INFLATION, FINANCE, AND GROWTH: A TRILATERAL ANALYSIS

by

Peter L. Rousseau and Hakan Yilmazkuday

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Inflation, financial development, and growth: A trilateral analysis

Peter L. Rousseau [a, b], Hakan Yilmazkuday [a, *]

[a] *Department of Economics, Vanderbilt University, Box 1819 Station B, Nashville, TN, 37235 USA*

[b] *National Bureau of Economic Research, Cambridge, MA 02138, USA.*

Abstract

A large body of evidence links financial development to economic growth, yet the channels through which inflation affects this relationship and its stability have been less thoroughly explored. We take an econometric and graphical approach to examining these channels, and find that higher levels of financial development, combined with low inflation, are related to higher rates of economic growth, especially in lower-income countries, but that financial development loses much of its explanatory power in the presence of high inflation. In particular, small increases in the price level seem able to wipe out relatively large growth effects of financial deepening when the annual rate of inflation lies between 4 and 19 percent, whereas the operation of the finance-growth link is less affected by inflation rates above this range. Growth is generally much lower, however, in such high inflation settings where financial development is typically repressed.

*JEL Classification***:** E31; E44; O3

*Keywords***:** Financial depth; Economic growth; Inflation; Cross-country analysis

***** Corresponding author: Tel: +1-615-343-2472; fax: +1-615-343-8495
E-mail address: hakan.yilmazkuday@vanderbilt.edu (H. Yilmazkuday)

1. Introduction

The burgeoning literature on the link between financial development and economic growth has made much progress over the past 15 years in characterizing statistically the relationships described earlier by Gurley and Shaw (1955), Goldsmith (1969), and McKinnon (1973).[1] Much of this newer literature uses panel data to examine differences in growth rates across broad samples of countries over long periods of time (e.g., King and Levine, 1993; Beck at al., 2000). These and other studies, including those using time series methodologies (e.g., Demetriades and Hussein, 1996; Rousseau and Wachtel, 1998), affirm that financial deepening and the expanding financial services that accompany it are growth promoting. Fewer studies, however, examine whether particular economic conditions, such as the inflationary environment, affect the strength of the basic finance-growth relationship (e.g., Haslag and Koo, 1999; Boyd at al., 2001). In particular, Rousseau and Wachtel (2002) identify a threshold for annual inflation that lies between 13 and 25 percent, depending on the measure of financial depth that is chosen, above which the positive cross-country relationship between finance and growth vanishes.

In this study we build upon Rousseau and Wachtel (2002) by illustrating the trilateral relation between inflation, finance, and growth using a series of three-dimensional graphs that offer an appealing visual interpretation. The method allows us to quantify directly the growth rates that might be achieved along the continuum of possible combinations of financial development and inflation with both regression planes and non-planar surfaces, providing intuitive answers to questions of how to interpret sets of coefficients from linear regressions and more complex non-linear ones. In particular, the method allows us to characterize the cost of inflation in terms of losses in the effectiveness of financial deepening for a broad range of

[1] Levine (2005) provides a useful survey of the literature to date.

countries as well as subsets of high- and low-income ones. We also use a data-driven methodology to determine precise *multiple* inflation thresholds where the relationships between finance and growth appear to shift.

Our results suggest that small increases in the price level seem able to negate relatively large growth effects achieved through financial deepening when the annual rate of inflation lies between 4 and 19 percent, whereas the operation of the finance-growth link is less affected when inflation rates lie outside this range. We also demonstrate just how low growth rates generally are in high inflation settings where financial development is typically repressed, and show that the negative effects of inflation are more severe for the low-income countries in our sample than for the higher-income ones.

To be clear, though our graphical analysis will among other things characterize combinations of finance and inflation that are associated with given levels of growth in real per capita income, we do not claim that policymakers actively engage in any real tradeoff between financial development and inflation in maintaining growth and macroeconomic stability. Rather, we note that controlling inflation through monetary policy can be accomplished at relatively low cost, especially when done in a measured fashion, and that restoring smooth operations of the financial sector after a bout of inflation can be far more costly. All of this points to monetary control as a crucial first step in achieving robust economic growth.

The article is organized as follows. In Section 2 we discuss the relevant mechanisms and extant literature that describe how inflation can influence the climate for financial development. Section 3 includes descriptions of our data and results from a baseline regression analysis. In Section 4 we introduce the trilateral graphical approach, present our main findings, and explore their sensitivity to extreme observations. In Section 5 we investigate how the inflation-finance-

growth relationships vary across high- and low-income countries. Section 6 examines the nature of multiple inflation thresholds in the finance-growth nexus, and we draw together our conclusions in Section 7.

2. Background

The direct link between inflation and growth has been widely studied, primarily because control of inflation is often seen as the single most important goal to which monetary policy can aspire in the pursuit of macroeconomic stability (see European Central Bank, 2008) while lack of control has been increasingly linked to banking and financial crises (e.g., Duttagupta and Cashin, 2008). Yet the nature of apparent non-linearities between inflation and growth remains imperfectly understood.[2] Influential studies of the early 1990s such as Fischer (1993) and Barro (1996) provide the empirical basis for the widely supported negative relationship, but Bruno and Easterly (1998) show that these results are due largely to high inflation observations in the underlying data, meaning annual inflation rates of more than 40 percent.

The latter finding is surprising because there are good reasons to believe that even moderate inflation can have negative effects on real activity.[3] The lack of a strong direct effect, however, may be attributable to inflation operating less directly through the financial sector in medium-inflation settings. For one, financial intermediation becomes more difficult as the flow of information about real investment returns becomes more uncertain and less readily available. This will lead lenders to focus more on short-term objectives when building their portfolios and

[2] Temple (2000) discusses a variety of theoretical arguments for why inflation and growth should be related and surveys the empirical literature.

[3] For example, Mehl et al. (2006) find a threshold for a negative effect of inflation on growth in a sample of South-Eastern European economies that is much lower than found in earlier studies. Haslag and Koo (1999) and Boyd et al. (2001) relate inflation to financial repression that in turn impedes economic growth.

to curtail long-term lending. In the end a larger fraction of credit will then be directed toward loans more likely be used to meet operating expenses than to fund long-term capital investments. Inflation can also repress financial intermediation by eroding the usefulness of money assets and leading to policy decisions that distort the financial structure. Thus, the channel through which inflation affects growth may run, at least in part, through the financial sector.[4]

To the extent that high and variable inflation disrupts the operation of financial markets, it threatens macroeconomic stability by raising uncertainties about prices, interest rates, and exchange rates, and renders a nation's currency more vulnerable to a speculative attack. Inflation also raises the costs of hedging financial risks among potential trade partners as financial instruments become more difficult to price. All of this is likely to discourage trade and lead to net outflows of capital as the economy becomes less well integrated with the rest of the world.

In light of the channels described above, we next proceed to investigate growth equations that include inflation and financial development both separately and together.

3. Baseline growth regressions

An almost standard empirical framework has emerged since Barro (1991) and Levine and Renelt (1992) introduced the cross-country regression as an empirical representation of the Solow growth model. King and Levine (1993) extend this framework to include measures of financial development, and we begin with their baseline. Specifically, we start with the average rate of growth in real per capita output averaged over 5-year periods from 1960-2004 as the dependent variable and then condition on combinations of the following explanatory variables:

- The log of initial per capita GDP for each five-year period in constant 1995 U.S. dollars.

[4] Dehesa et al. (2007) make a similar point when exploring relationships between inflation, finance, and creditor rights.

This is expected to have a negative coefficient due to convergence (i.e., the tendency for countries with lower starting levels of GDP to "catch up" with higher GDP countries).

- The log of the initial secondary school enrollment rate for each five-year period (i.e., percent of the high school aged population actually enrolled), which is expected to have a positive coefficient. School enrollment rates are more widely available than other more precise measures of human capital, and should reflect a country's commitment to the development of human capital reasonably well.
- One of two measures of financial sector depth – either the ratio of liquid liabilities (i.e., M3) to GDP or the ratio of M3 less M1 to GDP – each averaged within individual five-year periods. The broad money supply M3 includes all deposit-type assets and is presumed to relate to the extent and intensity of intermediary activity. M3 less M1 takes the pure transactions assets out of the ratio to reflect more closely the intermediation activities of depository institutions.
- The inflation rate measured as the average annual growth rate of the consumer price index in each five-year period. This allows us to examine explicitly the direct effects of price inflation on growth, and here we expect a negative coefficient.
- International trade (the sum of exports and imports) and total government expenditure as percentages of GDP averaged within each five-year period serve as additional control variables. We expect that openness to trade would have a positive effect on growth. Our priors for the role of government expenditure are weaker, but we suspect that large public expenditures would tend to crowd out potentially more productive private investments, especially in higher-income countries.

Our data are organized as a panel of country observations from the 2007 edition of the World Bank's *World Development Indicators* database and include as many as 84 countries.[5] Estimation is by instrumental variables (i.e., two-stage least squares), with initial values of financial depth, inflation, government expenditure and trade for each five-year period serving as instruments in the first stage. We include fixed effects for the five-year periods because global business cycle conditions often involve shocks with common growth effects across countries.

Table 1 presents the results. Column 1 contains what we call the baseline growth model. Here, the coefficient for initial GDP is negative and thus consistent with the theory of conditional convergence, but is not statistically significant, while the coefficient on the initial secondary enrollment rate (SEC) is positive and significant at the one percent level. As we expand the baseline specification in the remaining columns of the table, the coefficient on initial GDP remains negative throughout and is statistically significant in 6 of the 12 regressions. Initial secondary enrollment retains its positive and statistically significant coefficient throughout.

Column 2 of Table 1 includes trade openness and government expenditure as controls to form an extended baseline. Openness is positively and significantly related to growth in this specification and all others in which it appears while the coefficients on government expenditure are negative and statistically significant throughout. These findings are consistent with our priors for these controls.

When we add inflation to the baseline model in column 3 and to the extended baseline in columns 4, the coefficients on inflation are negative and statistically significant at the five percent level, which is consistent with earlier studies. When we add our two financial variables

[5] These are the same 84 countries used by Boyd, Levine and Smith (2001) and Rousseau and Wachtel (2002).

Table 1
Instrumental variables growth regressions, 1960-2004

	Dependent Variable: Growth of Per Capita Income (%)											
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log of initial GDP	-0.124 (0.107)	-0.040 (0.113)	-0.154 (0.106)	-0.065 (0.110)	-0.277* (0.110)	-0.169 (0.116)	-0.299* (0.110)	-0.196† (0.116)	-0.284* (0.111)	-0.178 (0.116)	-0.309** (0.110)	-0.207† (0.115)
Log of initial SEC (%)	1.101** (0.251)	1.033** (0.251)	1.154** (0.252)	1.082** (0.252)	0.912** (0.248)	0.883** (0.251)	0.923** (0.252)	0.896** (0.253)	0.951** (0.250)	0.917** (0.253)	0.971** (0.253)	0.940** (0.254)
Government (% GDP)		-0.062** (0.024)		-0.061* (0.024)		-0.068** (0.024)		-0.059* (0.024)		-0.067** (0.024)		-0.058* (0.024)
Openness (% GDP)		0.014** (0.004)		0.013** (0.004)		0.010** (0.004)		0.011** (0.004)		0.009** (0.004)		0.010** (0.004)
Inflation (%)			-0.012* (0.005)	-0.010* (0.005)					-0.006† (0.004)	-0.005 (0.005)	-0.008† (0.004)	-0.007 (0.005)
M3 (% GDP)					0.023** (0.005)	0.021** (0.005)			0.022** (0.005)	0.020** (0.005)		
M3-M1 (% GDP)							0.029** (0.006)	0.025** (0.005)			0.027** (0.005)	0.024** (0.005)
R-bar sqd.	0.18	0.21	0.20	0.23	0.22	0.24	0.22	0.24	0.23	0.25	0.24	0.25

Notes: †, * and ** indicate significance at the 10%, 5% and 1% levels, respectively. Standard errors are in parentheses. Growth rates are five-year averages. Estimation is by two-stage least squares. The initial values of government, openness, inflation, M3, and M3-M1 in each five-year period are used as instruments for the corresponding five-year averages. All equations include fixed effects for time periods that are not shown. The sample size in each equation is 485.

to the baseline and extended baseline in columns 5-8, we find that both measures are positively and significantly related to growth at the one percent level.[6] Finally, when we include both financial depth and inflation in the remaining columns of Table 1, the effects of the financial variables remain but the statistical significance of the inflation coefficients fall to the 10 percent level without the additional controls (columns 9 and 11) and are no longer significant when we include the full conditioning set (columns 10 and 12).

The dampening of the effect of inflation on growth when combined with financial development calls for explanation. Is the direct effect of inflation on growth as important as the regressions in column 3 and 4 of Table 1 suggest? Or does inflation inhibit growth primarily through its effects on the smooth operation of the financial sector as indicated by the regressions in columns 9-12? Is there a continuum of combinations of inflation rates and levels of financial development that are associated with a given rate of growth? If such a continuum exists, linear regression analysis seems unable to show it clearly, especially given the negative correlation between inflation and financial depth (-0.16 for M3 and -0.12 for M3-M1 in our sample), yet a graphical analysis can shed additional light possible so long as the dimensionality of the system can be held to three. We introduce explore such a trilateral graphical approach in the next section.

4. A trilateral graphical approach

Obtaining a trilateral graph requires reducing the dimensionality of the regression in, say, column 10 of Table 1. We do this by using the coefficient estimates for initial income, initial

[6] We also experimented with the ratio of total domestic credit to GDP as a measure of financial development that would bring non-depository intermediaries into the analysis, but found this variable not significant statistically in any of our specifications. This echoes results with recent data (i.e., covering the period from 1960-2004) obtained by Rousseau and Wachtel (2009, forthcoming). We therefore limit analysis to the two financial measures reported in Table 1.

secondary enrollment, openness, government expenditure, and the time effects (i.e., excluding inflation and the M3 to GDP ratio) from the full regression in column 10 of Table 1 to build a set of growth residuals, and then plotting these residuals in three dimensional space against the corresponding observations for inflation and the finance variable along with the resulting regression plane.[7]

We begin the graphical presentation with Fig. 1a, which uses data for all 84 countries in the sample over nine five-year periods. The brightness of the fitted planar surface in the three-dimensional space increases as the unexplained growth residuals become larger.[8] That is to say, the brightest part of the surface represents the highest level of growth.[9] The equation that we use to create the regression plane is shown at the bottom of the figure, where *GR* denotes the growth residuals, *INF* is the initial inflation rate, and *FIN* is initial M3 as a percent of GDP.[10] The base of Fig. 1a is a two-dimensional projection of the fitted surface. Here, the brightest area once again represents the highest level of growth associated with given levels of finance and inflation. The white lines on the projection show combinations of inflation and finance associated with a fixed level of growth. In this sense, the white lines are similar to indifference curves with each

[7] Alternatively, we could obtain residuals from the projections of growth, financial depth and inflation on initial GDP, initial SEC, openness, government expenditure, and the time effects, and then regress those for growth on those for financial depth and inflation. This would recover the coefficients in column 10 of Table 1 exactly. Plotting these residuals in three dimensions, however, offers little information beyond the original regression.

[8] From this point, we will use the terms 'growth' and 'growth residuals' interchangeably.

[9] We use the TableCurve 3D, Version 4.0 software. The plane-fitting algorithm produces a continuous gradient, but we discretize it in the base of our figures to aid in the exposition. Because the OLS regression that we use to generate the plane differs from the original IV regressions in Table 1 due to the construction of the growth residuals on the left-hand side (see footnote 7), the coefficients and standard errors will also differ.

[10] We obtained similar graphics using M3 less M1 (% GDP) as the measure of financial depth.

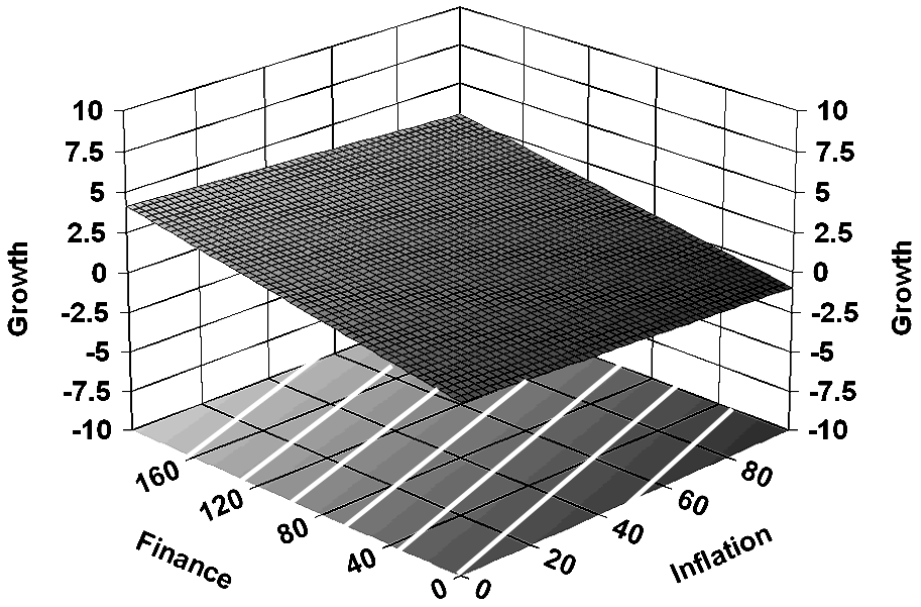


Fig. 1a. The trilateral relation between inflation, finance and growth

representing a different growth rate.

To get a clearer view of the projection of the surface and the white lines superimposed upon it, we present the projection alone in Fig. 1b. In this depiction, finance increases along the vertical axis and inflation increases along the horizontal axis, with the fixed annual growth rates associated with each set of finance-inflation pairs labeled. In particular, these lines suggest that steady growth cannot be sustained with a fixed level of financial depth as the inflation rate rises. More formally, the absolute value of their slope (technically a marginal rate of substitution in the indifference line analogy) is 0.63, meaning that a country with an inflation rate of one percentage point more than another otherwise identical country would have financial depth affect its growth as though its financial ratio were 0.63 percentage points lower.

Fig. 1c presents an alternate view of Fig. 1a (shifted clockwise 90 degrees) along with the sample points. What stands out here is that there are no instances of countries or time periods

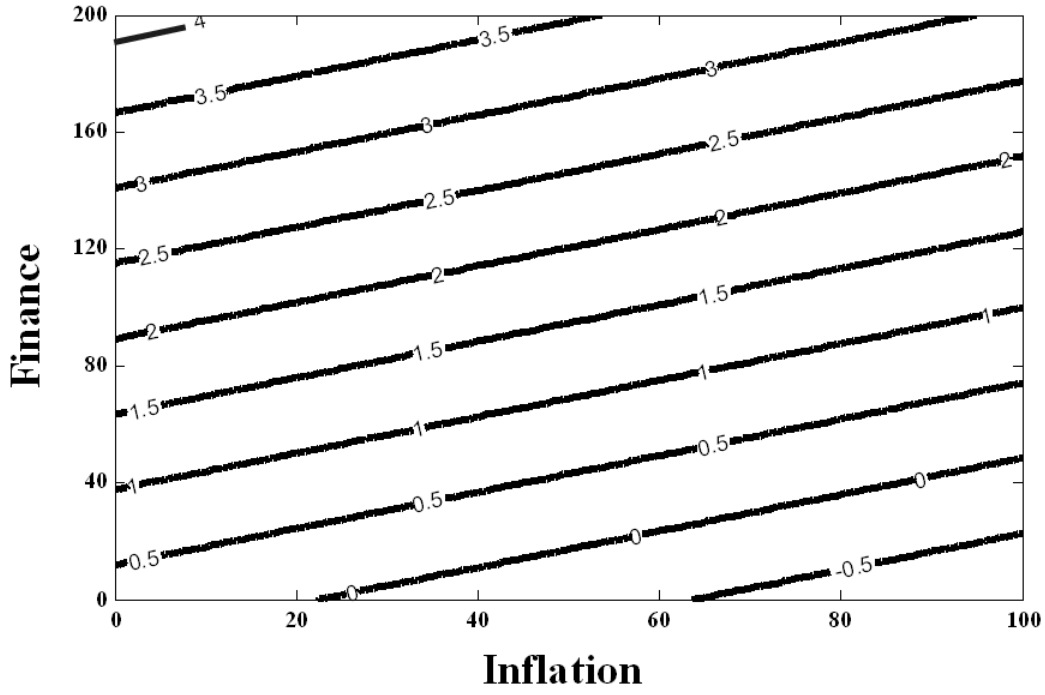


Fig. 1b. The projection of the surface in Fig. 1a.

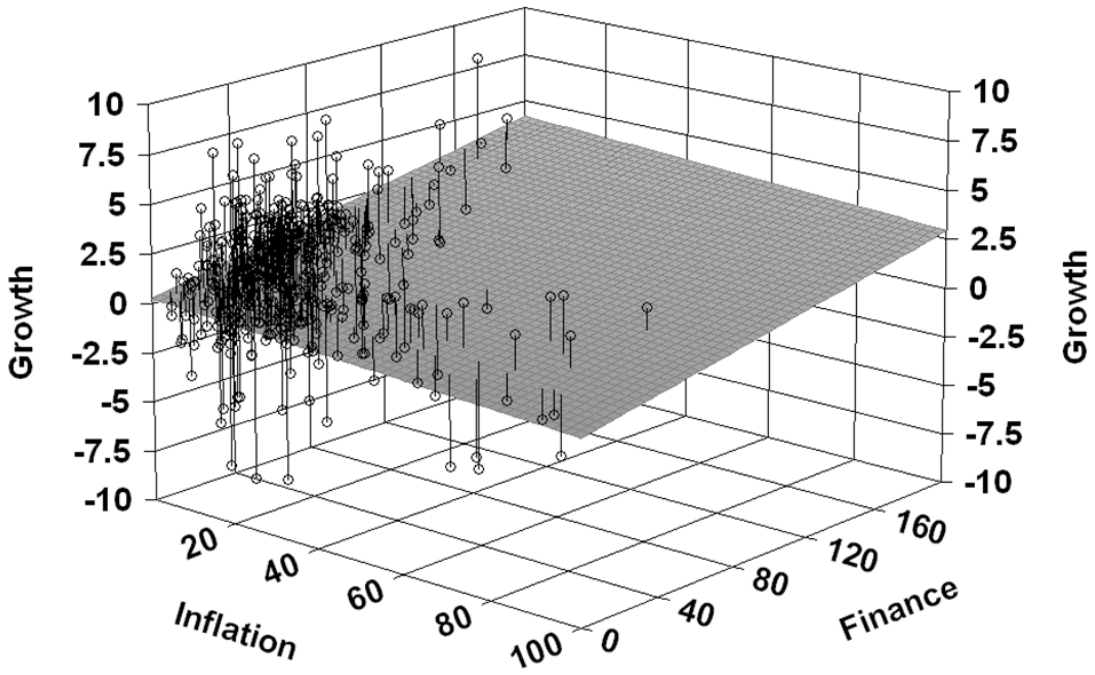


Fig. 1c. An alternate view of Fig. 1a with sample points included.

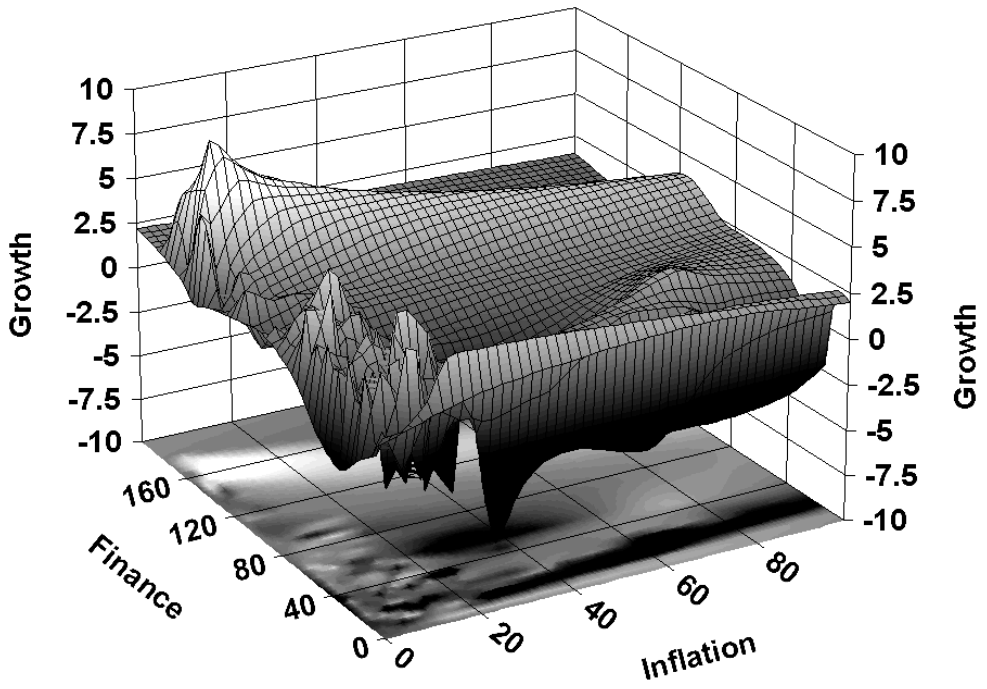


Fig. 1d. A non-planar view of Fig. 1a.

where high levels of inflation and finance co-exist to deliver the relatively high levels of growth suggested by the right section of the fitted surface. The surface also indicates that high levels of inflation may be more tolerable when there is adequate financial depth for investors to hedge at least partially against price level uncertainties. Put differently, rapid growth appears difficult to achieve under any inflationary circumstances in the absence of a well-developed financial sector.

Fig. 1d presents a non-planar relation between inflation, finance and growth that we construct using the same data.[11] The projection of this surface also indicates that growth is highest (i.e., the projection is brightest) when financial development is high and inflation is low.

[11] We use the method of natural neighbor interpolation as introduced by Watson (1994) to obtain a non-planar three-dimensional surface depicting the relation between inflation, finance and growth. This type of linear interpolation in natural neighbor coordinates is the equivalent of planar interpolation in rectangular coordinates. We once again use the software called TableCurve 3D, Version 4.0, for the analysis.

At the same time, there is some indication along the axis of the inflation variable that inflation has little effect on growth when the level of financial development is very low.

Fig. 2 explores the sensitivity of our results to the presence of high inflation observations. To do this, we repeat the analysis using only financial depth observations less than 100 percent and inflation observations less than 30 percent. The absolute value of the slope of the white lines in Fig. 2 is now about 1.42. That is, if inflation increases by 1 percentage point, the effect of finance on growth will be as if the level of financial depth were 1.42 percentage points lower. This change in the finance-inflation relationship is larger than that obtained with the full sample and suggests that the harmful effects of inflation on the operation of the finance-growth nexus are particularly applicable in settings with both moderate levels of inflation and financial depth.

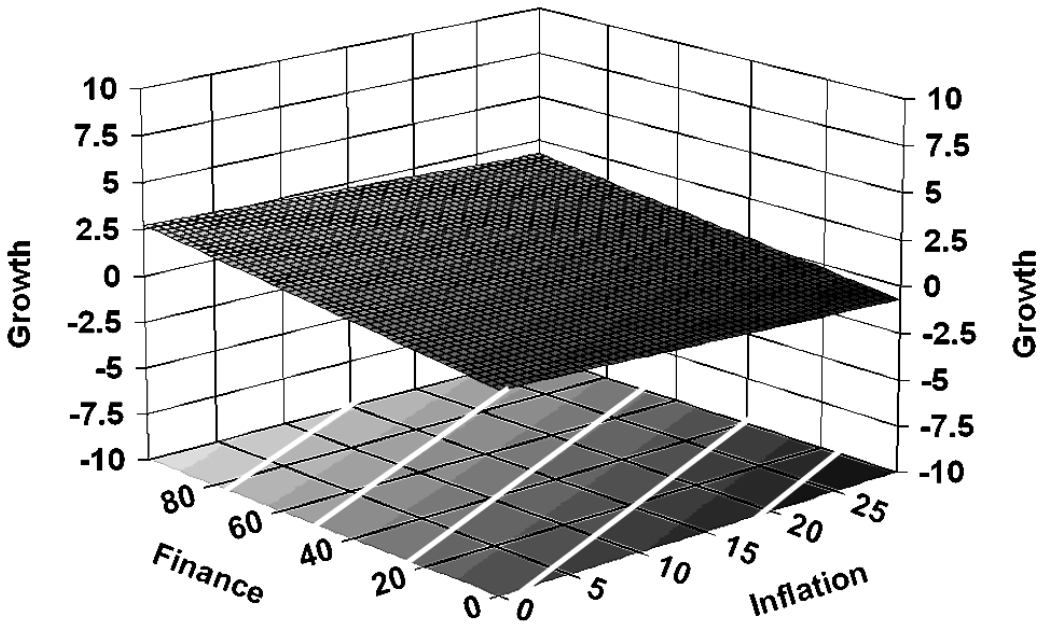


Fig. 2. The trilateral relation between inflation, finance and growth with observations for inflation under 30 percent and for the M3 to GDP ratio under 100 percent.

5. Higher vs. lower-income countries

In this section we investigate how the relationships between inflation, finance and growth differ across high and low-income countries. To classify countries, we use the World Bank's 2005 definition of a "developing" country as one with per capita income less than $3,225 USD; higher-income (i.e., "developed") countries are the complement.

Tables 2 and 3 present IV regression results for the high and low-income countries, respectively. The log of initial secondary education enters positively as expected and is statistically significant in all specifications, while the coefficient for the log of initial GDP is negative throughout but statistically significant only for the higher-income countries. More importantly, the coefficients for M3 and M3 less M1 as percentages of GDP are positive and significant in all equations for the higher-income countries and for all but two specifications for the lower-income countries. The exceptions occur for M3 less M1 when inflation is included in the model.

With financial depth excluded (columns 3 and 4), the coefficients on initial inflation are negative and statistically significant only in the simpler specification (column 3) for the higher-income countries and in both specifications for the lower-income ones. When we include the financial variables, however, the coefficients on inflation become markedly smaller and lose statistical significance in the full model for the high-income countries (columns 8 and 12 of Table 2), while they lose significance in all specifications for the lower-income countries (columns 7-8 and 11-12 of Table 3). Notably, the coefficients for inflation are more deeply negative and those on financial development are larger for the lower-income countries. This not only suggests that most of the negative effects of inflation are channeled through the financial

Table 2
IV growth regressions for the higher-income countries, 1960-2004

	Dependent Variable: Growth of Per Capita Income (%)											
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log initial GDP	-0.910** (0.262)	-0.486† (0.239)	-1.018** (0.223)	-0.573* (0.273)	-1.066** (0.252)	-0.676** (0.260)	-1.124** (0.257)	-0.730* (0.282)	-1.008** (0.245)	-0.614* (0.249)	-1.079** (0.258)	-0.674* (0.274)
Log initial SEC (%)	2.153** (0.562)	2.001** (0.492)	2.163** (0.550)	2.015** (0.499)	2.035** (0.554)	1.973** (0.514)	2.050** (0.547)	1.984** (0.515)	2.042** (0.536)	1.966** (0.494)	2.058** (0.531)	1.978** (0.495)
Government (% GDP)		-0.086* (0.035)		-0.080* (0.037)		-0.076* (0.034)		-0.071† (0.036)		-0.081* (0.034)		-0.076* (0.036)
Openness (% GDP)		0.019** (0.005)		0.018** (0.005)		0.014** (0.005)		0.013** (0.005)		0.015** (0.005)		0.014** (0.005)
Inflation (%)			-0.013** (0.005)	-0.006 (0.005)			-0.008* (0.004)	-0.004 (0.004)			-0.009* (0.004)	-0.004 (0.004)
M3 (% GDP)					0.021** (0.005)	0.015** (0.005)	0.019** (0.005)	0.014** (0.005)				
M3-M1 (% GDP)									0.024** (0.005)	0.018** (0.005)	0.022** (0.005)	0.017** (0.005)
R-bar sqd.	0.24	0.32	0.28	0.33	0.31	0.34	0.33	0.35	0.30	0.34	0.32	0.35

Notes: †, * and ** indicate significance at the 10%, 5% and 1% levels, respectively. Standard errors are in parentheses. Growth rates are five-year averages. Estimation is by two-stage least squares. The initial values of government, openness, inflation, M3, and M3-M1 in each five-year period are used as instruments for the corresponding five-year averages. All equations include fixed effects for time periods that are not shown. The sample size is 216. The 38 higher-income countries in our sample are Argentina, Australia, Austria, Barbados, Belgium, Canada, Chile, Costa Rica, Denmark, Finland, France, Greece, Iceland, Ireland, Israel, Italy, Japan, Korea Rep., Luxembourg, Malaysia, Malta, Mauritius, Mexico, Netherlands, New Zealand, Norway, Panama, Portugal, South Africa, Spain, Sweden, Switzerland, Trinidad and Tobago, Turkey, United Kingdom, United States, Uruguay, and Venezuela.

Table 3
IV growth regressions for the lower-income countries, 1960-2004

	Dependent Variable: Growth of Per Capita Income (%)											
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log initial GDP	-0.328 (0.230)	-0.364 (0.224)	-0.363 (0.220)	-0.384† (0.218)	-0.375† (0.221)	-0.409† (0.216)	-0.391† (0.216)	-0.416† (0.213)	-0.360 (0.220)	-0.383† (0.216)	-0.380† (0.215)	-0.394† (0.213)
Log initial SEC (%)	0.862** (0.288)	0.851** (0.290)	0.986** (0.285)	0.992** (0.288)	0.615* (0.298)	0.565† (0.303)	0.765* (0.307)	0.722* (0.311)	0.642* (0.314)	0.641* (0.317)	0.809* (0.323)	0.821* (0.326)
Government (% GDP)		-0.048 (0.037)		-0.052 (0.037)		-0.078† (0.040)		-0.075† (0.039)		-0.045 (0.038)		-0.049 (0.037)
Openness (% GDP)		0.008 (0.006)		0.005 (0.006)		0.006 (0.006)		0.004 (0.006)		0.006 (0.006)		0.003 (0.006)
Inflation (%)			-0.034* (0.017)	-0.036* (0.018)			-0.026 (0.018)	-0.027 (0.019)			-0.028 (0.018)	-0.031 (0.019)
M3 (% GDP)					0.027** (0.010)	0.033** (0.010)	0.021† (0.011)	0.027* (0.011)				
M3-M1 (% GDP)									0.033* (0.014)	0.032* (0.014)	0.023 (0.015)	0.023 (0.015)
R-bar sqd.	0.10	0.11	0.12	0.12	0.13	0.14	0.15	0.16	0.13	0.14	0.15	0.15

Notes: †, * and ** indicate significance at the 10%, 5% and 1% levels, respectively. Standard errors are in parentheses. Growth rates are five-year averages. Estimation is by two-stage least squares. The initial values of government, openness, inflation, M3, and M3-M1 in each five-year period are used as instruments for the corresponding five-year averages. All equations include fixed effects for time periods that are not shown. The sample size is 269. The 46 lower-income countries in our sample are Algeria, Bangladesh, Bolivia, Brazil, Cameroon, Central African Republic, Colombia, Cote d'Ivoire, Dominican Republic, Ecuador, Egypt, El Salvador, Fiji, Gambia, Ghana, Guatemala, Guyana, Haiti, Honduras, India, Indonesia, Iran, Jamaica, Jordan, Kenya, Lesotho, Malawi, Morocco, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Papua New Guinea, Paraguay, Peru, Philippines, Rwanda, Senegal, Sierra Leone, Sri Lanka, Sudan, Syrian Arab Republic, Thailand, Togo, and Zimbabwe.

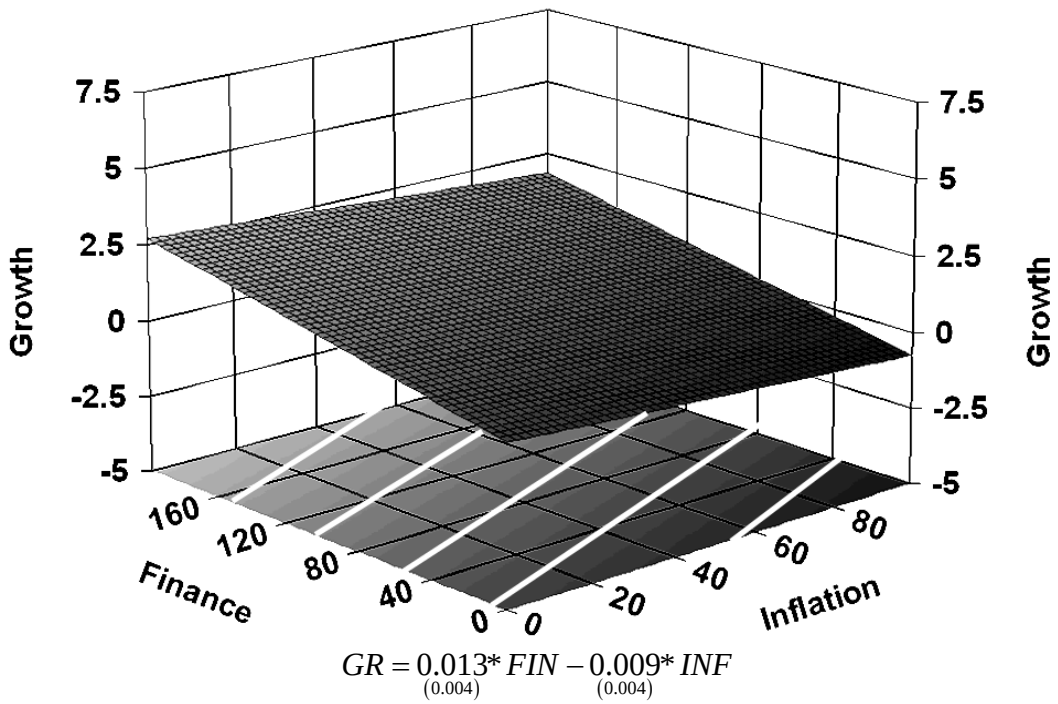


Fig. 3a. Trilateral graph for the high-income countries.

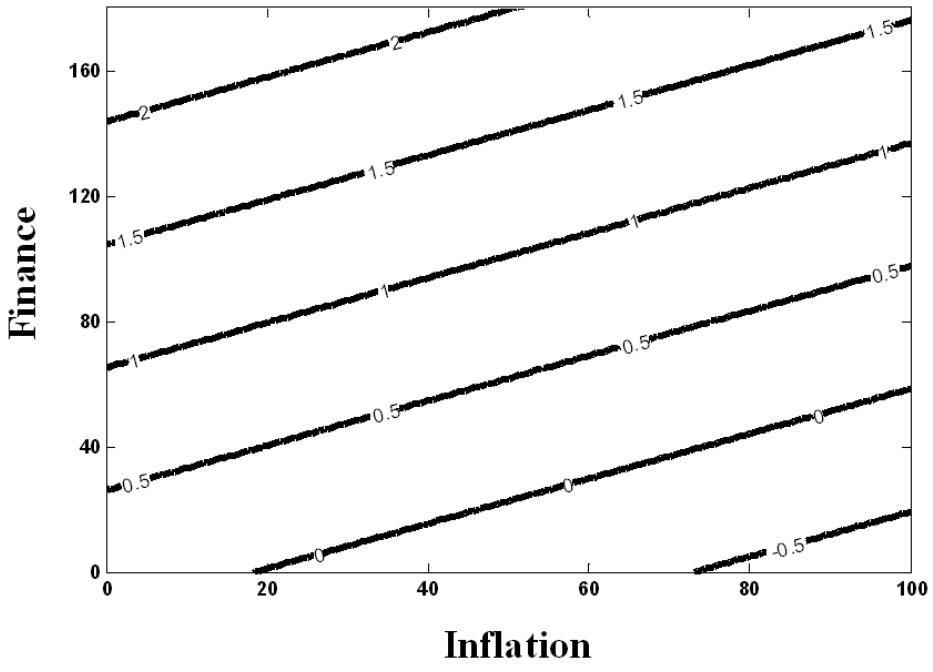


Fig. 3b. The projection of the surface in Fig. 3a (high-income countries).

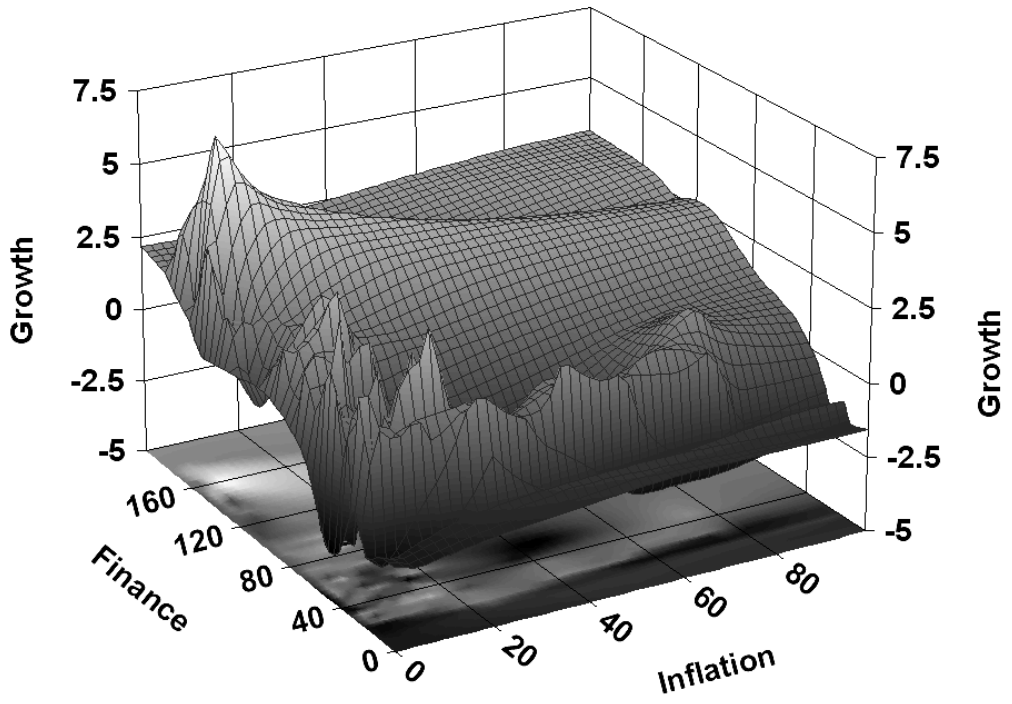
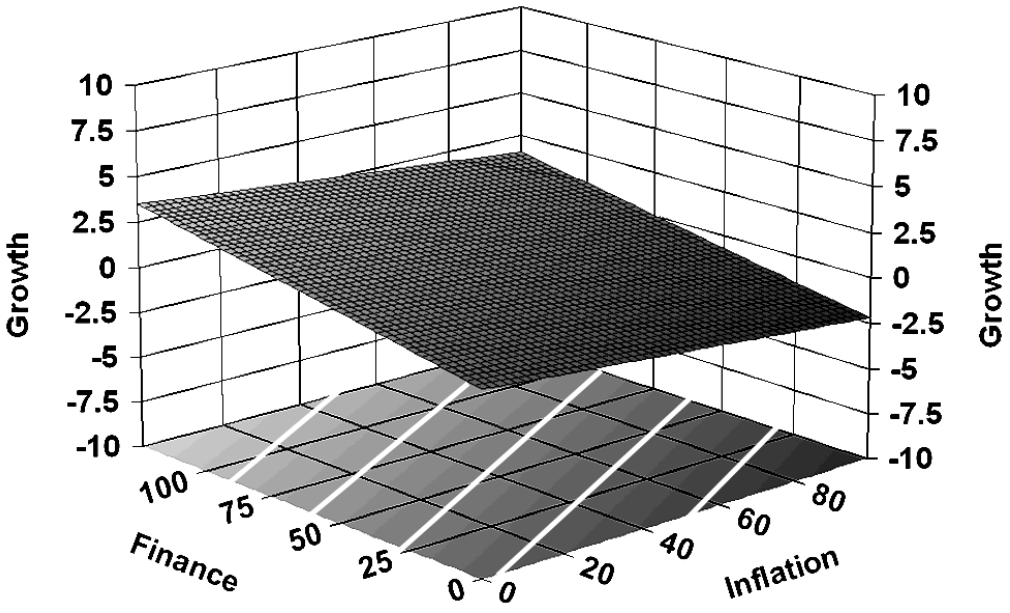


Fig. 3c. A non-planar trilateral graph for the high-income countries.

sector, but that inflation can disrupt the growth-enhancing role of finance severely for the low-income countries.

To examine these effects graphically, we apply our three-dimensional approach to each group separately. Fig. 3a is the resulting regression plane for the higher-income countries (using the ratio of M3 to GDP). Based on the equation beneath it, the slope of the white "indifference" lines is 0.69. That is, if inflation rises by one percentage point, finance operates on growth as if it were 0.69 percentage points lower. This slope is only a bit greater than what we found with the full sample, but when we label the projection of the regression plane in Fig. 3b, it is clear that the effects of finance on growth are smaller for the higher-income countries than they are for the full sample. In particular, the range of growth rates that are associated with given levels of finance and inflation are generally smaller than those obtained with all countries pooled (see Fig. 1b).

Fig. 3c is the non-planar version of Fig. 3a. Unlike Fig. 1d for the full sample of



$$GR = \underset{(0.008)}{0.030}^{*} FIN - \underset{(0.006)}{0.020}^{*} INF$$

Fig. 4a. A trilateral graph for the lower-income countries.

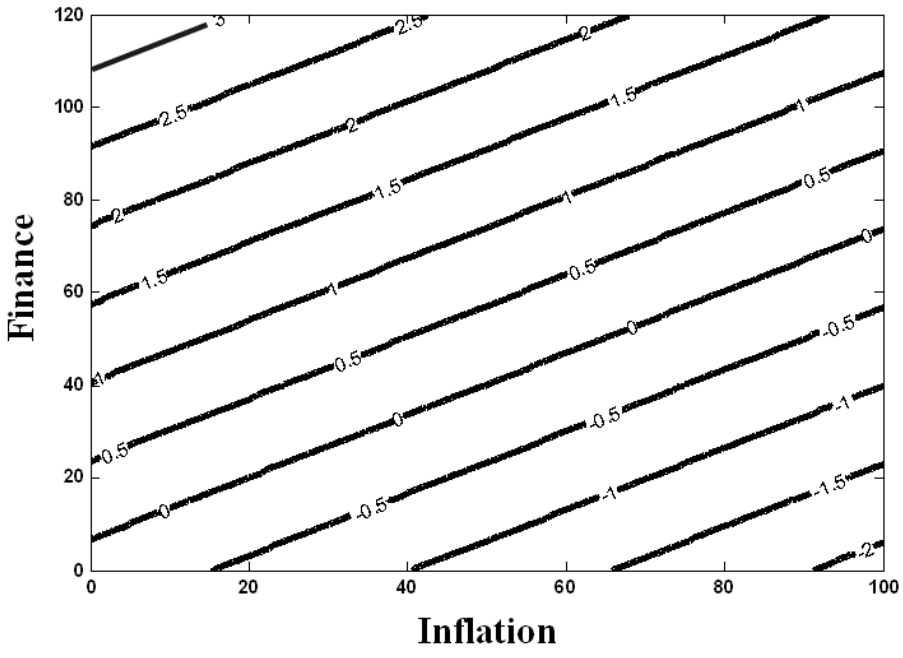


Fig. 4b. The projection of the surface in Fig. 4a (lower-income).

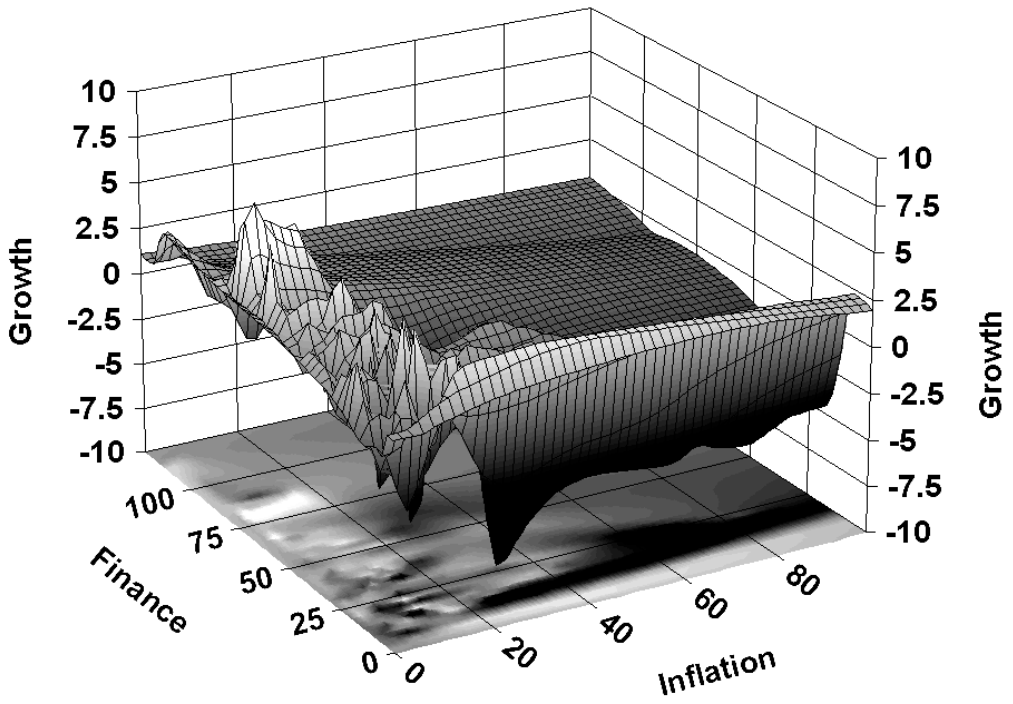


Fig. 4c. A non-planar trilateral graph for the lower-income countries.

countries, there do not appear to be any instances when moderate inflation is associated with reasonably high rates of economic growth when financial development is low.

Fig. 4a is the trilateral graph for the lower-income countries. To improve the exposition we truncate the axis at an inflation rate of 100 percent even though we generate the fitted plane using all of the observations. The white indifference lines in this case have a slope of 0.67. Once again this does not differ substantially from the developing countries or from the full sample, but a view of the projection in Fig. 4b with the growth rates labeled tells a different story. In this case, the range of fixed growth rates associated with given levels of finance and inflation is generally much wider (i.e., the regression plane is more sharply tilted) than that for the high-income countries and for all countries pooled, meaning that losses in the effectiveness of financial development related to inflation can have quite large effects on growth. For example,

using the coefficients for the regression planes, a high-income country with a level of financial development of 50 percent and annual inflation rate of 10 percent can expect to grow at a rate of 0.56 per year, while a similar low-income country would expect to grow at 1.3 percent. A rise in inflation by 20 percentage points would in either case make financial development act on growth as if financial depth were only about 36.4 percent (assuming a slope of 0.68 for the indifference lines), but annual growth for the lower-income country would fall more than twice as much (to 0.9 percent) than it would for the higher-income country (to 0.38 percent).

Fig. 4c is the non-planar surface for the low-income countries. Notably, the combinations of moderate inflation and reasonable growth seen along the inflation axis at the base of the figure are as prominent as the higher finance, lower inflation outcomes along the finance axis. This illustrates one of the challenges that developing economies face when financial development is costly and difficult. Rather than develop such an active intermediating sector, a short-term policy solution is reached whereby monetizing proceeds as in the McKinnon (1973, esp. ch. 6) model. If creating the simplest of financial assets (i.e., money) involves moderate inflation and if government direction of these freshly-supplied financial resources is a viable method of funding public projects and supporting current expenditures, it is perhaps not difficult to see why this trap has at times appeared so attractive.

6. Inflation Thresholds in the Finance-Growth Relationship

The trilateral graphs presented above suggest that the effects of inflation on the operation of the finance-growth link may differ across particular ranges of inflation rates. In this section we take a two-step, data-driven approach to determining such thresholds. In the first step, we impose the existence of two thresholds and then determine the specific inflation rates associated with them. In the second step, we use the calculated thresholds in a graphical analysis to demonstrate

how inflation makes finance less effective in promoting growth.

To implement the first step, we order our pooled five-year observations from those with the lowest inflation rates to those with the highest, divide the sample into three ranges of inflation rates, and then run the IV regression in column 6 of Table 1 (i.e., excluding inflation) with the M3/GDP ratio interacted with a dummy variable for each inflation range. After repeating this regression for every possible pair of break points along the inflation dimension, we choose the model that generates the smallest residual sum of squares. In other words, we assume a stable relationship between growth, initial GDP, initial SEC, trade, government expenditure, and time across the inflation groups, and allow the coefficients of the initial M3 to GDP ratio to differ within these intervals.

Table 4 presents estimates from the regression that uses the inflation thresholds of 3.95 and 18.62 percent determined by the procedure described above. All of the estimates have the expected signs and are statistically significant except for the interaction between financial depth and the dummy variable for high inflation. The adjusted R^2 indicates a considerably better fit for the threshold model than for any of the specifications reported in Table 1.

In the second step, we use the inflation thresholds (i.e., 4 percent and 18.6 percent) to show the relationships between inflation and finance that correspond to given growth rates. Note that two thresholds imply three such relationships. Fig. 5 shows the projection of the resulting tri-planar surface, which can be seen as an extended version of Fig. 1b that allows for two break points. We truncate the graph at an inflation rate of 30 percent to improve the exposition. Since each inflation range generates its own plane in three dimensions, the growth rates associated with the solid lines differ across each threshold and are noted on the figure.

Table 4
Growth equation with inflation thresholds, 1960-2004

Variables	Dependent Variable: Growth of Per Capita Income
Log initial GDP	-0.137 (0.119)
Log initial SEC (%)	0.893** (0.212)
Government (% GDP)	-0.062* (0.024)
Openness (% GDP)	0.008* (0.004)
M3 (% GDP) for low Inflation (up to 3.95%)	0.014** (0.004)
M3 (% GDP) for Medium Inflation (from 3.96% to 18.62%)	0.012** (0.004)
M3 (% GDP) for High Inflation Rates (higher than or equal to 18.63%)	0.006 (0.008)
R-bar sqd.	0.50

Notes: †, * and ** indicate significance at the 10%, 5% and 1% levels, respectively. Standard errors are in parentheses. Growth rates are five-year averages. Estimation is by two-stage least squares. The initial values of government, openness, inflation, M3, and M3-M1 in each five-year period are used as instruments for the corresponding five-year averages. All equations include fixed effects for time periods that are not shown. Dummy variables have been used to obtain the relevant finance coefficients related to different rates of inflation. The sample size is 485.

Interestingly, for the low-inflation segment (i.e., up to 3.95 percent per year), a given rate of growth can be achieved with lower financial depth so long as inflation is high enough (the indifference lines are upward sloping)! This is consistent with the literature on inflation targeting (e.g., Fischer, 1995), which suggests that inflation goals in the range of 2-3 percent per year are optimal in that they control growth in the price level while minimizing the possibility of deflation. At the same time, the labeling of the lines in the left panel of Figure 5 shows that growth is also generally low for any given level of financial development in such low-inflation

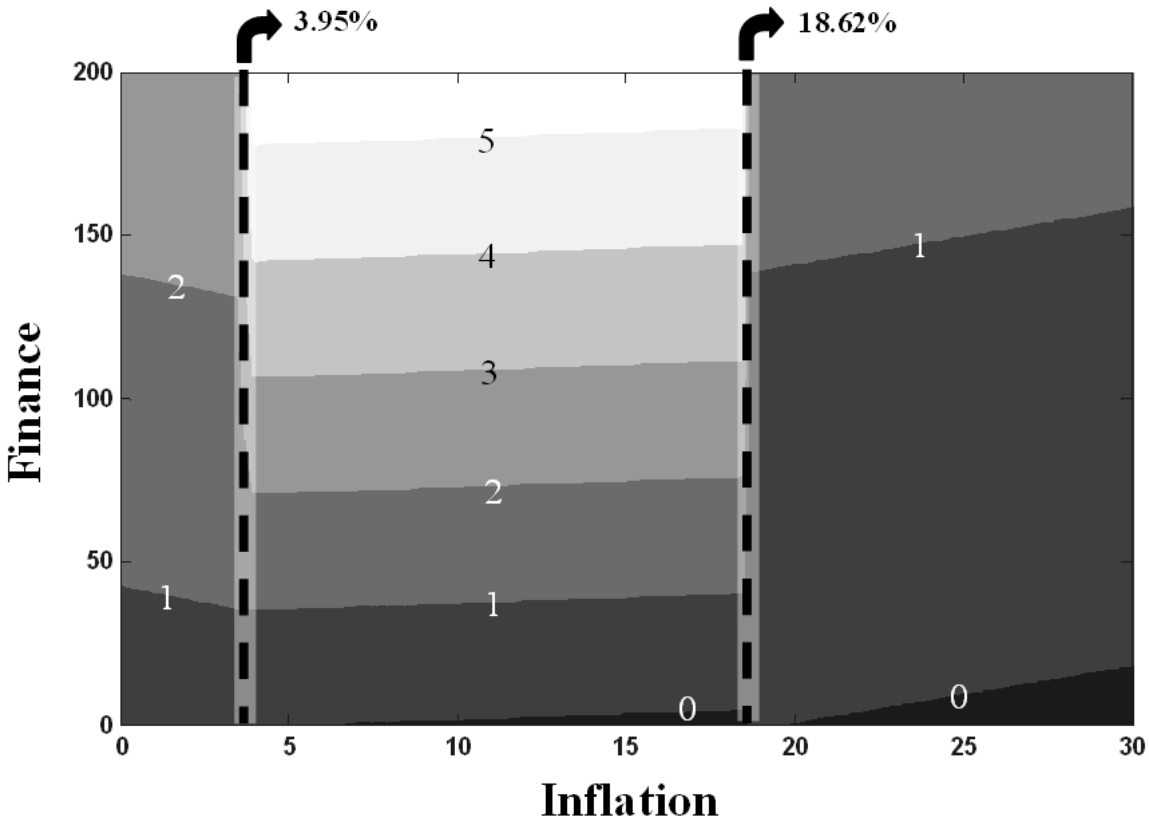


Fig. 5. Projection of the relationships between finance and inflation with thresholds.

settings. Yet because so many of the 97 observations from this segment of the sample are from countries with high levels of financial development, their average growth rate is actually a robust 2.11 percent per year.

A different view emerges, however, when inflation lies between 3.96 and 18.62 percent. For the 294 observations in this range, where the average annual growth rate is about 2.03 percent, the relationship reverses, suggesting that inflation can severely hamper the operation of the finance-growth relationship. The slope of the indifference lines for this middle inflation range is about 0.36, implying that a one percentage point increase in the inflation rate affects growth as if the level of financial depth were 0.36 percent lower. At the same time, it is also clear from the

labeling of the indifference lines that the gains of financial deepening in terms of growth are substantial in this range.

When inflation exceeds the upper threshold of 18.6 percent, the relation between inflation and financial depth remains negative with a slope of 1.75 for this region. Most striking, however, are the low growth rates associated with every level of financial development when inflation is so high, with the average growth rate for the 94 observations in this segment only 0.64 percent.

7. Conclusion

We take a trilateral graphical approach to analyzing the relation between finance, inflation and growth, and find that high levels of financial depth are important for achieving long-run growth and that inflation hinders the smooth operation of this linkage. High inflation disrupts the finance-growth nexus most seriously, but the effects of inflation are not that sensitive to its level once a country is in the high-inflation range. At middle-range inflation rates, the relation between finance and growth is quite strong, meaning that small changes in the inflation rate can have strongly negative effects on growth. We find that this holds for the lower-income countries in our sample as well.

Our findings underscore the importance of avoiding excessive inflation in formulating monetary policy, and imply that even moderate inflations (i.e., between 4 and 19 percent per annum) can have serious macroeconomic consequences. Developing institutional arrangements for controlling and fighting inflation, including the implementation of consistently low and credible inflation targets, would therefore seem to have potentially large benefits in terms of macroeconomic stability and growth.

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