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FINANCIAL DEPENDENCE AND GROWTH REVISITED

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ABSTRACT

In this note, we revisit an earlier, highly influential paper on Financial Dependence and Growth by Rajan and Zingales (1998), by re-examining their assumptions, and the robustness of their results to alternative theories and interpretations. We first show that they may be implicitly testing whether financial intermediaries allow firms to better respond to global shocks to growth opportunities, rather than the extent that financial intermediaries allow firms to grow in industries with an inherent (technological) financial dependence. Furthermore, if this is the case, we claim that there exists a more direct measure of growth opportunities. In particular, if U.S. capital markets are perfect, then actual growth in the U.S. is a good proxy for global growth opportunities. We test this directly, by including U.S. industry growth in Rajan and Zingales' original specification, and find that our direct growth measure outperforms their financial dependence measure and, moreover, is less vulnerable to controlling for outliers and level of development. This still suggests an important role for finance in the allocation of resources, but shifts the emphasis from 'financial dependence' to 'global growth opportunities.'

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In an earlier paper, Rajan and Zingales (1998) examine the relationship between financial market development and finance. This idea, that financial institutions play an important role in the resource allocation process, dates back to at least Schumpeter (1911), who conjectured that banks help to identify entrepreneurs with good growth prospects, and therefore help to reallocate resources to their most productive uses. Therefore, well-developed financial institutions will be crucial to an efficient allocation of resources in response to growth opportunities. The difficulty in testing this hypothesis is that growth opportunities are not generally observable to the econometrician: a firm (or industry, or country) may not be growing because there are no growth opportunities, or because there are opportunities, but no financing to allocate resources to them.

Rajan and Zingales (RZ) point out that this reallocation may be *differentially* affected by industry characteristics: those that require a lot of upfront outside financing (relative to generated cash flow), such as drugs and pharmaceuticals (perhaps due to R&D costs), will be less likely to grow in the presence of capital market imperfections than other industries where investment more closely coincides with cash generation. RZ further posit that this allows them to identify the extent to which financial market development facilitates the allocation of resources to needy entrepreneurs: industries that are 'external finance dependent' should grow relatively less in countries with underdeveloped capital markets.

In this comment, we begin by developing a simple theoretical model upon which we base a new test of the growth – financial development hypothesis. We assume that there exist global shocks to growth opportunities, due to demand shocks and/or shifts in factor prices. Further, following previous work, we claim that if firms in the United States respond perfectly to these shocks, then growth of firms in the U.S. should be a proxy for these growth opportunities. The extent to which firms in other countries respond to these opportunities, and therefore the degree to which growth in these countries is correlated with the growth of U.S. firms, will depend on the level of financial market development in these countries.

We then go on to present a model that yields a monotonic relationship between (unobserved) growth opportunities and reliance on external financial markets – firms that rely on external financial markets are naturally those with strong future opportunities relative to current cash-generating capacity. Based on this model, we show that RZ's original measure of 'technological' external dependence may be proxying for shocks to the global growth opportunities that we use to generate our own estimating equation. This would yield a substantively different interpretation of RZ's results: rather than suggesting that countries with well-developed financial markets have a natural 'affinity' *ex ante* for growth in certain industries, our explanation suggests that for *any industry*, when industry-specific opportunities present themselves, they will be most rapidly and effectively exploited by firms in countries with well-developed financial markets.[1]

If our modeling assumptions are correct, we claim that, rather than using RZ's external dependence measure, the estimating equation should use a more direct measure of these growth shocks, such as sales growth of firms within the United States. Our empirical specification, which closely parallels that of RZ, finds that the 'global shocks' hypothesis strongly outperforms the 'technological dependence' hypothesis. Moreover, we find that the RZ (technological dependence) result is much more vulnerable to the robust treatment of outliers, particularly once one controls for the standard trade-development theories of resource allocation, which posit that countries at similar levels of economic development should grow in similar industries. Since the techniques and variables utilized by Rajan and Zingales have been much utilized in the Finance

[1] Furthermore, in a related paper, we claim that the 'global shocks' hypothesis may be more efficiently tested using an entirely different methodology. See Fisman and Love (2003) for further details.

and Growth literature since the publication of their original paper[2], we believe that these results should be important in guiding both the formulation of new and related empirical tests, as well as the choice of variables in estimating these new models.

The rest of this paper is organized as follows: in Section 1, we describe our theoretical framework in greater detail. In Section 2 we describe our data and present our results. Section 3 concludes.

1. Financial Development and Growth: Theory

Rajan and Zingales hypothesize that some industries have an inherent need for outside financing due to a "technological" demand for external financing; these industries are referred to as "financially dependent". If financial development reduces the cost of external finance, such industries will have a relative advantage in countries with well-developed financial markets. RZ implement this model using the following functional form:

$$(1) \qquad Growth_{ic} = c*(FD_c)*EXTFIN_{USi} + \varepsilon_{ic}$$

In this expression, i indexes industry, c indexes country, $EXTFIN_{USi}$ is industry i's need for outside financing, which was measured using the US data (we have emphasized this assumption by adding the subscript US; note that their model also includes industry and country dummies which we omit for simplicity of notation).

To more fully develop the theory underlying this reduced form, we consider exactly what it is that determines a firm's external financing needs, and why this should be affected by

[2] See Beck (2003), Beck and Levine (2002), Cetorelli and Gamberra (2001), Klingebiel, Kroszner and Laeven (2002), Svaleryd and Vlachos (2002), Vlachos and Waldenstrom (2002), Fisman and Love (2003) among others who used this methodology and utilized the financial dependence measure.

financial development. We begin by emphasizing that a firm may not be growing either because there exist no opportunities, or because it is unable to take advantage of opportunities because of financing constraints. For simplicity of exposition, we assume that the degree of financing constraints is measured as a percent of desired external financing that the firm can actually raise in the financial markets. Thus, actual growth will be a function of growth opportunities (i.e. the potential increase in production or value added, represented by GO*) times the percent of desired financing the firm was able to obtain (FC*):

$$\text{(2)} \qquad \text{Actual Growth}_{ic} = GO^{*}_{ic} * FC^{*}_{ic}.$$

The subscripts above emphasize that for each firm or industry i, in a country c, growth opportunities will be industry and country specific (the time dimension is suppressed for notational simplicity). The asterisks underscore the fact that these variables are not observable to the econometrician.

The hypothesis that financial development loosens financing constraints, and therefore allows firms or industries to invest according to their growth opportunities, implies that $FC^{*}_{ic} = f(FD_c) + \eta_{ic}$, where $f'() > 0$, i.e., in countries with higher FD firms are able to obtain a larger portion of their optimal (desired) level of financing. Thus, the test of whether financial development improves the allocation of capital will be a test whether financial development reduces the financing constraints and therefore allows firms or industries to invest according to their growth opportunities. Substituting for FC in (2), and assuming a linear relationship between FC and financial development, we may rewrite (2) as:

(3) $(\text{Actual})\ \text{Growth}_{ic} = \beta GO^{*}_{ic} * FD_c + e_{ic}$

To derive an observable proxy for growth opportunities, we make two additional assumptions. First, as in RZ, we assume that capital markets in the United States function perfectly. Hence, to a first approximation, FC*=1, so that

(4) $(\text{Actual})\ \text{Growth}_{iUS} = GO^{*}_{iUS}.$

Additionally, we assume that there exist global industry-specific shocks to growth opportunities due, for example, to shocks to factor prices, or shocks to demand. Hence, some component of GO^*_{ic} is common across countries, so that:

(5) $GO^{*}_{ic} = \eta_i + \varepsilon_{ic}$

This assumption allows us to use industry-level growth opportunities in the US as a proxy for the growth opportunities in other countries. Substituting (4) and (5) into (3), and combining error terms, we get:

(6) $(\text{Actual})\ \text{Growth}_{ic} = \beta \text{Growth}_{iUS} * FD_c + e_{ic}$

Since we observe actual growth within the United States, (6) may now be readily estimated, with β reflecting the degree to which financial development loosens financing constraints.

To understand how our model potentially relates to the specification of RZ given in (1), we need to understand better what generates a firm's needs for external finance. In the appendix, we present a model whereby the desired level of external financing of a firm is a linear function of its growth opportunities, so that desired $EXTFIN^{*}_{ic} = f_i(GO^{*}_{ic})$, where $f_i(.)'>0$ The intuition is clear: Firms with high expected future demand, and hence a need to invest in capacity expansion beyond that which can be financed with current cash flow, desire more outside financing. Note that we allow the functional form to be industry-specific to reflect the fact that some industries might need more upfront financing in response to their growth opportunities, i.e. explicitly incorporating the original "technological dependence" idea of RZ.

Next, we observe that the *actual* level of external finance will be determined by a combination of the desired amount of external finance, and the extent of its financing constraints. However, if, as assumed by RZ, financing constraints are insignificant in the United States, then *actual* external finance will be equivalent to *desired* external finance for firms in the U.S., and hence measured external finance will be a function of growth opportunities. If growth opportunities, in turn, are translated into actual growth in an economy free of financing constraints, then external finance will be positively related to actual growth. Under this scenario, (1) may be directly transformed into (6). Thus, we claim that in addition to measuring any underlying technological or industry-specific need for external finance, the specification in (1) may be picking up on the fact that there exist global shocks to growth opportunities, and that by virtue of its well-developed capital markets, U.S. firms take advantage of these global shocks by seeking external finance. The positive coefficient on the interaction term in (1) would then be a reflection of the fact that firms in other countries with well-developed financial markets are also responding to these shocks, rather than an indication that firms in these countries are better positioned to take advantage of opportunities in inherently 'externally dependent' industries.

We can, in some sense, test these theories against one another, by simultaneously including the RZ external dependence measure, as well as a more direct measure of growth opportunities, such as sales growth in the U.S., essentially including the right-hand side variables from both (1) and (6). If the RZ measure of external dependence is simply picking up on correlated growth patterns across countries due to common shocks, then it should no longer be significant after we control for these shocks, using U.S. growth as a proxy. If, on the other had, RZ's measure does reflect an underlying 'technological' dependence then it should remain significant after adding this proxy. We provide the results of this test in the next section.

2. Data and Results

Our data are drawn primarily from Rajan and Zingales (1998), and described in detail in that paper. For our comparison with their work, the main outcome variable is real growth in valued added, estimated for each of 37 industries in 42 countries (UNCTAD, 1999). We supplement the RZ data with actual real sales growth in the US, USGrowth, which we calculate using all firms from Compustat (the same sample used by RZ to calculate EXTFIN, which we rename USEXTFIN to underscore that it is calculated using U.S. data).[3] Finally, we utilize their primary measure of financial market development, given by the sum of market capitalization and total domestic credit provided by banks to private borrowers, referred to as "Total capitalization". Definitions of all variables are given in Table 1, and basic summary statistics on US Sales

[3] We first calculate the real average growth rate for each firm in the sample for the decade of 1980's and then take the industry-level median of the firm-level averages of growth rates. We excluded 1% of the top and bottom tails of the distribution of firm-years of sales growth to eliminate cases of mergers, acquisitions, or disposals of assets. This parallels the approach used by RZ in calculating their EXTFIN measure.

growth (the only variable that is different from RZ) are in Table 2. We also note that the correlation of USgrowth and EXTFIN is 0.65, (significant at 1%) which is in line with our hypothesis that they are both related to growth opportunities.

The discussion in Section 2 suggests that the RZ specification in (1) be augmented as follows:

(7) $$Growth_{ic} = a*(FD_c)*USEXTFIN_i + b*(FD_c)*USGrowth_i + \varepsilon_{ic}$$

Table 3 presents results for a range of variants on (7). In specifications (1) and (2), we find that individually, USEXTFIN and USGrowth interacted with a measure of financial development each perform well in predicting the industrial pattern of growth across countries.[4] However, in (3), when both are included simultaneously, we find that the RZ measure of external finance loses its significance, while USGrowth remains significant, at the 5 percent level.

An additional econometric issue arises after closer examination of the distribution of the dependent variable – i.e. growth rates across countries and industries. We observe that its distribution has very long tails (see Figure 1 for the histogram).[5] This raises the concern that any set of OLS results may be driven by a few influential outliers. We repeat the specifications of (1) – (3), using two approaches to dealing with extreme observations: First, in (4)-(6), we allow for the robust treatment of outliers using the robust regression procedure in Stata.[6] This causes the USEXTFIN interaction to lose its significance; by contrast, FD*USGrowth remains

[4] Our model (1) is identical to the regression run by RZ in their Table 4, model (1).

[5] While the average and the median growth rate is about 3% in the sample, the 1st and 99th percentiles are –30% and +27% and the minimum and maximum are –51% and 100% (note that observations above 100% were removed by RZ). In addition, the kurtosis is equal to 26.5, again evidence of very "long tails", and the formal test for the normality of the distribution based on kurtosis is strongly rejected.

[6] Robust regression is an iterative procedure which begins with an OLS estimation, obtains residuals and residual diagnostics (such as Cook's D) and iteratively assigns weights using Huber's (1964) formulae such that observations with larger residuals (i.e. outlier observations) are assigned smaller weights. This procedure mitigates the effect of these influential observations. See Stata Manual, 2002, **rreg** procedure, for further details.

highly significant, though its magnitude is reduced. When both are included together, the coefficient on FD*USEXTFIN interaction actually reverses sign. Second, in (7)-(9), we drop the top and bottom 1 percent of observations by Growth. In this case, the original RZ result remain significant on its own, but once USGrowth is included, the coefficient again reverses sign. By contrast, the USGrowth interaction remains highly significant, regardless of the specification.

Thus, in summary, we find support for the hypothesis that financial development helps industries with good growth opportunities, based on the assumption that real growth in industries in the US is a good proxy for (industry-specific) world-wide growth opportunities.[7] We also find that the original RZ measure of external financial dependence loses its significance once a better proxy for the growth opportunities (such as sales growth) is included in the regression. These results suggest that the original external dependence measure is mainly capturing good growth opportunities (as industries with high external dependence are likely to be those industries with good growth opportunities), rather than "technological" dependence on external finance.

Financial versus Economic Development

Next, we address another potential alternative interpretation for the original results of RZ. As they recognized, their results could potentially be explained by the theory of Dornbush, Fisher and Samuelson (1977), that as technologies mature, industries involving those technologies migrate from developed to developing countries. Another closely related alternative explanation is based on the hypothesis laid out by Chenery (1960) which posits that countries at similar levels of development should grow in similar industries. Therefore, the RZ interaction may be picking up the fact that countries with higher level of economic development

[7] Fisman and Love (2003) relax this assumption regarding industry-level growth opportunities. In particular, they allow growth opportunities to be more similar in countries at more similar levels of economic development, and then go on to test the financial dependence – growth hypothesis using a different methodology.

(which are likely to have more developed financial markets as well) grow in similar industries as those that are growing in the US.

As a test for these alternative explanations RZ include the interaction of external dependence with the level of economic development, and find that their original interaction is robust to the inclusion of this additional interaction. We revisit this test, both for RZ's external dependence variable, as well as for our USGrowth variable, keeping in mind our observation on the presence of influential observations in the distribution of the growth rates. In Table 4 we reproduce the original RZ regression that includes the interaction with log GDP and also subject that regression to our two methods of robust treatment of outliers We find that in the baseline specification in Table 4, model (1), the FD*USEXTFIN interaction is only marginally affected by this addition, as originally reported by RZ. However, in model (3), which is a robust regression, the interaction of external dependence with financial development is no longer significant, while the interaction with GDP PC is significant. We obtain the same result in model (5) which excludes the top and bottom 1% in the distribution of the growth rates. By contrast, FD*USGrowth remains significant in all specifications, regardless of the accounting for outliers and the inclusion of log(GDP)*USGrowth. This further reinforces our hypothesis that the role of financial development is to reallocate resources to industries that have good growth opportunities and not to industries with "technological dependence" on external finance. It is true that good growth opportunities will necessarily result in the increased need for external finance, while the reverse does not seem to be supported by the data (i.e. the dependence on external finance as distinct from growth opportunities is not a significant predictor of growth).

Overall, therefore, we find that the original RZ test of the Finance and Growth hypothesis is quite fragile, and is sensitive both to the treatment of outliers, and the inclusion/exclusion of what we consider to be a more direct measure of growth opportunities. By contrast, interactions utilizing our proposed alternative measure, USGrowth, are robust to all specifications, and outperform the RZ USEXTFIN variable when both are included simultaneously.

3. Conclusions and Implications

In this paper, we revisit the finance and growth hypothesis, providing some theoretical underpinnings for the recent estimation of Rajan and Zingales (1998), and further proposing an alternative specification that is more directly related to our model. Empirically, we find that our preferred specification outperforms that of Rajan and Zingales, particularly once one allows for a more robust treatment of extreme observations. Since the techniques and variables utilized by Rajan and Zingales have been much utilized in the Finance and Growth literature since the publication of their original paper, we believe that this comment is important in guiding both the formulation of new and related empirical tests, as well as the choice of variables in estimating these new models.

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Table 1. Variable Definitions and Sources.

Abbreviation	Description
Industry-level variables.	
USEXTFIN	Dependence on external financing, industry-level median of the ratio of capital expenditures minus cash flow over capital expenditures (the numerator and denominator are summed over all years for each firm before dividing) for US. This variable measures the portion of capital expenditures not financed by internally generated cash. From Rajan and Zingales (1998).
USGrowth	Growth in real sales, industry-level median of firm average growth rages over 1980-1990 for US firms, from Compustat.
Industry growth	Annual compounded growth rate in real value added estimated for the period 1980-1990 for each ISIC industry in each country From Rajan and Zingales (1998).
Fraction	Industry's share of total value added in manufacturing in 1980 from Rajan and Zingales (1998).
Country-level variables:	
Domestic credit	Ratio of domestic credit held by monetary authorities and depositary institutions (excluding interbank deposits) scaled by GDP for 1980. Original source is International Financial Statistics (IFS).
Market cap.	Ratio of stock market capitalization to GDP in 1980. IFS.
FD	Financial Development, equal to the sum of Domestic Credit and Market Capitalization
Log GDP PC	Log of GDP per capita in US dollars in 1980. IFS

Table 2. Summary Statistics

See Table 1 for Variable Definitions and Sources. The industries are sorted in ascending order of USEXTFIN.

ISIC code	Description	USEXTFIN	USGrowth
314	Tobacco	-0.451	0.031
361	Pottery	-0.146	0.073
323	Leather	-0.140	0.024
3211	Spinning	-0.088	0.028
324	Footwear	-0.078	0.016
372	Non-ferrous metal	0.005	-0.017
322	Apparel	0.029	0.027
353	Petroleum refineries	0.042	-0.035
369	Non metal products	0.062	-0.001
313	Beverages	0.077	0.037
371	Iron and Steel	0.087	-0.002
311	Food products	0.137	0.036
3411	Pulp, paper	0.151	0.061
3513	Synthetic resins	0.159	0.047
341	Paper and Products	0.176	0.037
342	Printing and Publishing	0.204	0.065
352	Other Chemicals	0.219	0.056
355	Rubber products	0.226	0.022
332	Furniture	0.236	0.044
381	Metal products	0.237	0.039
3511	Basic chemicals excl. Fertil.	0.253	0.038
331	Wood Products	0.284	0.031
384	Transportation equipment	0.307	0.057
354	Petroleum and coal products	0.334	0.002
3843	Motor veichle	0.389	0.048
321	Textile	0.400	0.043
382	Machinery	0.445	0.033
3841	Ship	0.458	0.057
390	Other ind.	0.470	0.067
362	Glass	0.528	0.035
383	Electric machinery	0.767	0.068
385	Professional goods	0.961	0.064
3832	Radio	1.039	0.082
3825	Office, computing	1.060	0.123
356	Plastic products	1.140	0.088
3522	Drugs	1.492	0.084
	Mean	0.319	0.042
	Median	0.231	0.038
	Standard deviation	0.406	0.031
	Correlation between USEXTFIN and USGrowth	0.65	

Table 3. External Dependence and Growth

Dependent variable is real growth in value added for each industry and each country. See Table 1 for Variable Definitions and Sources. All regressions include industry and country dummies. Models (4)-(6) are estimated with robust regression procedure in Stata (the procedure assigns lower weights to influential observations). Modes (7)-(9) exclude observations in the top and bottom 1% tails of the distribution in the dependent variable. Heteroskedasticity robust standard errors appear in parenthesis. Significance levels ***, ** and * correspond to 1%, 5% and 10% respectively.

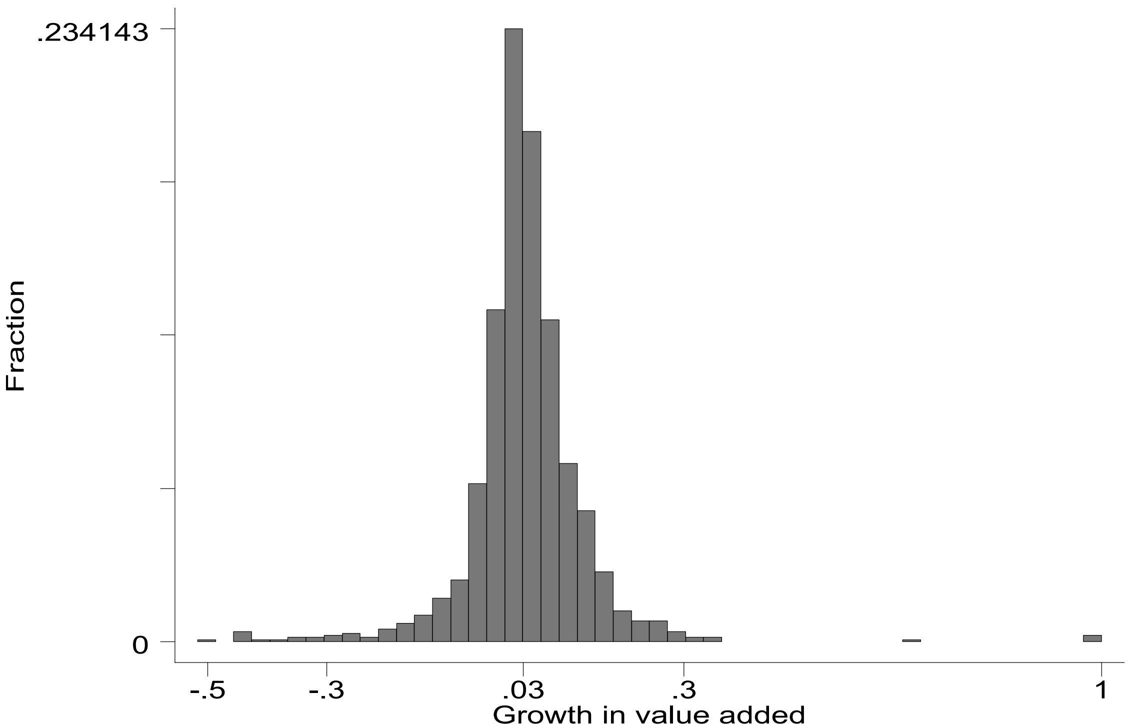
	OLS			Robust Regression			Excluding outliers		
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Fraction	-0.912	-0.905	-0.923	-0.188	-0.202	-0.188	-0.437	-0.45	-0.449
	(0.246)***	(0.243)***	(0.245)***	(0.079)**	(0.079)**	(0.079)**	(0.109)***	(0.106)***	(0.108)***
USEXTFIN * FD	0.069		0.033	0.010		-0.019	0.034		-0.001
	(0.023)***		(0.028)	(0.009)		(0.012)	(0.012)***		(0.017)
USGrowth * FD		1.069	0.775		0.461	0.68		0.745	0.753
		(0.351)***	(0.427)*		(0.124)***	(0.164)***		(0.215)***	(0.287)***
Observations	1217	1217	1217	1217	1217	1217	1200	1200	1200
R-squared	0.29	0.29	0.29	0.51	0.51	0.51	0.36	0.37	0.37

Table 4. Controlling for Economic Development

Dependent variable is real growth in value added for each industry and each country. See Table 1 for Variable Definitions and Sources. All regressions include industry and country dummies. Models (3)-(4) are estimated with robust regression procedure in Stata (the procedure assigns lower weights to influential observations). Modes (5)-(6) exclude observations in the top and bottom 1% tails of the distribution in the dependent variable. Heteroskedasticity robust standard errors appear in parenthesis. Significance levels ***, ** and * correspond to 1%, 5% and 10% respectively.

	OLS		Robust Regression		Excluding outliers	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Fraction	-0.944 (0.245)***	-0.925 (0.243)***	-0.209 (0.079)***	-0.245 (0.078)***	-0.474 (0.113)***	-0.468 (0.109)***
USEXTFIN * FD	0.049 (0.023)**		0.002 (0.010)		0.02 (0.013)	
USEXTFIN* LogGDP PC	0.013 (0.008)*		0.006 (0.003)**		0.01 (0.003)***	
USGrowth * FD		0.712 (0.292)**		0.318 (0.137)**		0.54 (0.218)**
USGrowth * Log GDP PC		0.223 (0.113)**		0.15 (0.037)***		0.131 (0.055)**
Observations	1217	1217	1217	1217	1200	1200
R-squared	0.29	0.3	0.52	0.52	0.37	0.37

Figure 1. Frequency distribution of the growth in value added (the dependent variable).


.234143
0
Fraction
-.5
-.3
.03
.3
1
Growth in value added

Appendix A. Simple model of Growth and External Financing.

Consider a standard model of profit maximization:

$$\max_{K} \; \Pi(K) - rK$$

Where K is the capital stock, which is the only input into the production function Π (K), r is the interest (or leasing) rate, there is no depreciation and price of output is normalized to one. Assume simple Cobb-Douglas production function: $\Pi(K) = \theta K^{\alpha}$ with decreasing returns to scale, so that $\alpha<1$. Here, an increase in the "technology" parameter θ is equivalent to an increase in growth opportunities.

We then have the FOC:

$$r = \alpha\theta K^{\alpha-1} = \alpha\, \Pi(K)/K$$

This is familiar relationship that equates marginal cost of capital to its marginal benefits. We further assume that initially, the firm is operating at the optimal capital stock, and that there are no barriers to entry. Thus, profits are zero, and:

$$K^* = \left(\frac{\alpha\theta}{r}\right)^{\frac{1}{1-\alpha}}$$

In this model, new growth opportunities are equivalent to increase in parameter θ. The increase in desired capital stock (i.e. the level of investment) will then be given by:

$$\frac{\partial K^*}{\partial \theta} = \left(\frac{1}{1-\alpha}\right)\frac{1}{\theta}K^*$$

We can rewrite the revenue function at the optimal capital stock as

$$\Pi(K^*) = \frac{r}{\alpha}K^*$$

Cash Flow (revenue minus interest expenses) will then be given by:

$$CF(K^*) = \Pi(K^*) - rK^* = \frac{r}{\alpha}K^* - rK^* = rK^*\left(\frac{1-\alpha}{\alpha}\right)$$

It is easy to see that if $\alpha > \frac{r}{1+r}$, which represent reasonable parameter values,[8]

$r\frac{1-\alpha}{\alpha} < 1$, and hence $\frac{\partial CF(K^*)}{\partial \theta} = r\frac{1-\alpha}{\alpha}\frac{\partial K^*}{\partial \theta} < \frac{\partial K^*}{\partial \theta}$

That is, an increase in cash flows will be less than the desired investment and therefore will require external financing. The amount of external financing required is directly proportional to the growth in capital stock :

$$EXTFIN = \frac{\partial K^*}{\partial \theta} - \frac{\partial CF(K^*)}{\partial \theta} = (1 - r\frac{1-\alpha}{\alpha})\frac{\partial K^*}{\partial \theta}$$

Since in this simple model new investment is proportional to growth (i.e. increase in the capital stock), it follows immediately that EXTFIN = c*GROWTH.

[8] It is reasonable to assume the curvature parameter α to be above 0.5; and the interest rate well below this level.