in x_{it} and the generated covariates $d_{itp}\tilde{\pi}_{it}$ are strictly exogenous.

⁵When $j = 0$, there are no threshold points, only the endpoints remain.

⁶The linear FE model has zero thresholds and one region; a specification with one threshold point has two distinct regions, and so on.

⁷See (Baltagi 2001) and (Wooldridge 2001).

The lack of knowledge of the number of threshold points and their values complicates estimation and inference.

We apply the results of (Gonzalo and Pitarakis 2002) to estimate the number of threshold points (j). As in the time-series literature⁸, their method selects the model that minimizes the Bayesian information criteria (BIC).^{9,10}

The parameters of the models are estimated using the sequential estimation procedure derived by (Hansen 1999, Hansen 2000, Gonzalo and Pitarakis 2002).¹¹ (Drukker and Hernandez-Verme 2005) discuss the details of the estimation procedure and the computation methods.

Our empirical specification is discontinuous in inflation at the threshold point(s). This discontinuity implies that small changes in inflation, in a neighborhood of the threshold point, may have different effects depending on whether initial inflation is above or below the threshold. Intuitively, in the spirit of (Huybens and Smith 1998) and the related literature, non-convexities in the economy may create a situation in which an increase in inflation causes a discontinuous drop in per capita growth when initial inflation is just below the threshold point. Similarly, reducing inflation in a country with initial inflation just above the threshold value may cause a discontinuous jump in per capita growth.

As is standard in the empirical, panel-data, growth literature, our specification is based on five-year averages of the dependent variable and of the covariates of interest. This practice is conventional because it allows researchers to analyze the long-run relationships without having

⁸For time-series examples, see (Hannan 1979, Lütkepohl 1993)

⁹(Hansen 1999, Hansen 2000) developed a likelihood-ratio (LR) testing procedure. We use the (Gonzalo and Pitarakis 2002) method because it is applicable to unbalanced panels and it avoids the multiple testing problem that arises when choosing among zero, one and two thresholds using Hansen's LR test procedure.

¹⁰In a related paper, (Khan and Senhadji 2001) include the threshold point as part of their semi-log transform so that the model for growth is continuous at the threshold point. Their specification does not directly fit into the (Hansen 1999, Hansen 2000, Gonzalo and Pitarakis 2002) framework for estimation and inference.

¹¹These authors were building on advances made in the time-series literature by (Bai and Perron 1998, Bai and Perron 2003).

to specify the short-run dynamics.¹² Thus, in our particular case, the sub-index t refers to the half-decade t or, equivalently, the length of each period t is five years.

B Covariates and predicted signs of coefficients

The dependent variable y_{it} is the five-year arithmetic average of the annual percentage growth rate of the GDP per capita in country i during the half-decade t . We chose our covariates so that they would be similar to those used by other researchers.¹³ We define our vector of covariates as $x_{it} = (igdp_{it}, dpop_{it}, dtot_{it}, tot_sd_{it}, open_{it}, open_sd_{it})$.

In the cross-sectional growth literature, some of these variables are treated as endogenous and instrumental variables (IV) estimators are used. The methods used in this paper have not yet been extended to the case of instrumental variables. This paper assumes that any endogenous components are perfectly correlated with the fixed effects, and therefore controlled for by our fixed-effect estimation procedure.¹⁴

Recall that the subscript i indicates the country and the subscript t indicates the half-decade. Henceforth, to simplify the notation, we drop the subscripts from the names of the covariates. $igdp$ is the arithmetic average of the annual percentage of GDP dedicated to investment. $dpop$ is the arithmetic average of the percentage change in population. $dtot$ is the arithmetic average of the annual percentage change in the terms-of-trade. As is standard in the literature, $igdp$, $dpop$ and $dtot$ each have a linear effect on the growth rate of per capita GDP.

tot_sd is the semi-log transform of the standard deviation of the terms-of-trade during the half-decade.¹⁵ $open$ is the arithmetic average of the natural log of openness. Openness is measured as

¹²Below we discuss the results based on five-year averages. In an unpublished appendix, we discuss the results based on four-year and six-year averages. Changing the window size for the average does not change any of the fundamental results.

¹³For the purpose of comparability, our choice of covariates is similar to the one used by (Khan and Senhadji 2001) for the open economy case, and (Islam 1995) for the closed economy case.

¹⁴While we plan to use IV methods in future research, the regression results reported here are an important baseline against which future IV results can be compared.

¹⁵As discussed in (Heston, Summers and Aten 2004), the terms-of-trade index is relative, with the base of 100

the share of exports plus imports in the GDP. Finally, *open_sd* is the natural log of the standard deviation of openness during the half-decade. *tot_sd*, *open* and *open_sd* each have a multiplicative effect on the growth rate of per capita GDP.

Although the threshold(s) and the semi-log transform of inflation complicate the computation of the marginal effect of inflation on long-run growth, the monetary-theory literature generates at least two interesting hypotheses about the γ_p coefficients. First, the null hypothesis that money is super-neutral can be investigated by testing whether all the γ_p are zero. Second, suppose that there is a single threshold point.¹⁶ In this case, evidence that $\gamma_0 \geq 0 > \gamma_1$, with γ_1 statistically significant would support the hypothesis of a nonlinear effect of inflation on long-run per capita growth in accordance with the theory in (Huybens and Smith 1998). The latter case would also provide evidence against the super-neutrality of money.

Defining the vector β as $\beta' = (\beta_{igdp}, \beta_{dpop}, \beta_{dtot}, \beta_{tot_sd}, \beta_{open}, \beta_{open_sd})$ simplifies the notation. Thus, β_{igdp} is the coefficient on *igdp*, β_{dpop} is the coefficient on *dpop*, β_{dtot} is the coefficient on *dtot*, β_{tot_sd} is the coefficient on *tot_sd*, β_{open} is the coefficient on *open* and β_{open_sd} is the coefficient on *open_sd*. Below we describe the interpretation of each one of these coefficients as well as their predicted signs.

The coefficient β_{igdp} indicates that an increase (decrease) of one point in the percentage of GDP dedicated to investment would result in an increase (decrease) of β_{igdp} points in the percentage growth of GDP per capita. The standard growth model would predict that $\beta_{igdp} > 0$. From a theoretical standpoint, there is no obvious reason to expect different coefficients when comparing industrial versus developing countries.

for the United States (US). This implies that the standard deviation of the terms-of trade for the US during a half-decade is always zero. But the univariate distribution of the five-year standard deviation of the terms-of-trade series indicated that a log specification was preferable to a level specification. To avoid dropping the US from the sample the same semi-log transform used for inflation was used to create *tot_sd*.

¹⁶There are more elaborate versions of this hypothesis for models with multiple threshold points, but the issue is much clearer in the case of a single threshold point.

An increase (decrease) of one point in the percentage growth rate of the population reduces (increases) the percentage growth rate of GDP per capita in β_{dpop} points. The standard growth model would predict that $\beta_{dpop} < 0$. However, some studies¹⁷ have observed the potential problem of endogeneity in this covariate, which could lead to evidence of $\beta_{dpop} \leq 0$, after controlling for fertility rates. However, the latter studies are cross-sectional in nature. We do not explicitly control for fertility in this paper because this series is not available as a time series with the frequency that we need.¹⁸

$dtot$ measures long-run changes in the real exchange rate, and standard trade theory would predict $\beta_{dtot} \leq 0$. tot_sd measures volatility in the terms-of-trade or the real exchange rate, and one would predict that $\beta_{tot_sd} < 0$.

With respect to the level of openness, while many theoretical models predict $\beta_{open} > 0$, many empirical studies have found it to be negative. Finally, in so far as $open_sd$ measures volatility in a country's commitment to a level of openness, standard theory would predict $\beta_{open_sd} < 0$.¹⁹

C Data

As discussed above, we use data from two different sources: the Penn World Tables 6.1²⁰ and the International Financial Statistics. From the Penn World Tables, we start with an unbalanced panel of 174 countries. This panel contained information for GDP per capita and the covariates, except inflation, for the period 1950 to 2000.²¹ For the same time span, we obtained data for the inflation rate for a sample of 149 countries from the International Financial Statistics.²² After

¹⁷See (Barro and Lee 1994) for an example.

¹⁸The country level FE control for fertility rates to the extent that they vary over countries but not time.

¹⁹Frequent changes in rules may reduce the expected returns to foreign investment and to domestic investment in exports. The fall in returns reduces the optimal level of foreign investment and diverts domestic investment to less productive sectors, thereby lowering growth.

²⁰The official citation of this dataset is (Heston, Summers and Aten October 2002).

²¹The series used for GDP per capita is the one reported in constant prices, Laspeyres' index in the Penn World Tables 6.1. Similarly, we used investment as a share of the GDP in current prices, population, openness in current prices and the price level of GDP.

²²The official citation for this dataset is (*International Financial Statistics* 2004).

first-differencing variables and matching the information from the aforementioned sources, we were left with an unbalanced panel of 138 countries.²³

As discussed above, in order to focus on long-run effects, we followed a procedure frequently used in the literature, which begins by partitioning each time series into nonoverlapping half-decade intervals. By including 2000 into the last of half-decades, we have 10 potential half-decade intervals.²⁴ After forming the partitions, we average the available data inside these half-decades into a single observation, creating an unbalanced panel of 916 observations from 138 countries.²⁵

As is standard in the empirical growth literature, we were interested in checking whether our results are similar for the industrialized and nonindustrialized countries in our sample. We use the IFS definition of industrialized countries.²⁶

III Results

Table 1 presents the model selection results for the three different samples. Models with one threshold point were selected for the full and nonindustrialized samples, while a two threshold-point model was selected for the industrialized sample. The fact that the linear FE model was not selected in any of the three samples is strong evidence in favor of the presence of at least one threshold.

Table 2 presents the estimates of the thresholds and the γ_p coefficients for all the different models and samples. The number in parentheses under the estimates of the γ_p coefficients, is the

²³The countries lost are Antigua, Azerbaijan, Bahamas, Bahrain, Belarus, Bermuda, Bhutan, China, Comoros, Cuba, Djibouti, Equatorial Guinea, Eritrea, Guinea, Iraq, Kuwait, Laos, Lebanon, Liberia, Mongolia, Oman, Puerto Rico, Qatar, Russia, Sao Tome and Principe, Saudi Arabia, Somalia, Sudan, Suriname, Taiwan, Tajikistan, Turkmenistan, Ukraine, United Arab Emirates, Uzbekistan and Yugoslavia

²⁴The intervals are 1950-1954, 1955-1959, 1960-1964, 1965-1969, 1970-1974, 1975-1979, 1980-1984, 1985-1989, 1990-1994, and 1995-2000.

²⁵In the estimations discussed below, we do not weight the observations to account for the unbalanced nature of the averages.

²⁶By this definition, the industrialized countries, for the years in our sample, are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

Table 1: Model selection for the original Specification

Sample	No. of thresholds	SSR	Parameters	BIC
Full	0	5063.7	154	9.676456
Full	1	4972.2	155	9.665663
Full	2	4935.6	156	9.665708
Full	3	4917.6	157	9.669506
Industrialized	0	341.5	39	6.768816
Industrialized	1	324.7	40	6.742298
Industrialized	2	311.2	41	6.723658
Industrialized	3	303.9	42	6.723983
Nonindustrialized	0	4625.3	131	9.680327
Nonindustrialized	1	4544.9	132	9.672248
Nonindustrialized	2	4508.9	133	9.673775
Nonindustrialized	3	4466.0	134	9.673703

number of observations in that threshold region.²⁷ Note that the estimates of the threshold points for the industrialized sample are smaller than their counterparts for the full and nonindustrialized samples. Inverting the semi-log transform produces the level estimates of 19.16% for the single threshold-point model in the full and nonindustrialized samples. The level estimates for the industrialized sample are 12.61% for the one threshold-point model and 2.57% and 12.61% for the two threshold-point model. All of the threshold regions contain strictly more observations than the minimum required by the estimation procedure.

Table 3 presents the point estimates and standard errors for the coefficients and threshold points. For the full and nonindustrialized samples, we report results for single threshold-point

²⁷The estimation procedure requires that there is a minimum number of observations between threshold points.

The results presented here require a minimum number of 15 observations between threshold points. In an unpublished appendix, we report estimates that enforce minimums of 10 and 20 observations. As is to be expected, using these two alternative minimums, changes some of the point estimates by small amounts, but all the model selection statistics remain the same, except that in the case of at least 10 observations, a two threshold-point model is selected for the full and nonindustrialized samples. Note that the linear FE model is not selected for any sample over all three cases of minimum observations.

Table 2: Threshold estimates

Sample	No. of thresholds	$\tilde{\pi}_1^*$	$\tilde{\pi}_2^*$	$\tilde{\pi}_3^*$	γ_0	γ_1	γ_2	γ_3
Full	0				-.20281 (916)			
Full	1	2.952739			.106364 (758)	-.296385 (158)		
Full	2	2.952739	3.061248		.078371 (758)	-.876014 (27)	-.275562 (131)	
Full	3	2.952739	3.061248	4.099721	.132461 (758)	-.814541 (17)	-.125527 (86)	-.330627 (55)
Industrialized	0				-.123496 (226)			
Industrialized	1	2.534730			.071569 (208)	-.419821 (18)		
Industrialized	2	0.945216	2.534730		1.14071 (49)	.110641 (159)	-.392363 (18)	
Industrialized	3	0.472216	0.945216	2.534730	-.236838 (20)	1.6281 (29)	.243785 (159)	-.283182 (18)
Nonindustrialized	0				-.198475 (690)			
Nonindustrialized	1	2.952739			.135708 (538)	-.271194 (17)	(135)	
Nonindustrialized	2	2.952739	3.061248		.10056 (410)	-.848798 (21)	-.250674 (107)	(152)
Nonindustrialized	3	2.413063	2.482869	2.952739	.012823	.92544	.15022	-.260373

Note: The number of observations in each threshold region is given in parentheses under the corresponding coefficient estimate. The total number of observations for sample is provided under the coefficient of the zero threshold-point model.

models. For the industrialized sample, we report results for a one threshold-point model and a two threshold-point model.²⁸ We used a cluster bootstrap with 2000 replications to estimate the standard errors.²⁹

That the full-sample estimate of γ_1 has the predicted signs and is statistically different from zero provides evidence in favor of the (Huybens and Smith 1998) model. More evidence in favor of this class of models is provided by the pattern in the estimates of the γ_p coefficients. In all the selected models, the estimates of γ_p are decreasing in p .

The signs of the coefficients on the covariates are in line with the theoretical predictions. It is worth highlighting that the estimates of the coefficients on both *open* and *open_sd* have the predicted signs and are statistically significant in the full and nonindustrialized samples.

The coefficient on *igdp* is positive and statistically significant for the nonindustrialized countries, as predicted by the neoclassical growth model. However, it is negative and insignificant for the industrialized countries.

IV Conclusions

In order to throw new light on the question of the super-neutrality of money, this paper applies new econometric techniques for estimation and inference in panel-data models with threshold effects to standard datasets. We find strong evidence that inflation has a nonlinear effect on growth.

In particular, our results support the newer theoretical work³⁰ in which inflation has a negative

²⁸We report results for both models to enable a more direct comparison of the coefficient estimates across samples.

²⁹In the cluster bootstrap, each country is a cluster, and each bootstrap sample draws uniformly over the clusters and selects whole clusters to be part of a bootstrap sample. Aside from the standard regularity conditions, treated in (Hansen 1999), this bootstrap method only requires independence over the clusters and is robust to within-cluster correlation.

³⁰For example, see (Huybens and Smith 1998).

Table 3: Coefficient Estimates

Coefficient	Full Sample	Industrialized 1	Industrialized 2	Nonindustrialized	H_0
igdp	.07869884* (.03298677)	-.0008136 (.06538358)	-.00786869 (.0612653)	.08546722 (.03601169)	$\beta_{igdp} > 0$
dpop	.04004897 (.44308504)	.56315732 (.54702438)	.49889868 (.52669043)	.01821566 (.51305887)	$\beta_{dpop} > 0$
dtot	-.04637448* (.02388336)	.01724174 (.03698134)	.01175966 (.04037888)	-.05022043* (.02644399)	$\beta_{dtot} > 0$
tot_sd	-.11291561 (.13827403)	-.46695158* (.18026063)	-.40730724* (.18754344)	-.05769045 (.1885233)	$\beta_{tot_sd} > 0$
open_av	1.341518* (.59568356)	.08480795 (1.2400415)	.39049208 (1.1075688)	1.5217344* (.66425252)	$\beta_{open} > 0$
open_sd	-.59122938* (.18920561)	-.47738841 (.22706086)	-.50857913 (.23575455)	-.64259756* (.2317477)	$\beta_{open_sd} > 0$
γ_0	.10636439 (.40851964)	.07156886 (1.0493123)	1.1407106 (1.1774337)	.13570771 (.41349783)	
γ_1	-.29638508* (.14238313)	-.41982096 (.42617385)	.11064136 (.74547128)	-.27119407 (.17292488)	
γ_2			-.39236268 (.37224348)		
$\tilde{\pi}_1$	2.952739* (.75821987)	2.5347304* (.70680222)	.9452157* (.26390206)	2.952739* (.76054499)	
$\tilde{\pi}_2$			2.5347304* (.57202002)		

effect on growth, but only after inflation reaches a threshold level. That the sign of the coefficient on investment differs between the industrialized and nonindustrialized subsamples, and that the coefficient on openness has a positive sign are interesting results. We are especially intrigued by the latter, since it is a standard theoretical result that has often eluded empirical researchers. In future research, we plan to investigate whether applying threshold techniques causes the estimate of the coefficient on openness to agree with standard theory in cases where it previously has not.

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