Acceleration, Stagnation and Crisis: the Role of Policies and Institutions

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Abstract

In this paper we study long run economic growth as a sequence of accelerations, slowdowns and crises, and estimate the role of institutions and macroeconomic policies in determining this sequence. We determine the joint effect of policies and institutions on the frequency of the four growth regimes: stable growth, stagnation, crisis and miracle-like fast growth. The results confirm the importance of institutions for growth but also show that macro-policies; inflation, trade openness, size of government and real exchange rate overvaluation matter for the growth process, even after controlling for institutional quality. Importantly, some policies affect regimes differentially; for example, trade makes episodes of fast growth more likely but also increases the frequency of crises. Finally, the effects of policies are nonlinear and dependent on the quality of institutions. For example, government spending reduces growth in countries with good institutions but can increase it when institutions are weak.

1 Introduction

Several recent papers have documented a large degree of within-country variation in the process of economic growth. For example, Hausmann et al. (2005) look for episodes of growth acceleration during 1950-2000 and find many such episodes even in countries that have under-performed during this period in terms of average growth. Similarly, Jerzmanowski (2006) identifies four distinct growth regimes and finds that periods of fast growth are possible even in countries with very low quality of institutions; what keeps average long run growth rates low is the inability of these countries to sustain growth. This approach highlights the

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complex nature of growth and implies that understanding long run growth requires studying the process of "growth transitions", i.e. switches between episodes of growth acceleration, stagnation and collapse. This paper studies the role of institutions and macroeconomic policies in determining the frequency of such episodes. We ask whether policies, like control of inflation or government spending, and institutions, such as rule of law or democracy, affect how frequently an economy goes through prolonged stagnation or experiences periods of rapid growth. Since in the long run, these frequencies determine average growth rates, the paper also re-examines the relationship between policies and long run growth. The question whether macroeconomic policies such as inflation, government spending, real exchange rate overvaluation, and trade openness matter for long run economic growth has a long history in empirical growth literature. Early research on determinants of growth in a cross-section of countries found significant effects of macroeconomic policies on long run growth (e.g. Barro 1991, Dollar 1992, Sachs and Warner 1995). Recent literature is more skeptical. Easterly and Levine (2003) argue that after controlling for institutions, policies do not affect the level of income. Easterly (2005) shows that the findings of significant effects of policies on growth are driven by extreme outliers. Finally, Acemoglu et al. (2003) argue that once institutions are controlled for, policies do not matter much for growth and volatility. The approach taken in this paper allows us to re-examine the question of policies and growth, while explicitly accounting for within-country variation in the growth process. This framework is richer than the standard average growth analysis since it allows policies to work through multiple channels by differentially affecting the likelihood of growth accelerations, stagnation and crisis.

The particular approach taken here builds on Jerzmanowski (2006) who estimates a regimes switching model of growth. According to his estimates a country's long run growth is determined by the frequency of visits to four growth regimes: stable growth, stagnation, crisis, and miracle growth. The stable regime corresponds to the growth experience predominant among developed economies, with long run average growth of about 2 percent, the stagnation regime is characterized by no growth on average, the crisis regime is an episode of large shocks to growth and finally the miracle regime corresponds to episodes of fast growth of about 6% per year.[1] Countries change regimes randomly according to probability distributions, which depend on the quality of institutions. Good institutions increase the frequency of visits to favorable regimes but most importantly make them more persistent; countries with weak institutions are capable of growth take-offs, however, they are unable to sustain them. The long run growth rate (and growth volatility) depend on the within-regime growth dynamics, as well as the long run ergodic distribution of regimes. The present paper asks how macroeconomic policies, in addition to institutions, affect this distribution. We use the regime probabilities obtained by Jerzmanowski (2006) to estimate the effects of policies on the frequency of the four growth regimes. That is, rather than asking whether a particular policy is correlated with average growth, we asks whether the policy is associated with the country spending more time in periods of growth, stagnation or crisis. This allows us to exploit the within-country variation in the growth process which is removed by averaging over time. It also allows policies to have an effect on growth through different,

[1] These regimes also differ with respect to persistence of shocks and volatility of growth, as will be described below.

perhaps offsetting, channels. For example, large governments may reduce the likelihood of fast miracle-like growth but also limit the probability of a crisis. The net effect on average growth may be small leading us to the incorrect conclusion that government size has no effect on the long run growth process. In addition, using a multinomial probability model to estimate the probabilities of growth regimes allows for nonlinear and interdependent effects of policies and institutions.

The results confirm some of the existing findings, namely that institutional quality is a key determinant of long run growth, as well as Easterly's finding that only extreme values of the distortionary policies (inflation rate and real exchange rate overvaluation) have a significantly negative effect on growth. However, macro policies, especially trade openness and the size of government also matter for changes in growth patterns and thus influence the average growth and volatility in the long run. Crucially, the policies also differ in the channel through which they affect long run growth. For example, trade lowers the probability of stable growth and increases that of a crisis, while also making miracle growth more likely. The size of government, on the other hand, lowers the chances of miracle growth, while increasing the probability of stable growth at moderate rates. In addition, the effect of policies depend in an important way on the quality of institutions. In general, low quality of institutions makes economies more vulnerable to the harmful effects of inflation and real exchange rate overvaluation. In some cases the direction of the effect is actually reversed; trade appears to be conducive to growth for countries with good institutions and detrimental to growth for countries with bad institutions. The size of government has the opposite effect - it lowers growth when combined with good institutions and increases it with weak institutions. Finally, when we extend the analysis to the effects of political institutions by including a measure of democracy among the explanatory variables, we find that, similarly to the rule of law, democracy increases the frequency of stable growth. Unlike rule of law, however, democracy significantly lowers the chances of miracle growth take-offs. We also find that accounting for democracy removes the negative effect of initial income on the probability of miracle growth, i.e. the convergence effect. This suggest that political economy, in addition to diminishing marginal product of capital or technological catch-up, is an important channel of convergence.

The paper is organized as follows. Section 2 details the idea of growth regimes, describes the approach to identify them and outlines the empirical approach. Section 3 presents and discusses the results and the final section concludes.

2 Growth and Regime Switching

Following earlier contributions by Easterly et al. (1993) and Pritchett (2000) several recent papers have focused attention on growth transitions, i.e. changes in the long run growth process. Hausmann et al. (2005) develop a methodology for identifying growth accelerations, defined as an increase in trend growth by more than 2% for seven years, with the resulting growth above 3.5%, and find that these episodes are quite common. They report that economic reforms are correlated with sustained accelerations, whereas shocks tend to produce short-lived growth. However, many growth accelerations do not appear to be spurred by any obvious changes in standard growth determinants, while many instances of reform fail to produce fast growth. Jones and Olken (2008) use the Bai-Perron test to detect structural breaks in the per worker output growth series and show that growth accelerations are mainly total factor productivity accelerations, while growth slowdowns are due to both capital and TFP slowdowns, with the latter playing a greater role. Finally, Jerzmanowski (2006) uses the regime switching approach to identify distinct growth regimes and the dynamics of transitions between them.

To illustrate the idea of growth regimes consider the following simple example. Suppose that there are only two possible states of the world - one in which the economy stagnates and another in which it grows at 3% per year. If over time a country switches between regimes, growth will be an uneven process. This is of course what growth looks like for many countries, for example Japan accelerated in the 1950's and 60's and the stagnated in the 1990's while India grew slowly until it took-off in the 1990's. If we further assume that these transition probabilities depend on some country-specific characteristic X (e.g. quality of institutions), we have a model where country characteristics, such as policies or institutional quality, shape long run growth by affecting the frequency of the two regimes.

Within a standard approach to growth, if a characteristic X is "good" for growth then countries with a high level of X are expected to be growing fast (say, at 3% per year) and countries with low levels of X are expected, all else equal, to be growing slowly (say, stagnate); this is a world where "you either have what it takes for growth or you don't". In the regimes approach having high X means more frequent episodes of growth; however, both the low and high X countries will stagnate from time to time. A stylized illustration of the switching process of growth for two countries is presented below in Figure 1.

Country one has a lower level of the growth-conducive characteristic X, and so it spends more time in the stagnation regime. However, it is capable of periods of fast growth. In fact, when it is growing, it grows as fast as country two. Of course, country two with high X visits the growth regime more frequently, and so in the long run it will grow faster. However, it too stagnates from time to time. What determines the long run growth performance of an economy is the within-regime dynamics (3% vs.0), and the frequency of visits to the two growth regimes.

The growth regimes approach calls for identifying the regimes as well as the properties of transitions, including the set of X's and their effect on regime changes. Jerzmanowski (2006) applies the framework of Markov-switching regression to identify the regimes. Assuming that there are four regimes, each with a distinct AR(1) growth process leads to the following model[2]

$$\hat{y}_{it} = \alpha_{s_t} + \beta_{s_t}\hat{y}_{it-1} + \varepsilon_{it}^{s_t}, \tag{1a}$$

$$\varepsilon_{it}^{s_t} \sim i.i.d.N(0, \sigma_{s_t}^2), \tag{1b}$$

where $\hat{y}_{t\,i}$ is the growth rate of country i in period t and s_t indicates the regime that is in effect at time t, that is for every t, $s_t \in \{1, 2, 3, 4\}$.

[2]Unfortunately the correct number of regimes cannot be tested with the simple likelihood ratio test. See Hamilton (1996) for discussion and references. The informal procedure followed by Jerzmanowski (2006) was to start with two regimes and increase the number of regimes as long as all estimated regimes appeared distinct.

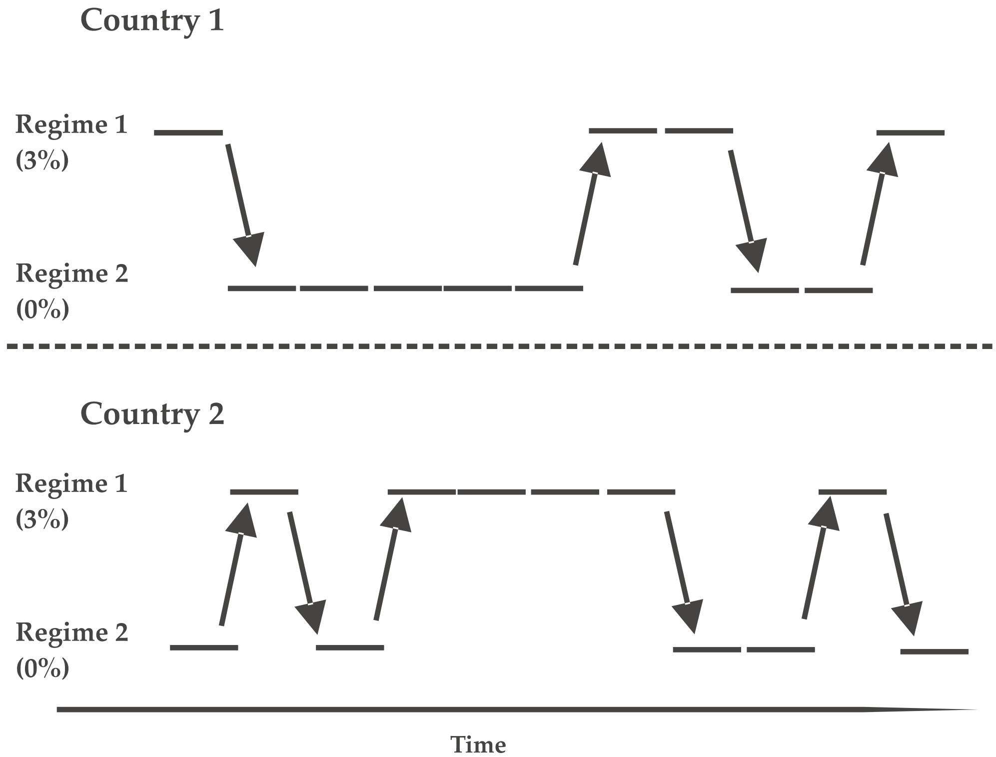

Figure 1: A stylized illustration of the switching process of growth. Some country-specific characteristic X makes the growth regime more likely (e.g. good institutions). Country one has low value of X and so it spends more time in the stagnation regime. However, it is capable of periods of fast growth. Country two has high X and so it visits the growth regime more frequently. However it too stagnates from time to time.

The growth process is fully characterized by the above within regime dynamics (1) and the evolution of regimes, which is assumed to follow a 4-state Markov process where the transition probabilities are allowed to depend on the country's quality of institutions. That is, $P\{s_{it} = k \mid s_{it-1} = j\} \equiv p_{jk} = p_{jk}(z_i)$ for $j, k = 1, ..., 4$, where z_i is a measure of the quality of institutions in country i. This model is estimated using maximum likelihood (see Jerzmanowski (2006) and the Appendix for details). The resulting estimates consist of the within-regime parameters(α's, β's, and σ's), the parameters of the transition matrix $p_{jk}(z_i)$ for $j, k = 1, ..., 4$, and the inference about regimes s_t for *t=1,...T*. We discuss them in turn.

Table 1 shows the parameter estimates. Each of the four AR(1) processes implies a different long run growth rate, i.e. the average growth rate that would obtain if the economy were to remain in that regime indefinitely, given by $\alpha/(1-\beta)$ and shown in the last column. Notice that the these average long run growth rates (from which we derive the regime labels) do not fully characterize the regimes. In addition to the long run average performance, regimes differ significantly in volatility of growth (σ) and persistence of growth shocks (β).[3] The sta-

[3]Note that the within-regime persistence of the growth process β, say 0.3761 for the stable growth regime, should not be confused with the persistence of the stable growth regime itself. The former is assumed to be a common to all countries property of the stable growth process, whereas the latter depends on the

ble regime corresponds to the growth experience predominant among developed economies, with long run average growth of about 2 percent. The volatility is relatively low and there is a great deal of persistence in the growth process. The stagnation regime is characterized by no growth on average and larger volatility of growth shocks. In this regime, periods of growth and decline occur but are not very persistent. The crisis regime is an episode of large shocks to growth. While these shocks tend on average to be negative reflecting economic crises, the dispersion is very large and positive shocks are also possible. These shocks have no persistence. Finally, there exists the regime of fast, miracle-like growth with an average long run growth of 6% and modest volatility.

	Constant (α_s)	AR Coeff. (β_s)	Std. Dev.(σ_s)	Long run Growth
Stable Growth	0.0132**	0.3761**	2.11%	2.12%
Stagnation	0.0010	0.1799**	4.56%	0.12%
Crisis	−0.0101**	-0.0045	13.16%	−1.00%
Miracle Growth	0.0536**	0.1417**	2.71%	6.25%

Table 1: Within regime estimates of $\hat{y}_{t\,i} = \alpha_{s_t} + \beta_{s_t}\hat{y}_{t-1\,i} + \varepsilon^{s_t}_{ti}$, and $\varepsilon^{s_t}_{ti} \sim i.i.d.\, N(0, \sigma^2_{s_t})$ for each of the four states. The first column shows the constant term, the second is the autoregressive coefficient and the third is the estimate of the standard deviation of the error component. The last column shows the implied long run growth. A * denotes significance at 10% level, ** denotes significance at 5% level.

The estimated transition probabilities imply that institutions are more important in sustaining growth than in igniting it. In particular, low quality of institutions countries have significant probability of entering growth regimes, however, the probability of exit is high. In the long run regimes follow an ergodic distribution where low quality of institutions leads to frequent stagnation and crisis whereas high quality, while not ruling out stagnation or crises, reduces their frequency and increases that of the growth regimes. Figure 2 shows the ergodic distribution of time spent in each of the four regimes.

Even if the true value of the parameter vector were known we would not be able to tell with certainty which regime was in effect at any particular moment since regimes are unobservable. However, conditional on the model, the estimated parameters and all the observations for a given country, we can form inference about the probability of the regimes during the sample period. These *smoothed probabilities*, denoted by $\hat{P}(s_t = j|\mathcal{Y}_{mT})$, where $\mathcal{Y}_{mT}$ stands for the entire time series for country m, give us an estimate of the likelihood of each of the four regimes for country m at all sample dates t. For example, $\hat{P}(s_{1979} = 1|\mathcal{Y}_{UST})$

country-specific transition probabilities, which will be discussed below.

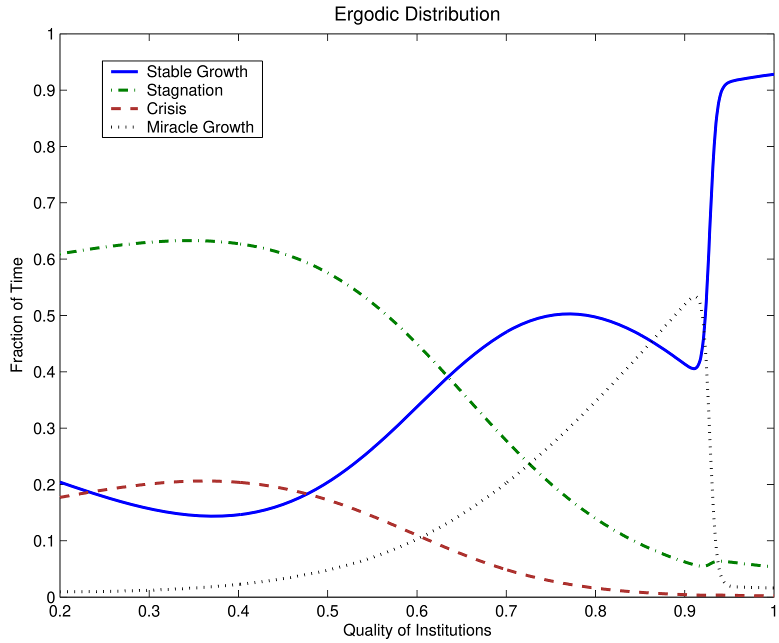

Figure 2: Ergodic probabilities of the four regimes as functions of the quality of institutions.

tells us the (conditional) probability that the US was in the stable growth regime in 1979. Figures 3 and 4 plot examples of the smoothed regime probabilities.

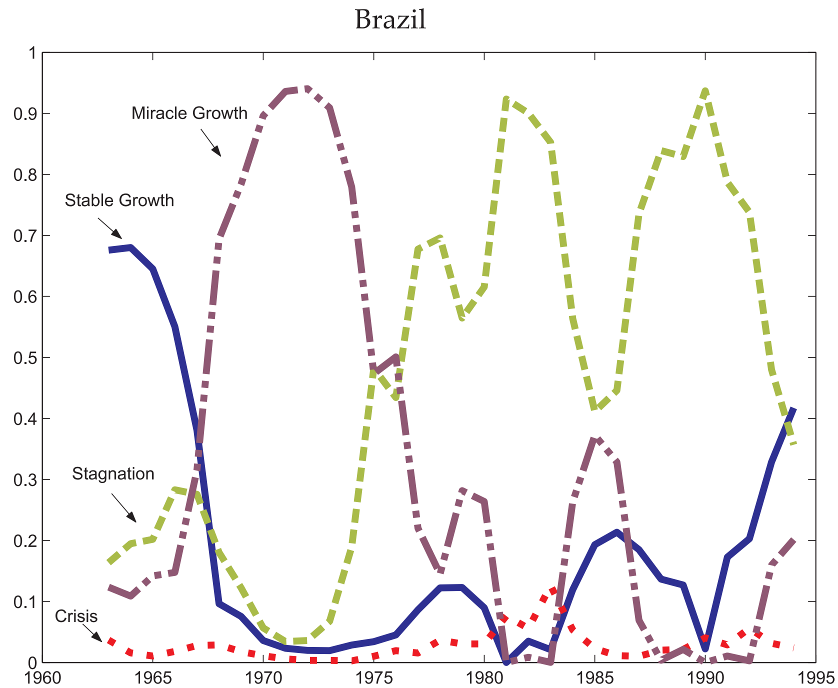

Figure 3: Regime probabilities: Brazil

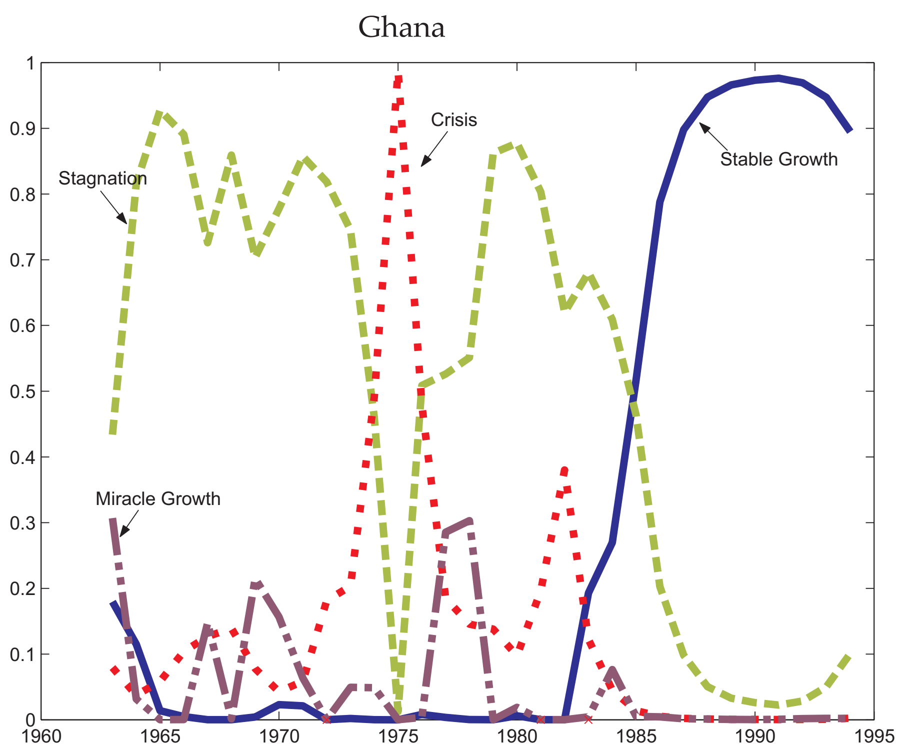

Figure 4: Regime probabilities: Ghana

Table 2 below presents the smoothed probabilities averaged over the sample period 1970-94 for each of the regimes for a selected group of countries. That is, for each country the first column gives the average probability of the stable growth regime $(1/T)\sum_{l=1}^{T}\hat{P}(s_l = 1|\mathcal{Y}_T)$, the second column gives the average probability of stagnation $(1/T)\sum_{l=1}^{T}\hat{P}(s_l = 2|\mathcal{Y}_T)$, and so on. These probabilities tell us what is the average (over sample years) probability that a country was in a given regime. For example, on average the probability that Japan was in the miracle growth regime is 33% while the average probability that it was stagnating is 5%.

country	Stable Growth	Stagnation	Crisis	Miracle Growth	Growth
Hong Kong	0.04	0.17	0.06	0.72	5.56%
Japan	0.62	0.05	0.00	0.33	4.31%
Thailand	0.13	0.33	0.03	0.51	4.36%
Portugal	0.51	0.13	0.01	0.36	3.92%
Malaysia	0.31	0.24	0.03	0.42	3.48%
Egypt	0.50	0.40	0.05	0.06	2.20%
India	0.37	0.51	0.03	0.09	2.10%
USA	0.89	0.07	0.00	0.03	2.04%
Mexico	0.52	0.35	0.02	0.11	1.68%
Chile	0.05	0.45	0.16	0.34	1.64%
Zimbabwe	0.05	0.72	0.15	0.08	1.03%
New Zealand	0.74	0.21	0.01	0.04	0.90%
Bolivia	0.45	0.43	0.08	0.03	0.10%
Cote d'Ivoire	0.02	0.61	0.15	0.22	0.07%

Table 2: The columns report average smoothed probabilities of regimes, i.e. the estimates of regimes' likelihood based on the entire sample. Let $\hat{P}(s_t = 1|Y_T)$, the smoothed inference about the likelihood that regime one was in effect in period t. Column one is $(1/T)\sum_{l=1}^{T}\hat{P}(s_l = 1|Y_T)$, column two is $(1/T)\sum_{l=1}^{T}\hat{P}(s_l = 2|Y_T)$ and so on.

In order to study the joint effect of institutions and policies on growth through their effect on regimes changes, one could follow the same approach as Jerzmanowski (2006) and extend the vector z in the transition probabilities matrix $P(z)$ to include measures of policy. In practice, the estimation is quite computationally intensive even with only one variable. Instead, we use the inference about likelihood of regimes obtained from the estimation of the above model (i.e. the smoothed probabilities) to calculate the average frequency of visits to each of the four regimes, as in Table 2. We assume that the averages frequencies approximate the ergodic regime distribution and use them to compute the average number of occurrences of each regime during the sample period. We then ask how country characteristics, such as quality of institutions and macroeconomic policies, affect the regime probabilities. In particular, we average the estimated probabilities over two subperiods 1970-82 and 1983-1994 and run a pooled multinominal logit. To check the robustness of the results we also estimate several linear specifications and report them in the Appendix. If, as was assumed by Jerzmanowski (2006), quality of institutions is the only variable determining transition probabilities, we would expect to replicate the estimates of the relationship between the ergodic distribution of regimes and institutional quality presented in Figure 2, with departures from this distribution purely random and unrelated to policies. Alternatively, if policies do matter, they will add additional explanatory power in fitting the observed regime distributions. Note that we are not studying the direct effect of policies on regime changes but instead we ask what is their effect on the long run distribution of the frequency of visits to each regime. This means that if we find that a certain policy increases the fraction of time spent in stagnation we will not be able to tell whether this is because the policy increases the persistence of stagnation or because it makes transition to stagnation from other regimes more likely. Unbundling the effect of policies in this way is an important next step and is left for future research.[4]

3 Results and Discussion

This section presents the empirical model and the results. We discuss the results and their relation to existing evidence and theories of economic growth. We also consider extending the model to account for differences along the political dimension of institutions.

3.1 Results

To determine the relationship between policies and institutions and regime frequencies we estimate the following multinomial logit model.

$$\Pr(\text{regime} = j)_i = \frac{\exp(X_i\,\beta_j)}{\sum_{s=1}^{4}\exp(X_i\,\beta_s)}, \qquad (2)$$

$$(3)$$

for $j = 1, 2, 3,$ and 4. $\Pr(\text{regime} = j)$ is the average probability of regime j during the sample periods, and X_i is a vector of country specific characteristics including initial income, quality of institutions and four policy measures: log of average inflation, real exchange rate overvaluation, share of government's consumption in GDP and trade to GDP ratio. Quality of institutions is measured using the rule of law index from Kaufmann et al. (2003). Policy variables are averaged over the relevant period and are taken from World Bank economic

[4] See Kerekes (2009) for an alternative way to extend the approach in Jerzmanowski (2006) to multivariate transition probabilities.

indicators, except the real exchange rate overvaluation, which comes from Dollar (1992). Table 8 in the appendix describes the data.

This model is a simple multinomial logit model with 4 (unordered) outcomes: stable growth, stagnation, collapse and miracle growth. Of course, as discussed above, we don't not actually observe whether a country is in a given regime in any given year but instead we have the (estimated) probabilities of regime occurrences. To proceed with the logit estimation we convert the data on regime probabilities into counts of regime occurrences by multiplying the probabilities by the number of years in the sample. For example, the data in Table 2 corresponds to the period 1970-94 and so multiplying the entries in the first row we attribute to Honk Kong one year of stable growth, four years of stagnation, one year of crisis, and 17 years of miracle growth.[5]

We estimate the above model using pooled data for subperiods 1970-82 and 1983-94. Since the coefficient estimates are not easily interpreted we do not report them here, instead we tabulate the estimated marginal effects at the median. Below we also examine how these effects vary over the entire distribution of the right hand side variables. This is important since, as Easterly (2005) points out, there are often significant outliers in the policy measures.

Table 3 shows the marginal effects of institutions, policies and income on the probability of each of the four regimes for a hypothetical country with all the right-hand side variables equal to the sample median (we refer to it as "median country"). The quality of institutions increase the probability of favorable outcomes - miracle growth and stable growth, while reducing the chances of unfavorable regimes - stagnation and crisis. The size of government lowers the likelihood of miracle growth but compensates by increasing the chances of stable growth and reducing the probability of stagnation and crisis. Trade lowers the probability of stable growth while increasing that of miracle growth; it also increase chances of crisis and stagnation. Both distortionary policies, inflation and real exchange rate overvaluation, increase the chances of stagnation and crisis and lower the chances of stable growth but the effect of inflation is not statistically significant. Their effect on miracle growth is also insignificant. Finally, the level of development as captured by initial income has an independent influence on regimes; it lowers the probability of miracle growth, which is the familiar convergence effect, albeit in a probabilistic sense. That is richer countries are less likely to grow at very rapid rates as predicted by the neoclassical model as well as technology catch-up models. This effect is, however, mitigated by the fact that income also increases the chances of stable growth. Higher income countries also appear to stagnate less and have less frequent crises.

We can use the marginal effect to calculate the change in the probability of each regime given a one standard deviation change in the right hand side variables. These results are displayed in Figure 5.

Clearly, institutions not only deliver the desirable effects (more frequent growth states, less stagnation and crises) but quantitatively also have a large impact. However, the effects

[5] An alternative strategy, would be to estimate a linear model of the log odds-rations, which are given by $\ln(\Pr(\text{regime} = j)_i / \Pr(\text{regime} = 4)_i = X_i \beta_j$ for $j = 1, 2, 3$. where we have normalized $\beta_4 = 0$. Here we could use the probabilities of regime occurrences (Table 2) without the need to compute regime counts. This approach gives very similar results but has the disadvantage of considerably over-predicting (in sample) the probability of miracle growth and we do not pursue it.

Variable	Stable Growth	Stagnation	Crisis	Miracle Growth
Rule of Law	0.202***	-0.199***	-0.064***	0.060***
	(0.026)	(0.026)	(0.012)	(0.015)
Inflation	-0.110	0.058	0.015	0.037
	(0.100)	(0.073)	(0.014)	(0.027)
Overvaluation	-0.310***	0.240***	0.043**	0.026
	(0.065)	(0.057)	(0.018)	(0.031)
Gov't	2.086***	-0.806**	-0.056	-1.224***
	(0.445)	(0.394)	(0.153)	(0.400)
Trade	-0.434***	0.228***	0.046	0.161***
	(0.072)	(0.071)	(0.032)	(0.034)
Initial Income	0.132***	-0.078***	-0.018**	-0.035**
	(0.028)	(0.025)	(0.008)	(0.016)

Table 3: Multinomial logit: marginal effects at the median. Standard errors in parentheses. Significance levels:* 10%, ** 5%, *** 1%.

of government size and trade openness are also nontrivial but they are, to some extent, off-setting across regimes. For example, a one standard deviation increase in trade share means 3.5% more time spent growing fast and 10% less time growing at moderate stable rates. To translate the effects on probabilities of regimes into effects on long run growth we can multiply the effects from Figure 5 by the average long run growth numbers for each regime, reported in Table 1. We can perform a similar calculation for volatility of growth. The results are shown in Table 4. Note that the median growth rate in the sample was 1.46% , so that for the median country a one standard deviation improvement in rule of law results in growth increasing to 2.38% (1.46 + 0.92). On the other hand, a one standard deviation increase in government's size results in growth falling to 1.26%. This relatively small change is a net effect of the offsetting forces; larger government leads to less miracle growth but also less stagnation and more stable growth. Overall, we can conclude that at the median the effect of institutions on growth is much greater than that of any policy.[6] This reflects two findings. First, institutions do have a quantitatively large effect on growth, and second, for some policies the effects on long run growth are off-setting across regimes. Similarly, note that despite evidence of convergence (richer countries are less likely to grow very fast) poor

[6] Policies affect volatility more than average growth but again institutions are more important.

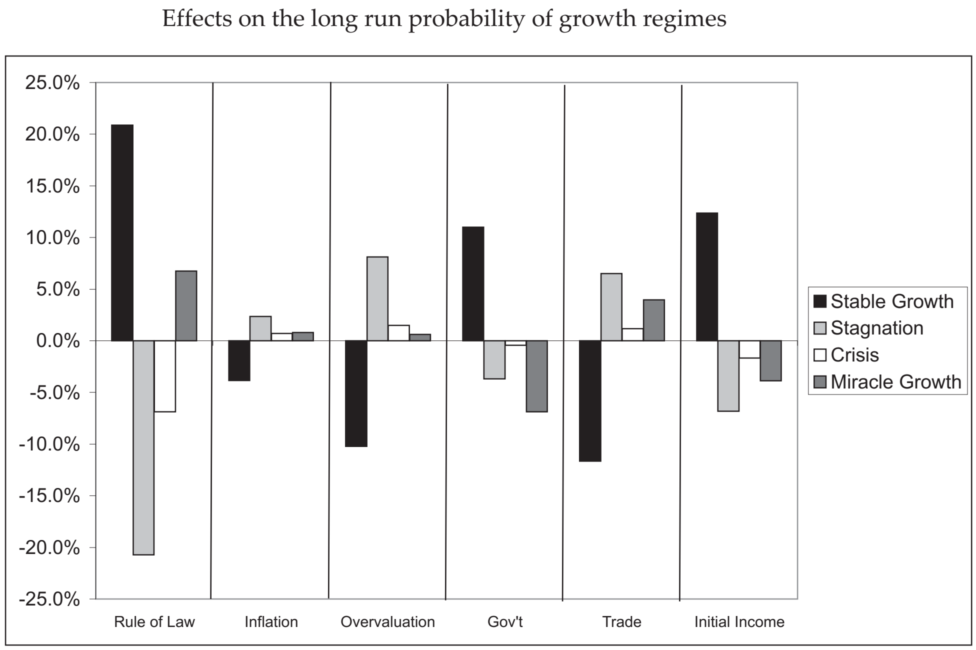

Figure 5: Effects of a one standard deviation change in the right-hand side variables on long run regime probabilities. All right-hand side variables set to the sample median.

countries do not grow faster than rich ones. This is because at lower income levels they are also more susceptible to prolonged periods of stagnation.

Variable	Growth	Volatility
Rule of Law	0.922	-1.270
Inflation	-0.037	0.149
Overvaluation	-0.188	0.388
Gov't	-0.200	-0.195
Trade	-0.004	0.294
Initial Income	0.029	-0.387

Table 4: Change in the average growth rate and volatility in response to one standard deviation change in the right hand side variables. In % points.

Of course, the above calculations do not fully characterize the effects of policies as these are nonlinear and depend on the value of other explanatory variables. That is, the effect of inflation may be much different when it is close to the median level (as in the table above) than when it is in the hyperinflation range. Similarly, the effect on inflation may be different in countries with different quality of institutions. Finally, the distributions of the right hand side variables may be skewed so that a one standard deviation change (as in the table above) may be large or small relative to realistic changes in these variables. To get a better understanding of these effects we will graph them for the entire distribution of the right hand side variables. We will also look at whether the effects differ significantly across countries with different institutional environments.

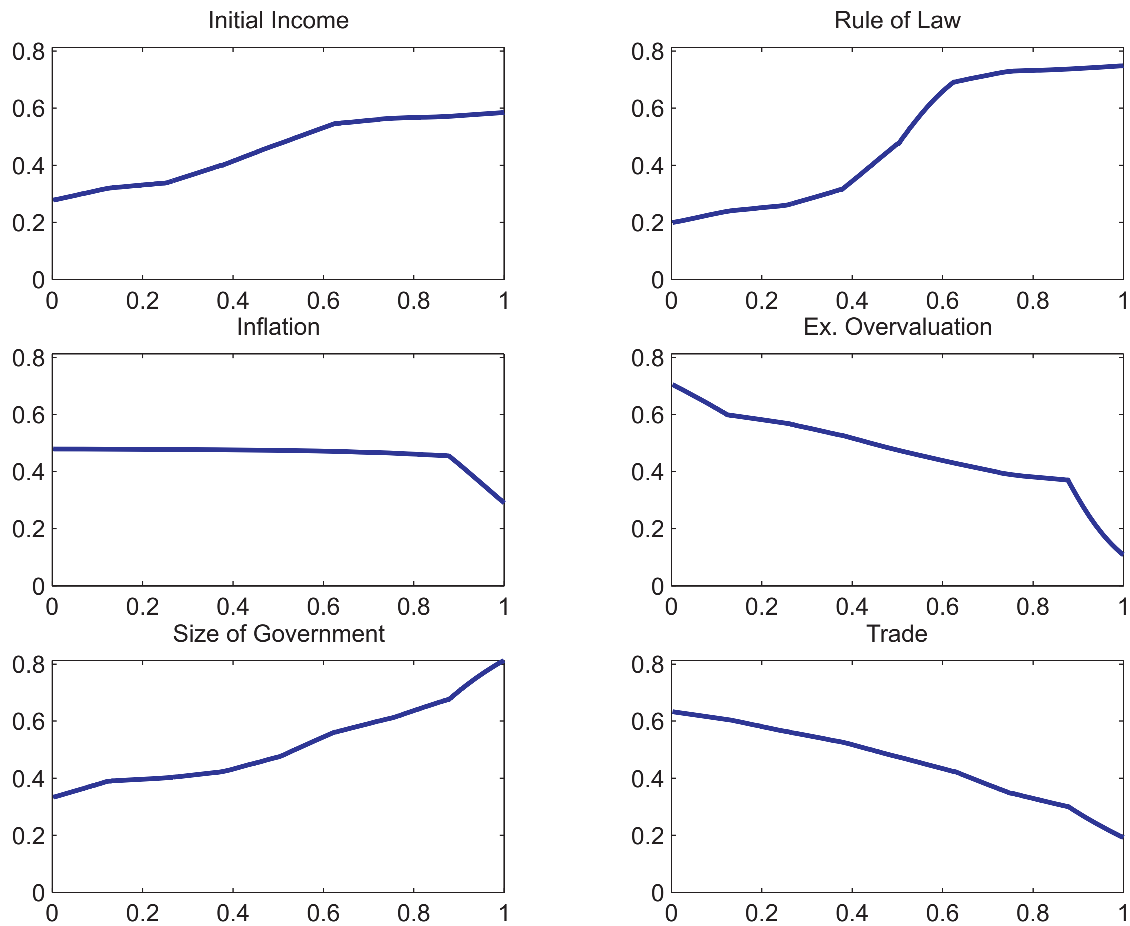

Figure 6: Probability of Stable Growth for the "median country".

Figure 6 shows plots of the probability of the stable growth regime as functions of the six explanatory variables. In each box the probabilities are calculated by setting the value of five variables to the sample median and varying the remaining variable over the percentiles of the sample distribution. The first box shows that for a median country the probability of stable growth is increasing with income. With low income the long run probability of growing at stable rates is one-third, while for the richest country it is 60%. The quality of institutions also improves the chances of stable growth (box two), however, the effect is small in the lower part of the institutions' distribution, it rises sharply around the median, and flattens out again around the 60th. Inflation (box three) has very little effect except for values above the 88th percentile of the distribution where it significantly lowers the likelihood of stable growth. This corresponds to 0.287 log inflation or about 33% annual rate of inflation. Notice that while the effect of inflation on stable growth is consistent with the idea that only extreme values of inflation matter, the threshold is not exceedingly high. Real exchange rate overvaluation has a significant negative effect throughout the distribution but similarly to inflation the effect is much more pronounced beyond the 88th percentile, which is an overvaluation of 47%. The size of the government increases the chance of stable growth; the estimates imply that going from 10% of government consumption in GDP to 20% increases the long run probability of stable growth from 40% to 60%. Finally, trade lowers the probability of stable growth; quantitatively the estimates imply that increasing the trade to GDP ratio from 36% to 96% results in the long run likelihood of stable growth falling from 60% to 20%.

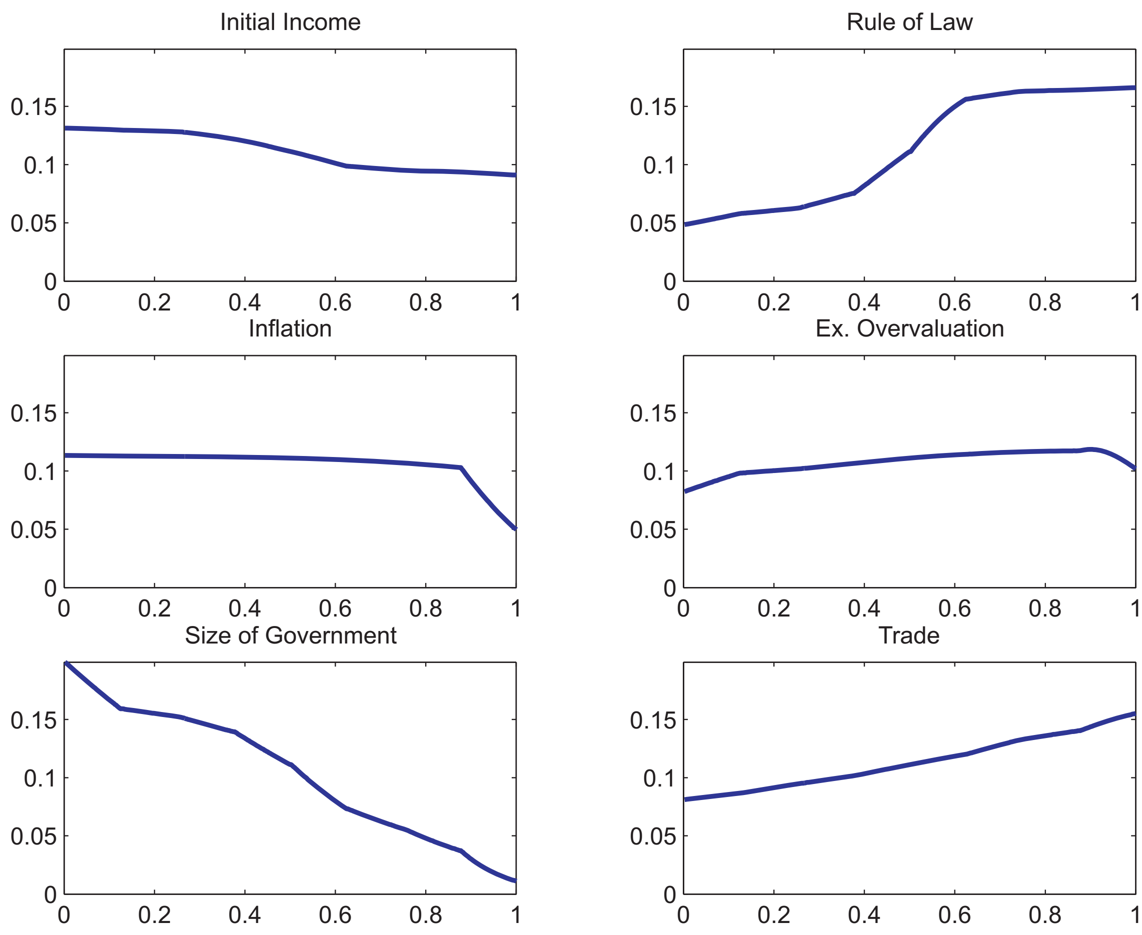

Figure 7: Probability of Miracle Growth for the "median country".

Figure 7 shows the probabilities of the miracle growth regime for a median country. Income lowers the chance of fast growth reflecting convergence but the effect is not very large. As with stable growth, institutions have a positive effect which again is steepest in the middle of the distribution. Inflation matters only above the 88th percentile where it lowers the chances of miracle growth. Real exchange rate overvaluation does not appear to have a large effect. Government size significantly reduces the probability of a growth miracle; increasing the share of government consumption from 10% to 20% reduces the probability from 15% to only 5%. Finally, greater trade openness appears to increase the chances of a growth take-off.

Note that in none of the boxes does the probability of miracle growth exceed 20%. In fact, a hypothetical country with all the right hand side variables set to the most miracle-growth conducive values is predicted to spend 55% of time in miracle growth regime - below actual values for countries like Hong Kong (72%) and Korea (86%). Of course, neither of these countries had the hypothetical perfect policy mix and consequently the model predicts they should spend even less than 55% of time in miracle growth. We conclude from this that while institutions and policy variables do affect the likelihood of miracle growth, there are other factors at work (including possibly pure chance). Section 3.5 below looks at the political dimension of institutions - democracy. It turns out that accounting for both the rule of law and political institutions improves the fit of the miracle growth regime.

Figures 15 and 16 in the appendix show the probability of stagnation and crises, respectively. Both income and quality of institutions significantly lower the chances of stagnation and crisis. The effect of income is particularly pronounced in the case of crisis; a median country beyond the 60th percentile in either the income or the rule of law distributions has a negligible probability of crisis. Values of both inflation and real exchange rate overvaluation above their respective 88th percentiles increase the chances of stagnation and crisis, with overvaluation increasing them slightly even at lower levels. Larger government consumption lowers the probability of stagnation and has no effect on the likelihood of crisis. Finally, trade increases the frequency of crises and also, interestingly, increases the probability of stagnation. Recall that stagnation is a regime where periods of growth are not unlikely; however, they tend not to be sustained and are, in the long run, offset by equally frequent periods of decline, leading to zero long run average growth.

Because of the nonlinear nature of the probability model the effects of one variable depend on the level of the remaining variables. The above calculations were performed keeping those remaining variables at the sample median. It is however interesting to ask how the effects change when we alter the value of some of the other variables. In particular, some authors have investigated the relationship between the quality of institutions and the effects of various other country characteristics on growth(e.g., Burnside and Dollar 2000, Serven et al. 2005). Aghion et al. (2004) show that the relationship between financial openness and volatility may depend on the degree of development of financial markets, which is presumably highly correlated with measures of institutions such as protection of property rights - a part of the rule of law index.[7] The figure below show plots of the miracle growth regime probabilities, calculated as above, for two hypothetical economies: one with the sample's highest value of quality of institutions (solid line) and another with the sample's lowest (dashed line). All other variables remain at the median level.

Figure 8 compares the probabilities of the miracle growth state. The large gap between the two lines indicates how much higher the probability of the miracle regime is for countries

[7]Similarly, Aghion et al. (2008) provide a model and some evidence showing that the effects of fiscal policy on growth again depend on the development of financial markets.

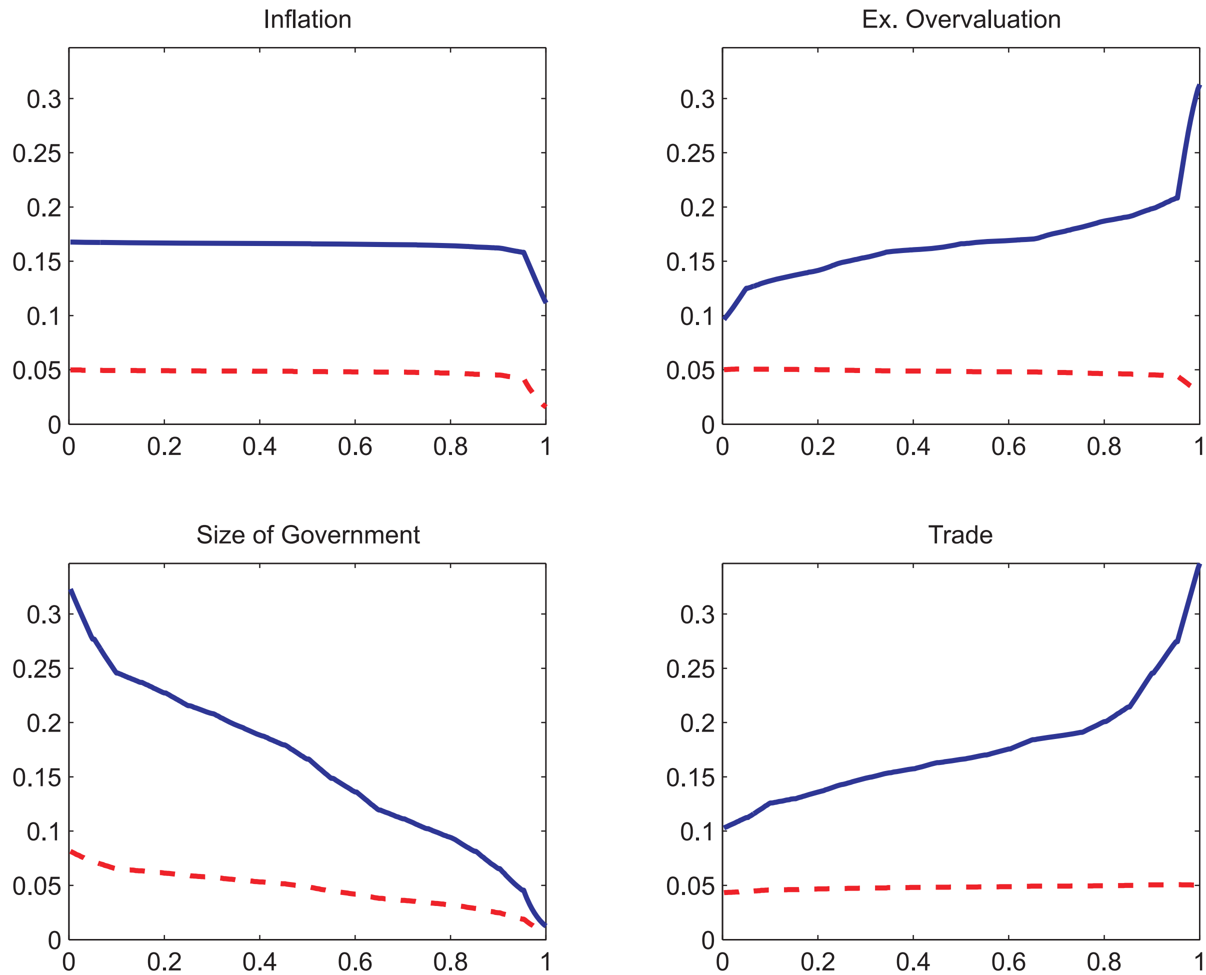

Figure 8: Probability of Miracle Growth for good (solid line) and weak (dashed) institutions countries.

with good institutions. With the exception of inflation, policies have very different effects depending on the quality of institutions. Exchange rate overvaluation, which appears to have no effect for countries with weak institutions, increases the chances of miracle growth for countries with good institutions. The opposite is true for the size of government; while it appears to have little effect when institutions are weak, it greatly reduces the likelihood of fast growth where institutions are strong. Finally, trade does not affect the probability of fast growth with weak institutions but greatly increases it with good institutions.[8]

[8]Plots for the other regimes are presented in the appendix (Figures 18 and 19). The main findings are that: (1) greater share of government consumption in GDP reduces the probability of stagnation for weak-institutions countries, while also increasing, albeit by much less, the chances of a crisis, (2) trade significantly increases the probability of a crisis but only for countries with weak institutions, and (3) extreme inflation increases the chance of a crisis everywhere, but the effect is much stronger with weak institutions.

3.2 Long Run Growth

We can take the approach used to construct Table 4 and translate the effects in Figures 6 - 8 into effects on long run growth and volatility. First, consider again a country with all variables except that of interest set to the sample median (the “median country”) without distinguishing between high and low quality institutions.

	10th Percentile	Median	90th Percentile
Inflation	0	0	−−
Real Exchange Overvaluation	−	−	−−
Government Spending	−	−	+
Trade	−	−	−
Rule of Law	+	++	0
Initial Income	+	+	0

Table 5: Effect on long run growth at the 10th percentile, the median, and the 90th percentile of variables' distribution. Effects are categorized as strongly negative (−−), negative (-), negligible (0) , positive (+), and strongly positive (++).

Figure 9 shows the effects of policies on long run growth for the median country (The qualitative summary is presented in table 5). Inflation does not significantly affect growth as long as it remains below the 88th percentile or about 33%, however, instances of extreme inflation have a devastating effect on growth. Exchange rate overvaluation, especially when it is extremely high, lowers growth. The size of the government initially lowers growth and then raises it but the overall effect is small. This is a result of two offsetting forces affecting the median country. As government size increases the likelihood of miracle growth falls, however, so does the probability of stagnation, and the probability of stable growth rises significantly. This suggests that otherwise identical countries with different sizes of government may grow at similar rates but the nature of the growth process will be different. Countries with lower size of government will go through periods of stagnation but will also enjoy periods of fast growth. Countries with higher size of government are more likely to grow at moderate but uninterrupted rates.

Figure 10 shows the effect of initial income and quality of institutions. As could be anticipated from the effects on regime probabilities, institutions have a stronger effect on long run growth than any of the policies examined in Figure 9. Note however, that the effect is greatest around the median of the quality of institutions distribution. While the levelling off could well be expected at high levels of institutional quality, the relatively smaller effect for low quality of institutions is not obvious. It suggests the existence of a “threshold effect” with regards to institutions and casts doubt on the possibility of a sustained acceleration of growth in weak rule of law countries by gradual improvement of institutions.

Figure 11 contrasts the long run growth effects of policies for countries with good (solid

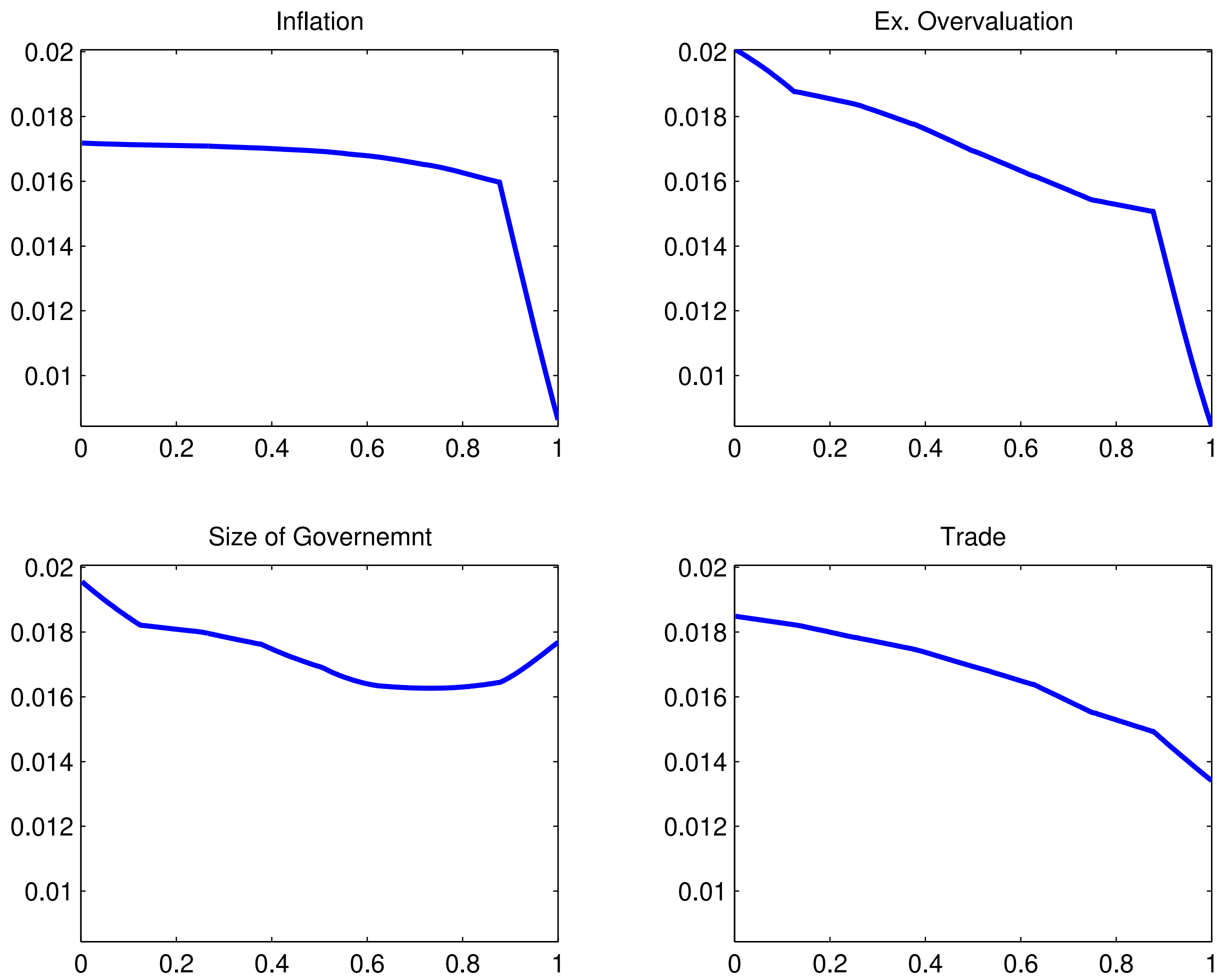

Figure 9: Effects of policies on growth in the "median country".

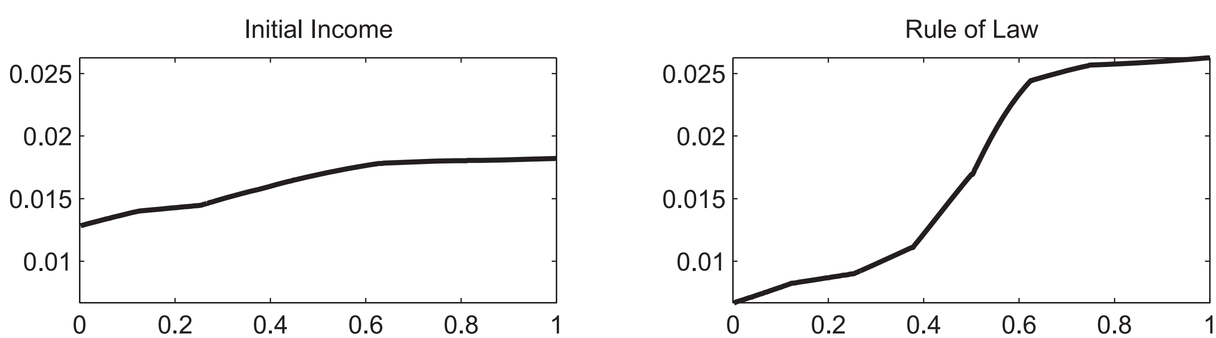

Figure 10: Effects of initial income and institutions on growth in the "median country".

line) and weak institutions(dashed line). The plots show growth relative to that of a country with all variables set to the sample median. Weak institutions appear to make economies more vulnerable to the damaging effect of real exchange rate overvaluation and high inflation. The size of government lowers growth for countries with good institutions in the entire range, while for countries with weak institutions it lowers growth, albeit less strongly, below median and raises it sharply above the median. As discussed above, this is a consequence of the differential effect of government on the likelihood of stable growth versus miracle growth - it increases the former while lowering the latter. For good-institutions countries, where stable growth is the most likely regime this lowers average growth. However, for weak-institutions countries, where stagnation dominates, stable growth is rare and miracle growth is even rarer, it raises growth.

Trade's effect on growth also depends on institutions; it is positive when institutions are good but turns strongly negative when they are weak. The beneficial effect of trade is to increase the likelihood of miracle growth while the cost is the increase in a probability of a crisis. The former effect is very strong with good institutions but virtually nonexistent with weak ones (Figure 8). The latter on the other hand is insignificant for countries with good institutions and quite strong for weak institutions (Figure 19 in the appendix).

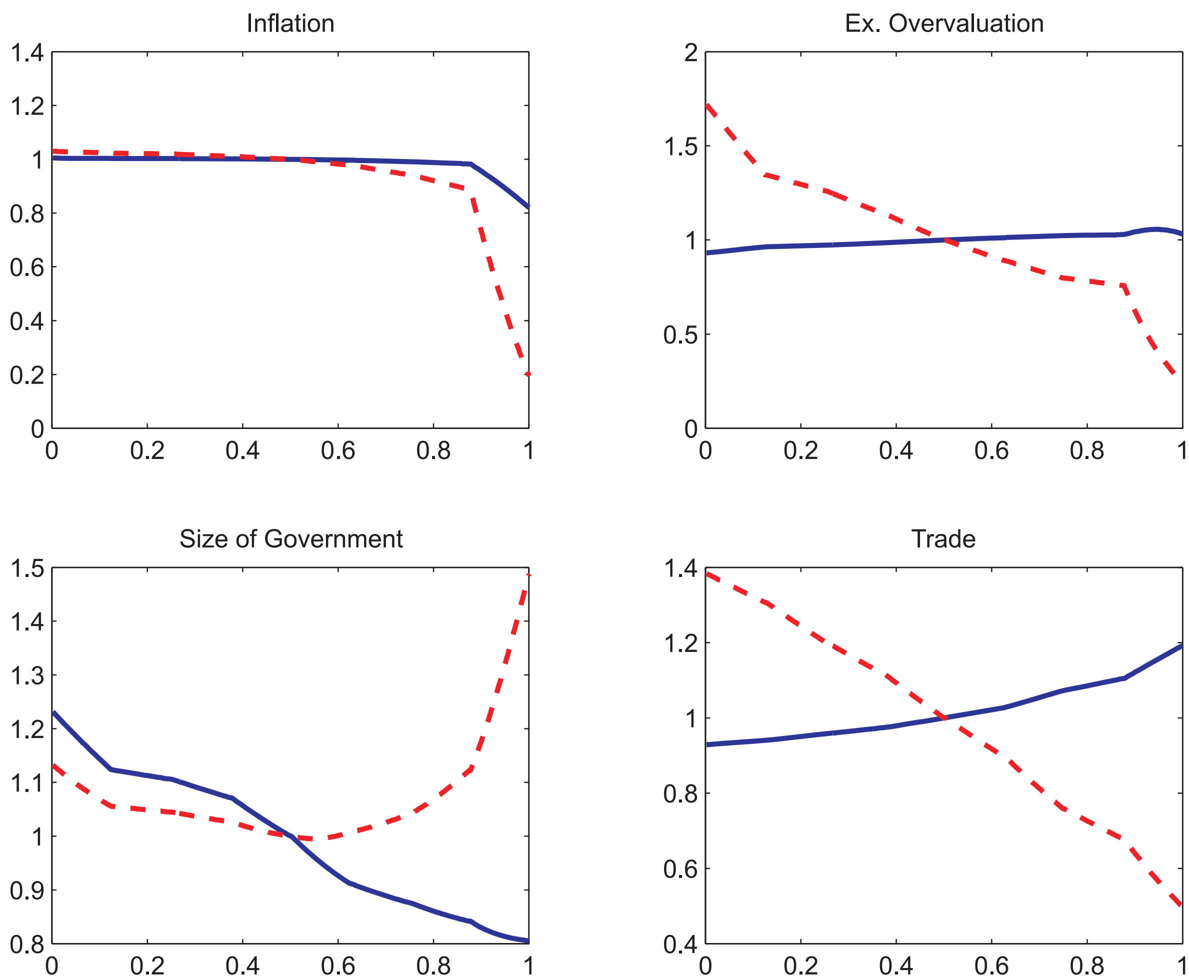

Figure 11: Effects of policies on growth for good (solid line) and weak (dashed) institutions countries. The vertical axis measures growth relative to an economy where all variables are equal to the median.

These results, summarized in Table 6, suggest that the relationship between policies and institutions is potentially quite complex and goes beyond the view that bad policies are merely a manifestation of weak institutions, which are the ultimate determinants of economic development (e.g. Acemoglu et al. 2003).

		10th Percentile	Median	90th Percentile
Inflation	Good Inst.	0	0	−
	Weak Inst.	0	0	−−
Real Exchange Overvaluation	Good Inst.	0	0	0
	Weak Inst.	−	−	−−
Government Spending	Good Inst.	−	−	−
	Weak Inst.	−	0	++
Trade	Good Inst.	+	+	+
	Weak Inst.	−	−	−

Table 6: Effect on long run growth at the 10th percentile, the median, and the 90th percentile of variables' distribution; good institutions vs. weak institutions. Effects are categorized as strongly negative (−−), negative (−), negligible (0) , positive (+), and strongly positive (++).

The four growth regimes differ not only with respect to average growth rates but also volatility of the growth process. Below we present the estimated effects of policy variables on the volatility of growth. Figure 12 shows the effects for the median country. Only extreme values of inflation raise volatility significantly while both real exchange rate overvaluation and trade increase volatility at all levels. The size of the government tends to reduce volatility, especially above the median of the sample distribution. This is the effect of trading-off fast growth for stable growth seen before.

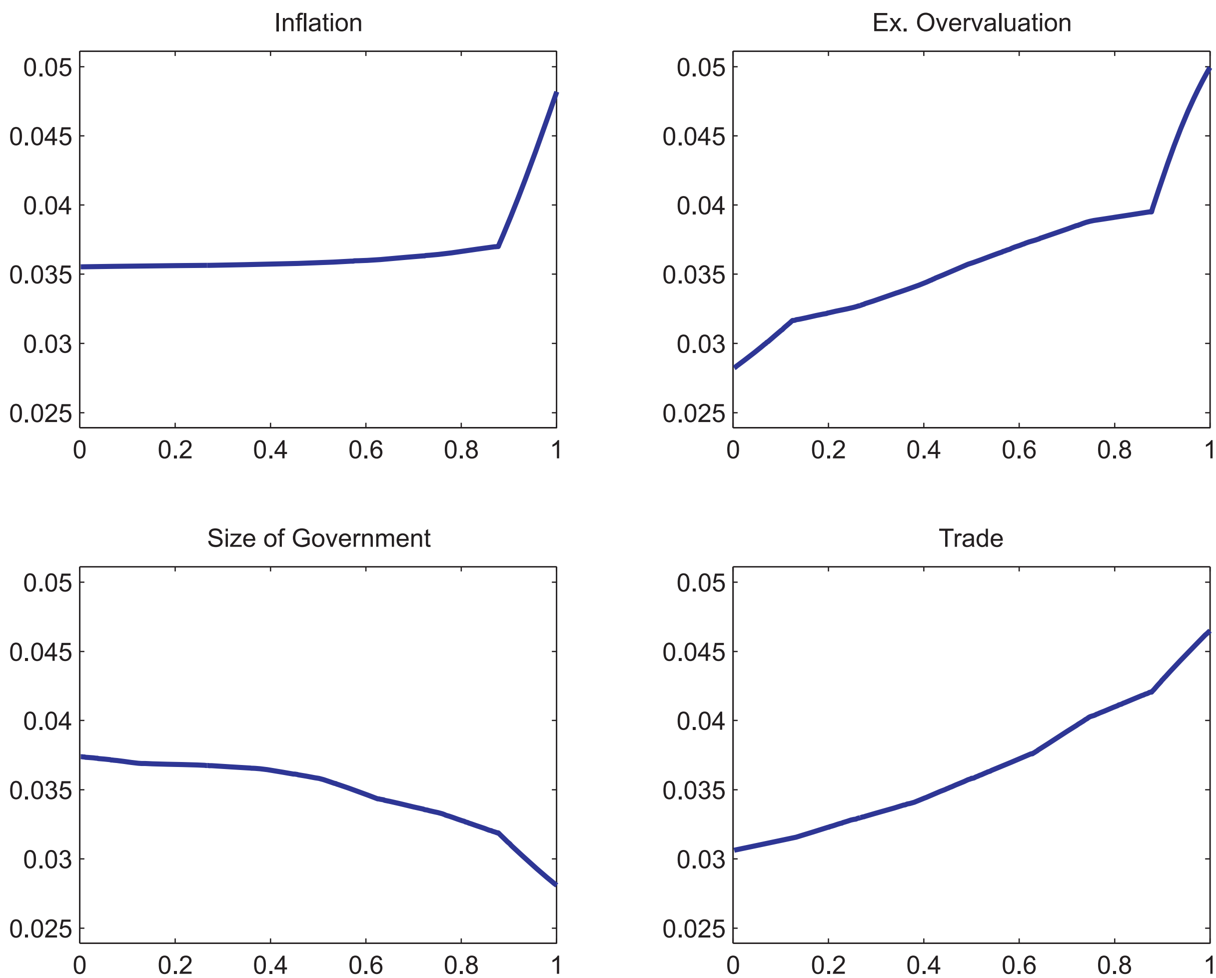

Figure 12: Effects of policies on volatility in the “median country”.

3.3 Discussion

The most interesting results can be summarized as follows: (1) Institutions have a strong effect on growth and volatility but this effect is also nonlinear; it is greatly diminished for both very high quality of institutions and, more surprisingly, for very low quality of institutions. (2) Macro policies have a smaller, but non-negligible, influence on the growth process. While only extreme values of inflation and real exchange rate overvaluation affect growth, government size and trade have significant effects even at the median. There are, however, offsetting forces governing the effects of the latter two policy variables. While government size increases the likelihood of stable growth and reduces that of a crisis, it also limits the economy's ability to grow very fast. On the other hand, trade increases the chances of miracle growth but also makes crises more frequent. (3) The effects of macro policies depend on the quality of the underlying institutions. In general, weak institutions make economies more vulnerable to the adverse effects of high inflation and exchange rate overvaluation. Moreover, government size is harmful to growth in countries with good institutions while it is conducive to growth in countries with weak institutions. Trade on the other hand, is conducive to growth in countries with good institutions while it is harmful to growth in countries with weak institutions. That is, there may not be a"one-size-fits-all" growth strategy. (4) While there is evidence of the *convergence* effect - lower income increase the probability of miracle growth, there is also a countervailing effect - high income (independently of the quality of institutions) makes stable growth more likely and reduces frequency of crises.

The beneficial effect of institutions is consistent with the large body of evidence from cross country growth studies as well as most theories that model the link between the protection of property rights and growth (e.g. Murphy et al 1993). However, the finding that at low levels of institutions improvements in their quality lead to relatively small growth gains is new. It suggests that incremental institutional reform as the key to sustained growth is unlikely to succeed in countries with very low initial quality of institutions. It suggest a possibility of an *institutional poverty trap*. Similarly, the positive effect of trade on miracle growth is consistent with the idea that trade fosters technology transfer and enhances efficiency. On the other hand, the adverse effect of trade - manifested through greater likelihood of crisis and stagnation is consistent with many theoretical models suggesting negative effects of trade on development (Young 1991, Mountford and Galor 2008). Trade may, for example, lead to specialization in a few sectors resulting in less diversification and greater potential for crisis. In addition, specialization in sectors with limited potential for learning by doing or technology transfer may result in long run stagnation.[9] The results further imply that good institutions appear to allow the economy to reap the benefits of trade while minimizing the adverse effects.[10] Larger government, usually found to be detrimental to growth (Barro 1991) is also identified as having two offsetting effects. First, it lowers the chances of fast growth. This could be because of crowding out of private investment or because large government leads to greater distortions, a higher degree of intervention, large and inefficient

[9]Recall that stagnation is a regime where periods of growth are not unlikely; however, they tend not to be sustained and are, in the long run, offset by equally frequent periods of decline, leading to zero long run average growth.

[10]See Chang, Kaltani and Loayza (2005) for similar empirical findings and some theory.

state sector, limits on competition, etc. However, large government size also makes the economy more stable and less prone to stagnation. Note that this implies that an optimal policy for an open economy may involve maintaining a large government. This is in fact what Rodrik (1998) finds in the data. It is also consistent with his explanation, namely that large government offsets the volatility due to external shocks. Again, the relative strength of the two opposing effects of government size depends on the quality of institutions. With good institutions the negative effect dominates and government size is harmful to long run growth. With weak institutions, however, the positive effect may dominate making government size conducive to growth. One potential explanation of this finding relies on the idea of weak and strong states. In a recent paper Acemoglu (2005) builds a model with self-interested rulers of various degree of economic power (ability to tax).[11] He argues that economically weak states are detrimental to growth because self-interested rulers are unlikely to invest in growth-enhancing infrastructure and provide public goods (for e.g. courts, law enforcement, etc.) with no prospect of appropriating the fruits of growth. On the other hand, strong states may also be detrimental to growth by excessively taxing or otherwise expropriating citizens and thereby eliminating incentives to invest and innovate. If we view the size of government as a proxy for the strength of the state, the present findings are consistent with the idea that in countries with weak rule of law benefits from stronger states dominate; perhaps because weak rule of law discourages private provision of infrastructure or other public goods. On the other hand, in countries with strong rule of law the negative side of strong state is more powerful.[12]

In a recent paper Aghion et al. (2008) argue that effects of fiscal policy may depend on the degree of development of financial markets. In the model they present volatility has a negative effect on growth in a credit constrained economy because it decreases investment in long term innovative projects. Counter-cyclical fiscal policy, by limiting volatility, may thus be conducive to growth in countries with weak credit markets. They provide evidence in support of this conclusion using a panel of OECD countries. The present paper uses data on developed as well as developing countries and does not use a specific measure of counter-cyclicality of fiscal policy. However, we can, in a loose and somewhat indirect way, compare the present results with their paper. It may appear that our results are similar since we find that the size of government, which may capture at least the potential for stabilizing fiscal policy, does appear to promote growth in countries with weak rule of law, an aspect of institutions crucial for development of financial markets. However, the mechanisms seems different from the one proposed by Aghion and his co-authors since higher average long run growth is a result of greater frequency of stable growth and lower frequency of stagnation.

[11] Acemoglu also considers political power (ability to stay in office)

[12] Another explanation of this differential effect may be that government provides public goods (e.g. infrastructure) and its size is only detrimental to growth beyond a certain threshold (see Barro 1990) and it is the rich/good-institutions countries that have the largest governments. However, in our sample the correlation between size of government and rule of law index is only 0.36. Alternatively, the explanation may lie with the different composition of spending between countries with high and low qualities of institutions. However, the pattern of the effects of government on the different regimes suggest that the explanation has to do with the stabilizing role of large government (lower probability of crisis) and its ability to avoid prolonged stagnation, on the one hand, and the detrimental effect on the possibility of miracle growth take-offs, on the other.

The likelihood of fast miracle-like growth, which presumably would increase with faster rate of innovation, actually declines with larger government.[13] Note finally, that the finding that large government may be conducive to growth when institutions are underdeveloped, combined with the relatively weak effect of improving institutions when their quality is very low, may suggest maintaining large government while building institutions as a growth maximizing strategy for low quality of institutions countries. When institutions are sufficiently good the country would switch to "small government" policy. This is similar to Aghion et al (2004) idea of appropriate institutions, whereby at early stages of development limiting competition may be optimal. As in their case, this policy may run into political economy problems when government incumbents resist a switch to a policy that limits their power.

Finally, the level of income seems to have an independent effect on regime probabilities. It lowers the likelihood of miracle growth but also increases the chance of stable growth and reduces those of a crisis. These effects are consistent with various convergence mechanisms (diminishing returns, technology diffusion) as well as with the idea that greater development allows greater diversification (e.g. Acemoglu and Zilibotti 1997).

3.4 Robustness and Relation to Growth Regressions

Two important questions may be posed about the above analysis. First, are the results robust to the various modeling choices made (the Markov-switching model for probability detection, the multinomial logit model for regime probabilities, etc.). Second, how different are these result from standard growth regressions estimated using average growth rates. The issue of robustness is explored more fully in the appendix, which uses linear probability specifications as well as an alternative regime detection method to obtain very similar results (it also attempts a rudimentary endogeneity correction with the linear specifications). Here we present one of the linear specifications highlight the distinctness of the above results from conventional growth regressions.

Columns 2-5 of Table 7 present the results of a linear (panel) probability model estimated using the same data as the multinomial logit above. Obviously, this specification does not allow for the nonlinearities discussed above but the average effects appear similar to those reported for the logit model. We again find the differential effect policies across regimes, for example the size of government increase the chances of stable growth but lowers that of miracle growth while trade shows the opposite pattern. To contrast this with the conventional approach, the first column reports the estimate of a standard growth regression (i.e. one with average growth on the left-hand side) using the same data. The results reflect the standard findings in the literature, in particular we find no effect of government size or trade and a significant and negative effects of initial income. Thus it appears that averaging growth over episodes of fast growth, stagnation, stable growth and crises makes us miss the rich pattern of the effects government size, trade openness and initial income on the growth process.

[13]In a similar spirit, Aghion et al. (2006) argue that development of financial markets mitigates the negative effects of exchange rate volatility on growth. In one of their empirical specifications they show that the effect of the real exchange overvaluation is harmful to growth at lower levels of financial development but turns positive at higher levels. Again this is consistent with the effect of overvaluation of growth in panel two of Figure 11, if we treat rule of law as a proxy for the development of finical markets.

Variable	Avg. Growth	Stable Growth	Stagnation	Crisis	Miracle Growth
Rule of Law	0.012^{***}	0.141^{***}	-0.145^{***}	-0.058^{**}	0.062^{**}
	(0.003)	(0.058)	(0.035)	(0.021)	(0.033)
Inflation	-0.009^{***}	-0.050	0.006	0.010	0.033
	(0.003)	(0.084)	(0.043)	(0.043)	(0.031)
Overvaluation	-0.018^{***}	-0.197^{**}	0.135^{**}	0.084	-0.022
	(0.006)	(0.102)	(0.072)	(0.050)	(0.047)
Gov't	-0.028	1.556^{***}	-0.568^{**}	0.063	-1.051^{**}
	(0.049)	(0.635)	(0.333)	(0.397)	(0.610)
Trade	0.005	-0.328^{***}	0.136^{**}	0.021	0.171^{**}
	(0.007)	(0.130)	(0.077)	(0.043)	(0.102)
Initial Income	-0.012^{***}	0.106^{**}	-0.042	-0.018	-0.045^{*}
	(0.003)	(0.058)	(0.041)	(0.016)	(0.028)
R^2	0.31	0.55	0.58	0.38	0.13
N	118	110	110	110	110

Table 7: Panel. Standard errors clustered by country in parentheses. Significance levels:* 5%, ** 1%.

If countries with different sizes of government do not grow at significantly different rates over longer periods of time, it is not because government size does not matter for growth, as the convectional regressions suggest, but because government has offsetting effects by facilitating slower but stable growth at the expense of rapid accelerations. Knowing this is obviously important for understanding economic growth, both from the theoretical and practical perspective, but it is something conventional regressions cannot inform us about. For example, if we can determine what about government spending makes stagnation less frequent, and what makes miracle growth less likely, we are in better position to design growth-promoting policies.

3.5 Democracy

The above analysis used a measure of the rule of law as an indicator of institutional quality. The rule of law, while itself a fairly broad concept, captures only a limited, if important, aspect of institutional environment. Given the recent consensus on the importance of institutions in the process of development there is a growing interest in “unbundling” institutions

- i.e. studying in greater detail the effects of different aspects of institutions and the channels through which they affect development. One such unbundling would be a separation of "economic" institutions, i.e. those that have to do with protection of private property, enforcement of contracts, etc. from political institutions, i.e. the way in which government is chosen and what constraints on its actions exist. This section attempts such unbundling by treating the rule of law index as a measure of "economic" institutions and extending the above analysis by including a Polity IV measure of democracy alongside the rule of law in the set of explanatory variables.[14] This decreases the sample size somewhat so we decide to treat this analysis in separation from the above main results.

The question about the relationship between democracy and development is an old one and a consensus in the literature has emerged suggesting that democracy may have little effect on development (Tavares and Wacziarg 2001) or an inverted U relationship with growth (Barro 1996). These results are usually explained by arguing that democracy has both positive and negative effects on growth. In particular, Tavares and Wacziarg show that democracy fosters accumulation of human capital, but retards that of physical capital and increases the size of the government. The resulting net effect on long run growth is slightly negative. In the context of the present approach it is therefore natural to ask whether democracy affects the likelihood of growth regimes differently (and possibly in an offsetting fashion). Another motivation for extending the list of explanatory variables comes from the fact that the model does not do a good job at explaining miracle growth. Figure 20 (in the appendix) shows a plot of the fitted versus actual probabilities of miracle growth. Clearly, the model severely underestimates the likelihood of sustained miracle growth of the kind we have observed in several East Asian countries. It turns out that controlling for the level of democracy improves the model's performance considerably as can be seen in Figure 21 in the appendix.

The inclusion of democracy does not change the estimated effects of policies substantially so we omit their exposition and focus on the effects of the rule of law, level of income and democracy.[15] Figure 13 below shows the estimated effects, evaluated at the median, of a one standard deviation change in initial income and the rule of law index from the model without democracy (these are the same estimates as in figure 5 and table 4).

As discussed above, rule of law increases the probability of good regimes (miracle and stable growth) while income increases the likelihood of stable growth and lowers that of stagnation but also decreases the frequency of miracle growth (convergence effect). Figure 14 shows the effects in a model with democracy included among the explanatory variables.

Democracy increases the likelihood of stable growth and the estimated effects of rule of law and income are now reduced. Democracy also slightly increases the probability of stagnation and has a negative effect on the chance of a crisis that is similar in magnitude to that of rule of law. Most importantly, however, democracy significantly lowers the likelihood

[14]In practice the variable rule of law aggregates information on protection of property right, contract enforcement as well as some aspect of the judiciary and the overall level of crime and violence.

[15]One interesting change is that the effect of the rule of law on growth does not flatten out at high levels, i.e. it goes from being S-shaped (see figures 6-16) to being J-shaped. It suggests that the flattening out was a consequence of the correlation between democracy and rule of law.

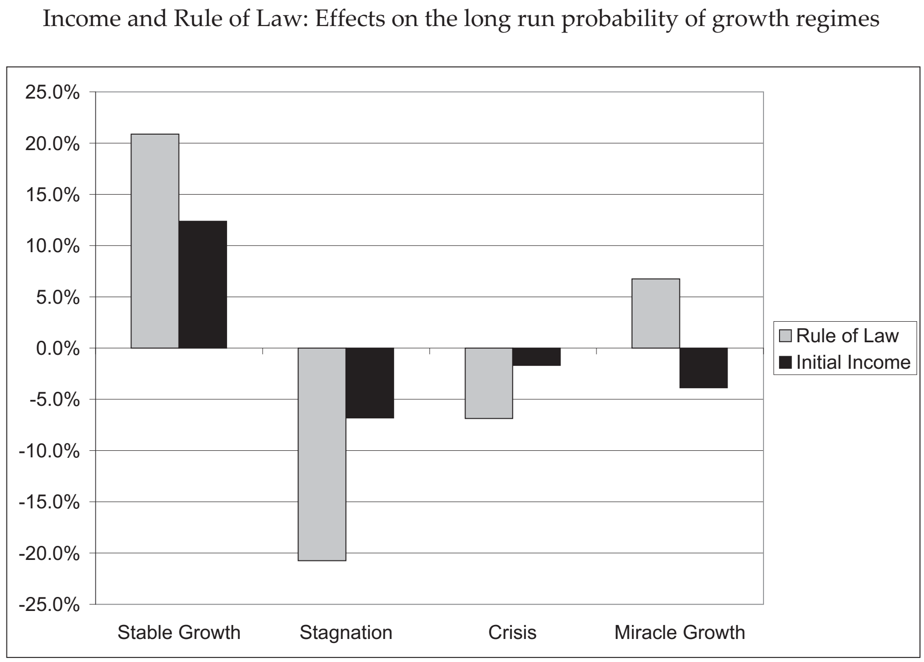

Figure 13: Effects of a one standard deviation change in initial income and rule of law index on long run regime probabilities. All right-hand side variables set to the sample median. Model without democracy.

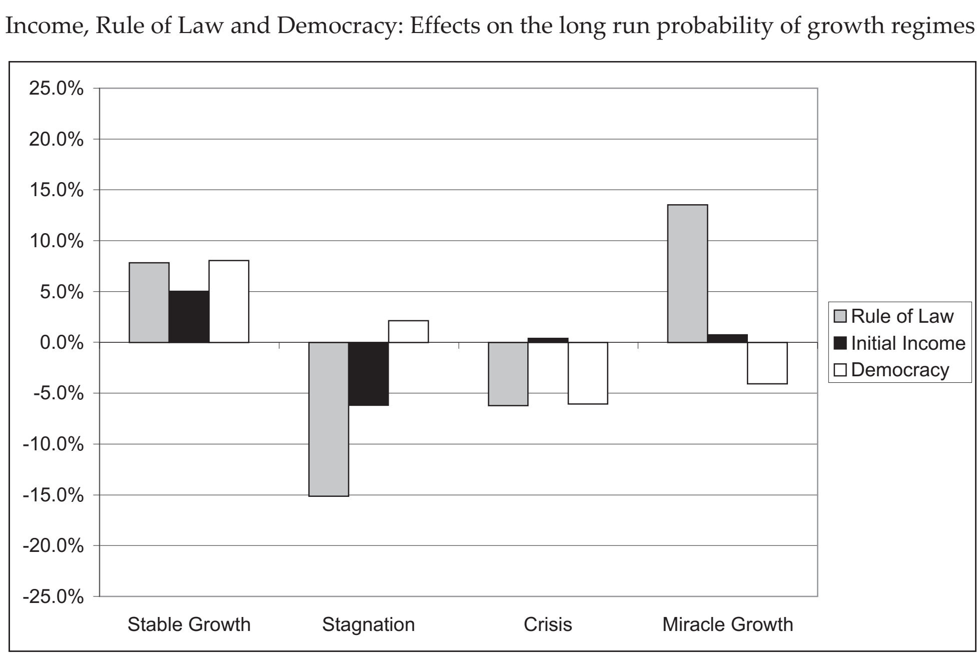

Figure 14: Effects of a one standard deviation change in initial income, rule of law index and democracy score on long run regime probabilities. All right-hand side variables set to the sample median.

of miracle growth episodes. Furthermore, once democracy is accounted for, income has a positive and small effect on the probability of miracle take-off. That is richer countries are less likely to grow rapidly because they are more democratic. This suggests that the convergence effect uncovered before works mainly through the political economy channel and not through standard channels such as diminishing marginal product of capital or technological catch-up.[16] This is consistent with the view of Olson (1982) who argued that democratic societies may stagnate in the long run due to the detrimental effect of special-interest groups which are able to organize and lobby for inefficient policies. Overall, the results imply that democracy favors the middle at the expense of extremes - either very fast growth or severe crises.

4 Conclusions

Recent empirical growth literature has documented a large degree of within-country variation in the process of economic growth (Hasumann et al. 2005, Jones and Olken 2008, Jerzmanowski 2006). Growth appears to be a sequence of accelerations, slowdowns and crisis rather than a smooth process, which is well characterized by the long run average alone. This approach highlights the complex nature of growth and implies that understanding long run growth requires studying the process of "growth transitions", i.e. switches between periods of growth acceleration, stagnation and collapse. The present paper contributes to this literature by analyzing the role of institutions and macroeconomic policies in these transitions. Within this framework it also reexamines the link between policies and long run growth and is thus related to the the recent literature, which finds little association between macroeconomic policies and growth once institutions are accounted for (e.g. Acemoglu et al 2003, Easterly 2005).

The approach we take builds on Jerzmanowski (2006), who identifies four growth regimes: stable growth, stagnation, crisis and miracle growth. We estimate a multinomial logit and examine the joint effect of policies and institutions on growth through their effects on frequencies of visits to the four regimes. The results confirm some of the existing findings, namely that institutional quality is a very important determinant of long run growth, as well as Easterly's finding that only extreme values of the inflation rate have a significantly negative effect on growth. However, macro policies; inflation, trade openness, size of government, and real exchange rate overvaluation also matter for changes in growth patterns and thus influence the average growth and volatility in the long run. Crucially, the policies also differ in the channel through which they affect long run growth. For example, trade lowers the probability of stable growth and increases that of a crisis, while also making miracle growth more likely. The size of government, on the other hand, lowers the chances of miracle growth, while increasing the probability of stable growth at moderate rates. In addition, the effects of policies depend in an important way on the quality of institutions. In general, low quality of institutions makes economies more vulnerable to the harmful effects of inflation and real exchange rate overvaluation. In some cases the direction of the effect is actually

[16]Note that to the extent that Lipset hypothesis holds, i.e. democracy increases with income, this effect will still lead to the standard convergence, whereby poor countries are catching up to the rich. However, see Acemoglu et al (2008) for evidence against the Lipset hypothesis.

reversed; trade appears to be conducive to growth for countries with good institutions and detrimental to growth for countries with weak institutions; it raises volatility regardless of institutions. The size of government has the opposite effect - it lowers growth when combined with good institutions and increases it with weak institutions. Extending the model to include a measure of the political institutions we find that democracy favors the middle at the expense of extremes - either very fast growth or large crises.

The next step should be a more detailed analysis of the role of policies in the dynamic process of changing regimes rather than just in determining the average time spent in each regime as was done here. As the results with democracy highlight, a further unbundling of institutions should be pursued. It should also be noted that the measure of institutions used here together with initial income and policy variables have limited power to explain the probability of fast miracle-like growth. Accounting for democracy improves this aspect of the model's performance but other factors omitted from the present analysis may also be important determinants of miracle growth.

While the estimated effects of policies are smaller than that of institutions, the latter effect is strongest around the median of the institutions distribution and is less powerful for countries with exceptionally weak institutions. On the other hand, the joint influence of policies on growth and volatility and thus welfare is not negligible. Moreover, the recent evidence linking institutions to events in distant past, such as colonial experience, suggests that institutions are difficult and slow to change. Thus the moderate effects from policies might be the best that can be achieved, at least at reasonable time horizons.

A Additional Figures and Tables

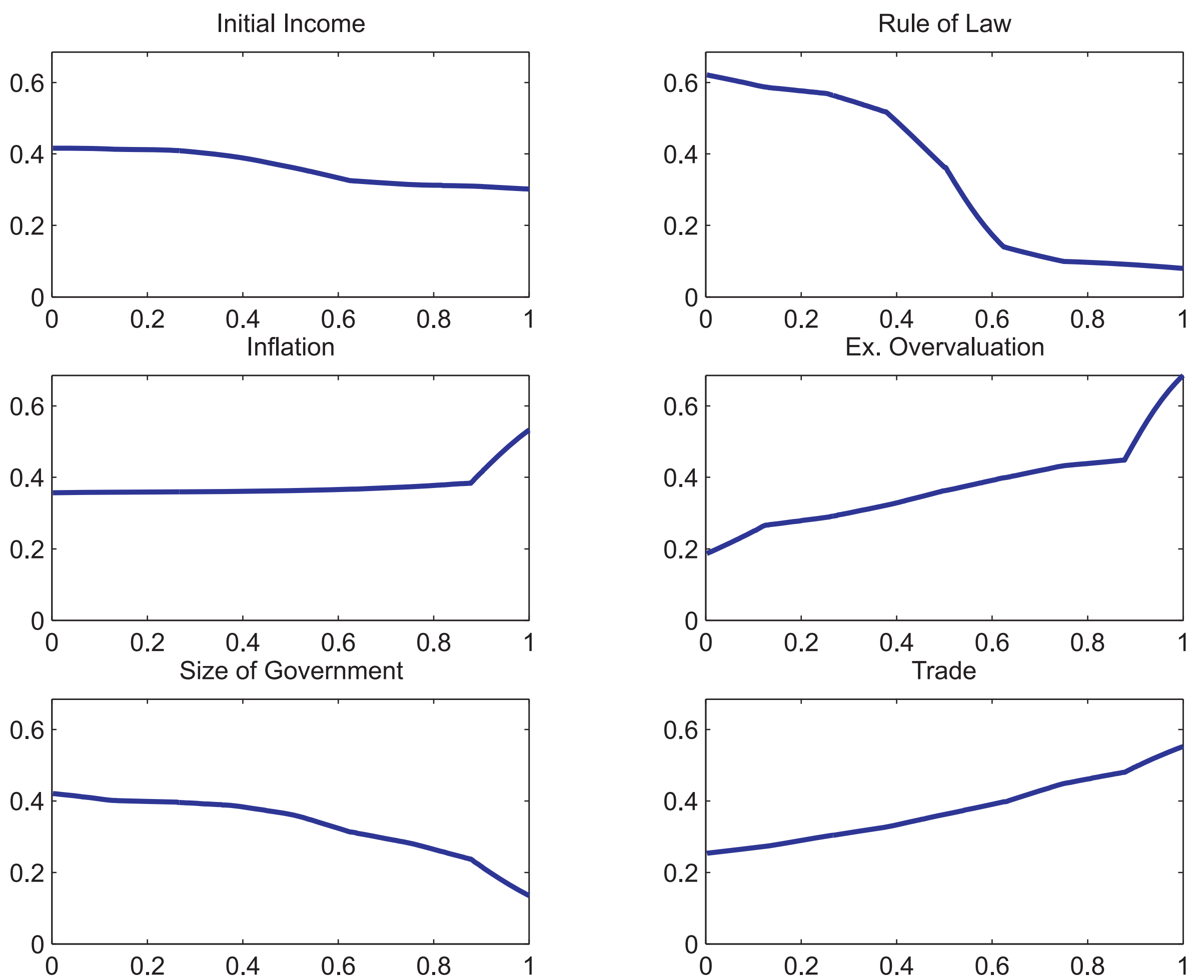

Figure 15: Probability of Stagnation for the "median country".

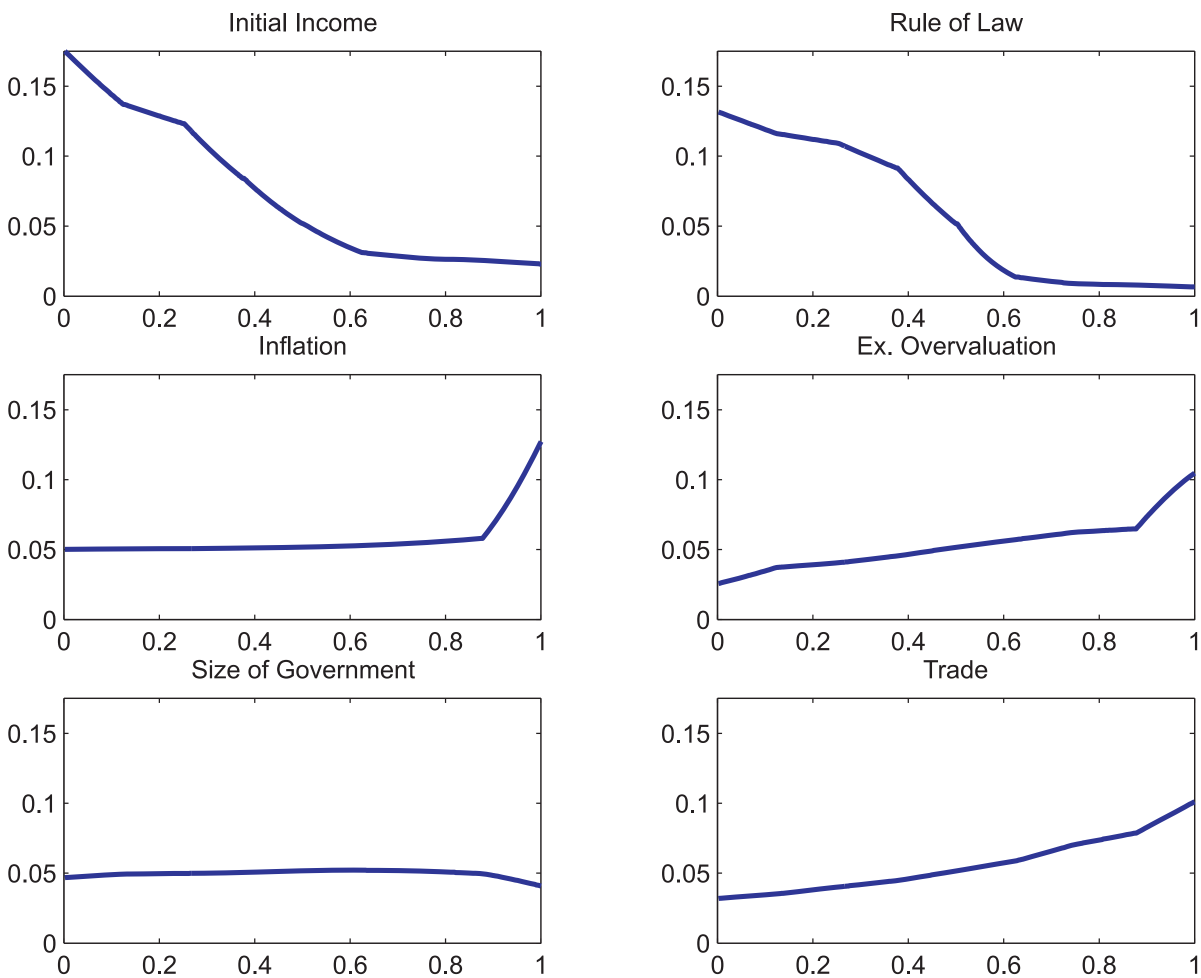

Figure 16: Probability of Crisis for the "median country".

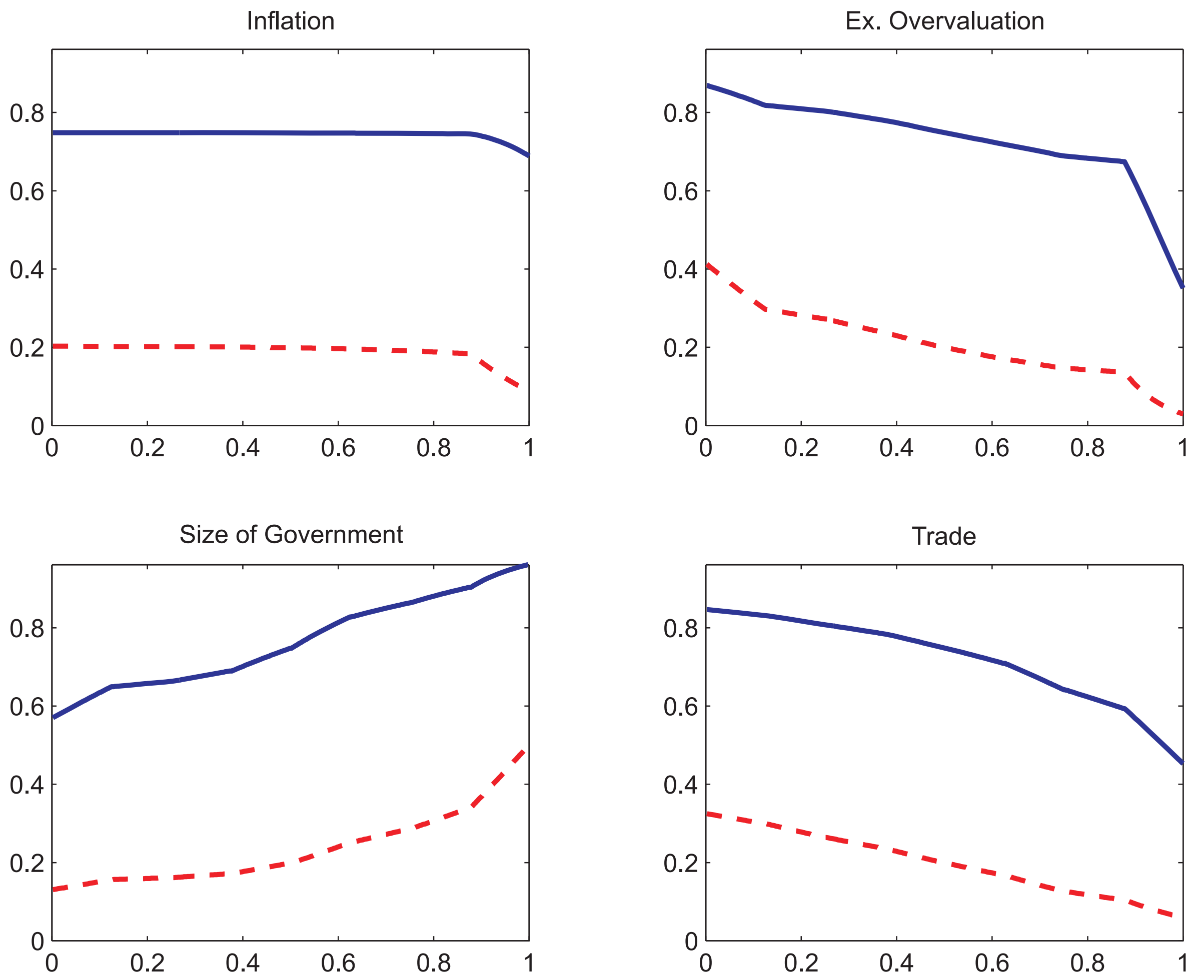

Figure 17: Probability of Stable Growth for good (solid line) and weak (dashed) institutions countries.

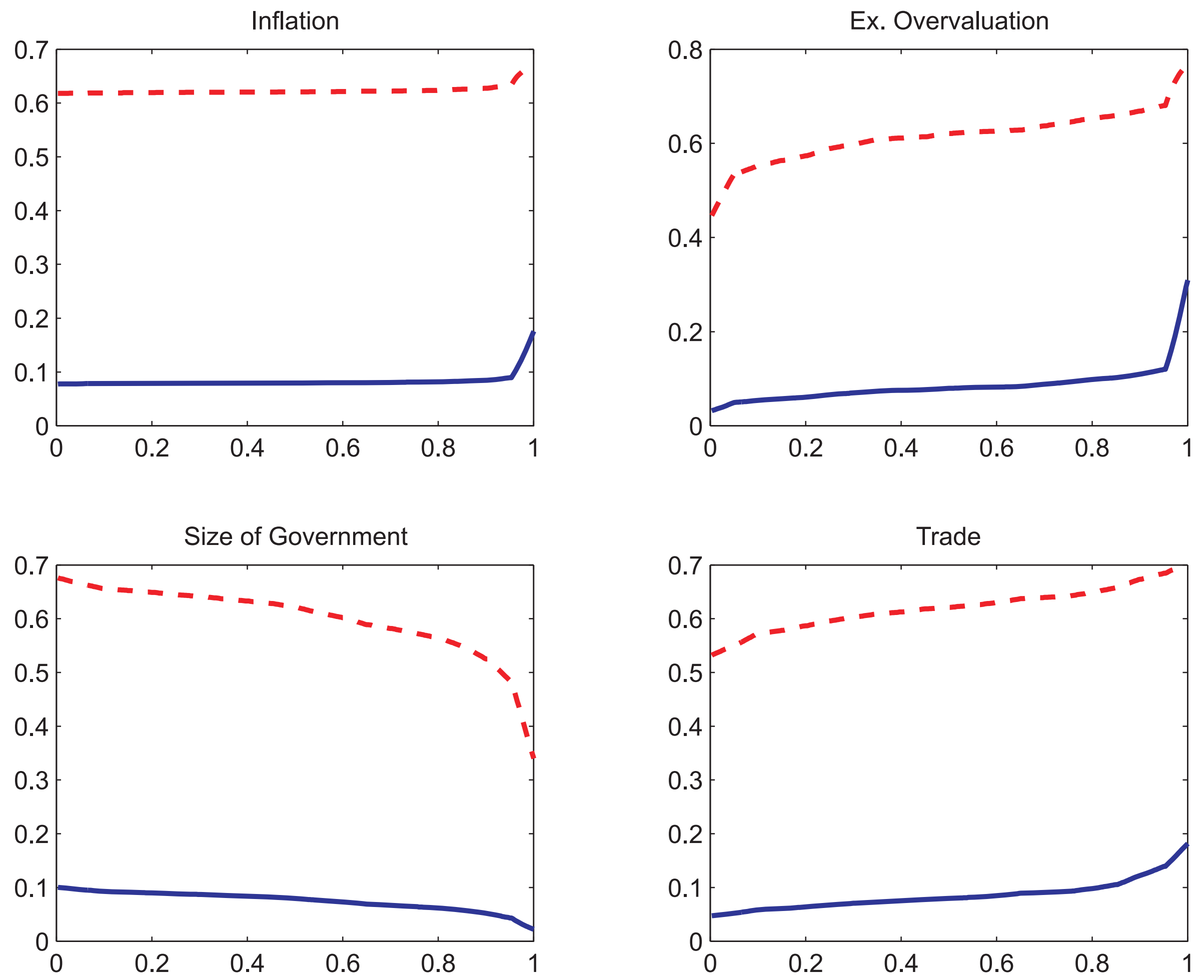

Figure 18: Probability of stagnation for good (solid line) and weak (dashed) institutions countries.

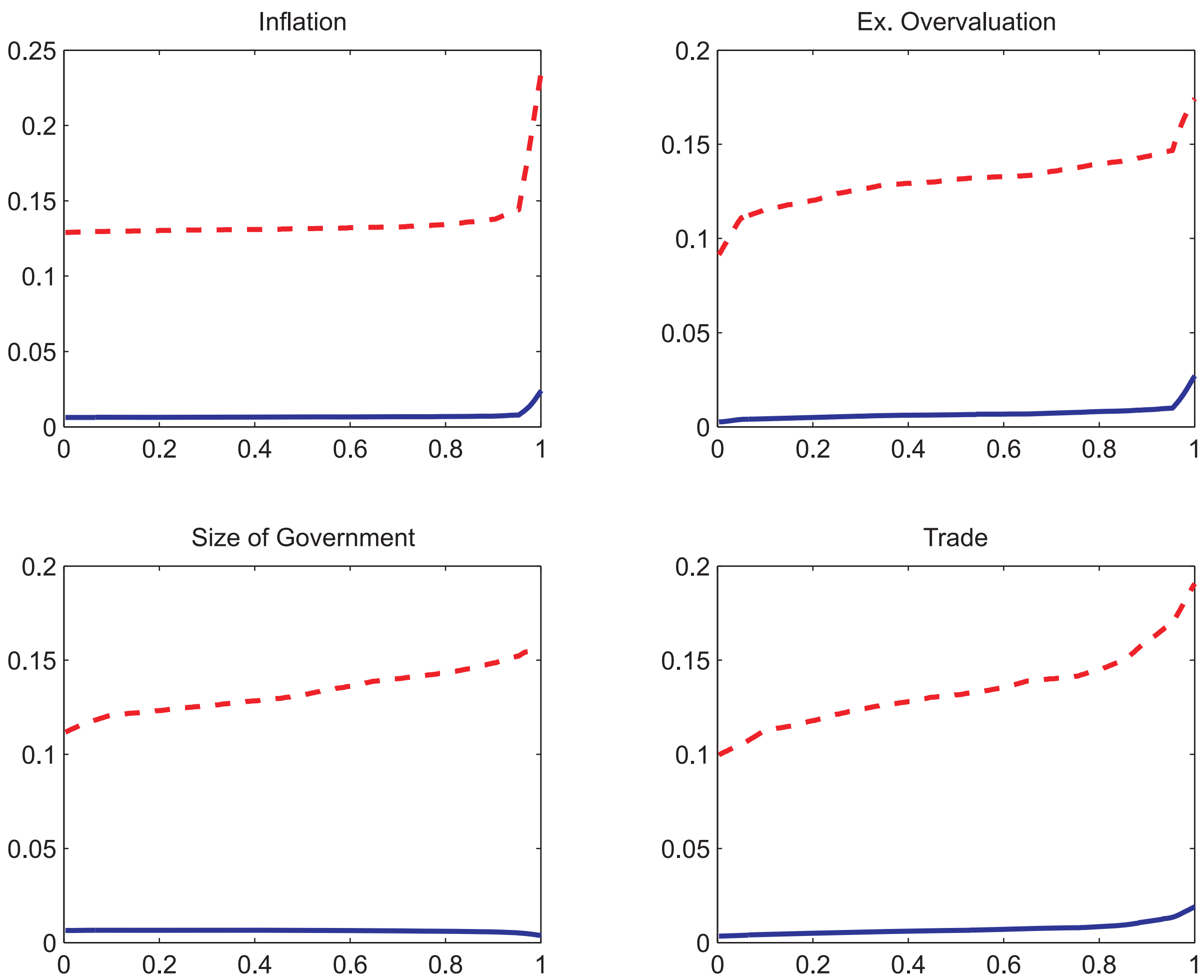

Figure 19: Probability of crisis for good (solid line) and weak (dashed) institutions countries.

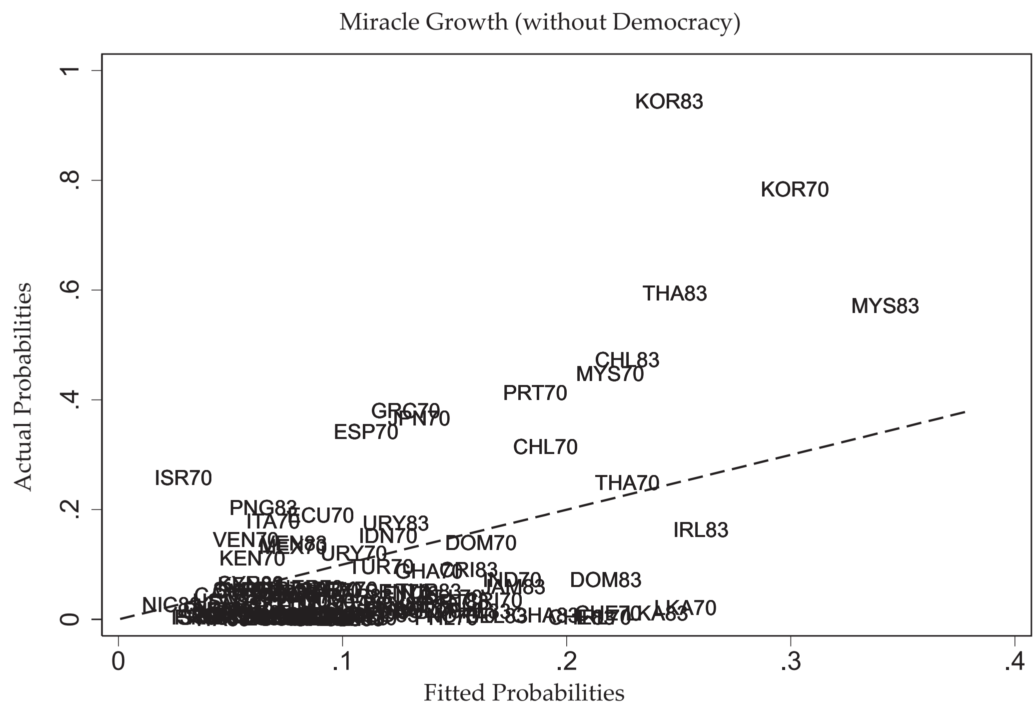

Figure 20: Fitted versus actual frequency of miracle growth regime in the baseline model (without democracy).

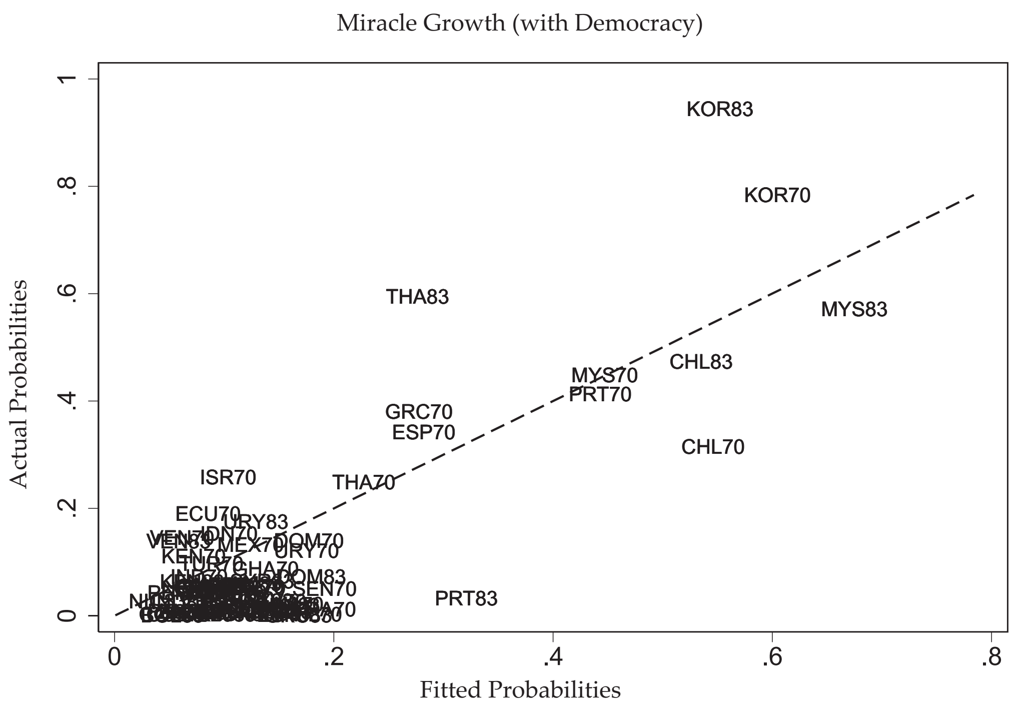

Figure 21: Fitted versus actual frequency of miracle growth regime in the model with democracy.

Variable	Mean	Std. Dev.	Min	Max
Rule of Law	0.48	1.07	-1.10	2.17
Inflation	0.21	0.44	0.01	3.22
Gov't Size	0.15	0.06	0.06	0.38
Overvaluation	0.03	0.35	-0.90	1.93
Trade	0.55	0.24	0.12	1.35
Initial Income	9.46	0.89	7.54	10.70
Probability of Stable Growth	0.50	0.39	0.00	0.98
Probability of Stagnation	0.33	0.27	0.02	0.91
Probability of Crisis	0.08	0.13	0.00	0.69
Probability of Miracle Growth	0.09	0.16	0.00	0.94

Table 8: Descriptive statistics.

B Robustness

The above analysis relied on the particular model adopted to detect and classify growth patterns (the Markov regime-switching approach), employed a nonlinear probability model instead of the more common linear specification and did not attempt to deal with the main problems of cross-country growth analysis - endogeneity and omitted variables. This section attempts to, at least partially, address these issues.

B.1 Linear Regressions

Consider using a liner formulation for the model in (2). While a probability model seems more appropriate for this problem, the linear model is more transparent and allows us to easily exploit the panel nature of the data and use instrumental variables estimation. The basic specification is as follows

$$\Pr(\text{regime} = j)_i = X_i \beta + \varepsilon_i, \tag{4}$$

where, as in the original specification, $\Pr(\text{regime} = j)$ is the average of the estimated likelihood of regime j during the sample period (1970-94, 1970-82 or 1983-94 depending on the estimation method), and X_i is a vector of country specific characteristics including initial income, quality of institutions and four policy measures: log of average inflation, real exchange rate overvaluation, share of government's consumption in GDP and trade to GDP ratio.

The above equation is estimated separately for each of the four regimes; stable growth, stagnation, miracle growth, and crisis. Table 9 shows the results using the 1970-1994 cross-section and instrumenting institutions with (log) settler mortality (see Acemoglu et al. 2001). The first column shows a standard growth regression where the dependent variable is the average growth between 1970 and 1994. Institutions and overvaluation both affect growth significantly, while the size of government is borderline significant. As usual, controlling for policies and institutions there is significant convergence effect. Overall, these result are typical of what is obtained in the literature. They are also broadly consistent with the idea that institutions are the fundamental determinant of growth and policies simply reflect their quality.

The regime-probability regressions, however, tell a richer story and one that is similar to the logit results above: the effects of policies on the likelihood of different growth regimes are significant even when institutions are included in the regression and these effects differ across regimes in direction and magnitude. Again we find the offsetting effects of trade and government size and the opposite effect of these two policies on the likelihood of a growth acceleration.

Variable	Avg. Growth	Stable Growth	Stagnation	Crisis	Miracle Growth
Rule of Law	0.041^{***}	0.240^{**}	-0.345^{***}	-0.115^{***}	0.221^{***}
	(0.013)	(0.136)	(0.110)	(0.056)	(0.100)
Inflation	0.021	-0.024	-0.129	-0.035	0.188
	(0.017)	(0.178)	(0.143)	(0.073)	(0.130)
Overvaluation	-0.039^{***}	-0.224	0.234^{**}	0.098^{*}	-0.108
	(0.015)	(0.159)	(0.128)	(0.065)	(0.116)
Gov't	-0.139^{*}	0.910	0.268	0.491	-1.669^{***}
	(0.092)	(0.984)	(0.792)	(0.403)	(0.720)
Trade	0.017	-0.256^{*}	0.074	-0.026	0.208^{***}
	(0.014)	(0.169)	(0.136)	(0.069)	(0.124)
Initial Income	-0.034^{***}	0.034	0.113	0.027	-0.174^{***}
	(0.011)	(0.115)	(0.093)	(0.047)	(0.084)
Obs.	54	51	51	51	51

Table 9: Cross Section 1970-94 using settler mortality to instrument for institutions. Standard errors in parentheses. Significance levels:* 5%, ** 1%.

Table 10 divides the sample period into two subperiods (1970-82 and 1983-94) and uses lagged values to instrument for policies.[17] Table 11 uses a panel (1970-82 and 1983-94) and clusters errors by country.[18] The overall pattern of effects is again very similar to the nonlinear results, with generally less significance in the IV case.

Variable	Avg. Growth	Stable Growth	Stagnation	Crisis	Miracle Growth
Rule of Law	0.034***	-0.034	−0.264**	0.002	0.296***
	(0.006)	(0.873)	(0.061)	(0.965)	(0.037)
Inflation	-0.002	-0.533	0.111	0.200**	0.222***
	(0.912)	(0.211)	(0.719)	(0.070)	(0.046)
Overvaluation	−0.049***	0.227	0.242	-0.087	−0.382***
	(0.011)	(0.642)	(0.424)	(0.515)	(0.030)
Gov't	-0.067	1.606	0.150	-0.068	-1.688
	(0.609)	(0.329)	(0.890)	(0.862)	(0.232)
Trade	0.010	−0.405**	0.160	0.016	0.229*
	(0.352)	(0.057)	(0.113)	(0.569)	(0.129)
Initial Income	−0.019***	0.148	0.021	0.009	−0.178**
	(0.034)	(0.341)	(0.813)	(0.760)	(0.081)
Obs.	42	42	42	42	42

Table 10: Cross Section 1983-94 using IV. Robust standard errors in parentheses. Significance levels:* 5%, ** 1%.

We take the above results as suggestive that the main message of the paper, that policies matter for regime probabilities even when institutions are included in the regression and, for most variables, the magnitude and direction of effects vary across regimes, is robust to the choice of the estimation method. The issue of endogeneity and omission of relevant variables is extremely difficult to overcome in a cross-country growth framework. The limited attempt at dealing with these issues here suggests that the main results are not driven by these biases but clearly more work is needed. Ultimately, however, we think establishing even partial correlations between institutions and policies on the one hand and the frequency

[17]Since our measure of institutional quality is constant we again use settler mortality as the instrument.

[18]Note the low R^2 in the miracle growth regression in Table 11. It implies that institutions and policies together have limited power for explaining episodes of very fast growth, as discussed above.

Variable	Avg. Growth	Stable Growth	Stagnation	Crisis	Miracle Growth
Rule of Law	0.012^{***}	0.141^{***}	-0.145^{***}	-0.058^{**}	0.062^{**}
	(0.003)	(0.058)	(0.035)	(0.021)	(0.033)
Inflation	-0.009^{***}	-0.050	0.006	0.010	0.033
	(0.003)	(0.084)	(0.043)	(0.043)	(0.031)
Overvaluation	-0.018^{***}	-0.197^{**}	0.135^{**}	0.084	-0.022
	(0.006)	(0.102)	(0.072)	(0.050)	(0.047)
Gov't	-0.028	1.556^{***}	-0.568^{**}	0.063	-1.051^{**}
	(0.049)	(0.635)	(0.333)	(0.397)	(0.610)
Trade	0.005	-0.328^{***}	0.136^{**}	0.021	0.171^{**}
	(0.007)	(0.130)	(0.077)	(0.043)	(0.102)
Initial Income	-0.012^{***}	0.106^{**}	-0.042	-0.018	-0.045^{*}
	(0.003)	(0.058)	(0.041)	(0.016)	(0.028)
R^2	0.31	0.55	0.58	0.38	0.13
N	118	110	110	110	110

Table 11: Panel. Errors clustered by country in parentheses. Significance levels:* 5%, ** 1%.

of growth episodes on the other, is an important step forward in the new research of the patterns of economic growth.

B.2 Regime Classification

The above analysis relied on the particular model chosen to detect and classify growth patterns - the Markov regime-switching approach with four regimes and the AR(1) within-regime structure estimated by Jerzmanowski (2006). One can wonder to what extent the results depend on this choice. To investigate the robustness of the findings to a different method for classifying growth patterns we consider an alternative based on the approaches taken by Hausmann et al. (2005) and Jones and Olken (2008). We start by searching for structural breaks in the growth process and then we categorize periods according to the estimated trend growth between two breakpoints. In particular we estimate the following model (we drop country subscripts for brevity)

$$y_t = \alpha + \gamma t + \varepsilon_t, \tag{5}$$

where y_t is the logarithm of real output per worker in country i and α and γ are allowed to change over time, i.e. undergo structural breaks. Using the Bai-Perron test we can then detect the breaks and use the estimated trend growth γ to classify a period between two breaks as either a stable growth, stagnation, crises, or miracle growth period. The fraction of time spent in each regime can then be used in a logit regression like the one above and the results compared. The obvious mapping would be between the estimated period trend growth and the regime long run average growth rates from Table 1. The problem with this approach is that we have to map a one dimensional measure (trend growth between break points) into the four regimes that differ along multiple dimensions (average long run growth, volatility, persistence). Consider for example classifying a period as a regime of stable growth (with average growth of 2% in the long run) when γ is greater than 1% and less than 3%. This seems like a reasonable choice, however, recall that the stagnation regime also displays occasional bursts of faster growth, which are, in the long run, offset by equally frequent episodes of decline. Because it ignores within-regime persistence, the structural breaks test would likely pick out the bursts of growth and subsequent declines as separate regimes. That is, a brief period of growth at around 2% per year followed by an offsetting decline would be classified as a separate episode of stable growth by the breaks approach but would likely be counted as part of a longer spell of stagnation in the Markov regime-switching framework. Additionally, since the number of years between breaks cannot be too small (in the implementation below it is assumed to be no less than 5 years) we have very little chance of detecting one-time growth shocks such as the crisis regime unless several occur in a streak. Mindful of these difficulties we can however attempt to carry out the above exercise, that is to classify periods based on the structural break model and to use the resulting frequencies in the logit model. The classification we adopt is as follows

$$\text{Regime} = \begin{cases} \text{Miracle Growth} & \text{if } \gamma > 0.055 \\ \text{Stable Growth} & \text{if } 0.013 < \gamma \leq 0.055 \\ \text{Stagnation} & \text{if } -0.021 < \gamma \leq 0.013 \\ \text{Crisis} & \text{if } \gamma \leq -0.021 \end{cases} \tag{6}$$

The choice of the cutoff points was made so that the fraction of sample years in a regime based on the structural break classification is roughly equal to the average sample time spent in that regime based on the Markov-switching model (9%, 50%, 33%, and 8% for the miracle, stable, stagnation, and crisis regimes, respectively). Note the imperfection of this mapping signalled above; some episodes of miracle growth, say with sustained growth of 5% per year, are going to be classified as stable growth. Also bursts of moderate growth, which occasionally occur in the stagnation regime, will be counted as stable growth. Similarly, periods of decline, again an occasional feature of stagnation, will be classified as crises. Finally, periods of sustained moderate growth slightly below 1.3% per year will be considered stagnation while in the regime-switching model they would be classified as a high likelihood of stable growth.

The results of the logit regression using the structural break regime frequencies are shown in Table 12, which, as in Table 3, presents the marginal effects evaluated at the median.

The most interesting results appear to be preserved; policies matter even when institutions are accounted for, they have differential effect on the frequency of the four regimes,

Variable	Stable Growth	Stagnation	Crisis	Miracle Growth
Rule of Law	0.233**	-0.208**	-0.049**	0.024**
	(0.027)	(0.026)	(0.012)	(0.007)
Inflation	0.204**	-0.171*	0.022**	-0.055*
	(0.071)	(0.070)	(0.008)	(0.027)
Overvaluation	-0.548**	0.450**	0.066**	0.032**
	(0.075)	(0.072)	(0.015)	(0.011)
Gov't	-0.138	1.053*	-0.346**	-0.570**
	(0.464)	(0.442)	(0.110)	(0.175)
Trade	-0.264**	0.247**	-0.006	0.023**
	(0.062)	(0.062)	(0.031)	(0.007)
Initial Income	-0.147**	0.148**	0.020*	-0.022**
	(0.027)	(0.027)	(0.009)	(0.005)

Table 12: Multinomial logit: marginal effects at the median. Standard errors in parentheses. Significance levels:* 5%, ** 1%.

the effects of government size and trade on the chances of miracle growth go in opposite directions. Moreover, policies have offsetting effects; government size discourages crises at the expense of periods of fast growth while trade sacrifices stable moderate growth but increases the likelihood of miracle growth. There also appear to be several notable differences from Table 3. First, the signs on the effect of government size change; the effect on the probability of stable growth becomes negative and insignificant and that on the likelihood of stagnation turns positive. A similar change of direction occurs for the effect of initial income; the sign on the likelihood of stable growth goes from positive to negative and that on stagnation becomes positive. The most likely explanation for these changes is the fact that the classification based on the cutoff points in (6) confounds some of the regimes; in particular, as already pointed out, the new stable growth periods are likely to include a number of episodes of miracle growth as well as the growth-bursts parts of stagnations, the new stagnation periods are likely to include episodes of stable growth, and the new crisis regime includes periods of sustained decline, previously classified as part of the stagnation regime. This implies that, for example, the original stagnation regime is a combination of the present stagnation and crises regimes, which makes the effects of trade and government in the two specifications even more similar. In summary, we view the above results as suggestive that the method chosen for finding and classifying growth episodes is not driving the main results of the paper.

C The EM Algorithm

This section of the appendix describes the estimation algorithm. First we explain the basic idea using a simplified model. Later the specification estimated in Jerzmanowski (2006) is presented.

C.1 A simple case

Consider estimating a model for only one country. We start by assuming the following process for the growth rate of output per worker. To avoid notational clutter we drop the "hats" from $y's$.

$$y_t = \alpha_{s_t} + \beta_{s_t} y_{t-1} + \varepsilon_t^{s_t}, \tag{7a}$$

$$\varepsilon_t^{s_t} \sim i.i.d.N(0, \sigma_{s_t}^2), \tag{7b}$$

Every period a country can switch between regimes. Assume that this transition is governed by an 2-state Markov process. That is $s_t \in \{1, 2\}$ and

$$\begin{aligned} &P\{s_t = j \mid s_{t-1} = i, s_{t-2} = k, ...\} = \\ &P\{s_t = j \mid s_{t-1} = i\} \equiv p_{ij}. \end{aligned}$$

That is the probability distribution over next periods states depends on the history of states only through the current state. Suppose further that the transition probabilities depend on a the value of an exogenous variable z,

$$P\{s_t = j \mid s_{t-1} = i\} \equiv p_{ij}(z).$$

The particular functional for assumed is[19]

$$\begin{aligned} p_{s_t 1}(z) &= \frac{\exp(z'\lambda_{s_t 1})}{1 + \exp(z'\lambda_{s_t 1})}, \\ p_{s_t 2}(z) &= 1 - p_{s_t 1}(z). \end{aligned}$$

for $s_t = 1, 2$

W can collect the coefficient as follows. Let $\gamma_s = (\alpha_s, \beta_s, \sigma_s^2)'$ and $\mu_s = \lambda_{s1}$ for $s = 1, 2$, and $\gamma = (\gamma_1', \gamma_2', \gamma_3')'$, $\mu = (\mu_1, \mu_2, \mu_3)'$. Finally we can collect all the parameters in one vector $\theta = (\gamma', \mu')'$.

Let the density function for observation t be $f(y_t, s_t | z; \theta)$. Also let $\mathcal{Y}_t = (y_t, y_{t-1}, ..., y_0)$ be the all observations on y through period t and denote by $\mathcal{S}_t = (s_t, s_{t-1}, ..., s_0)$ the corresponding history of unobserved states. The the likelihood function for the data can be written as

[19]Note that with only one country and time-invariant z we could equally well treat the transition probabilities as parameters. Of course, later we introduce multiple countries and thus variation in z. To keep the notation similar we therefore introduce z in this section

$$L_k(\mathcal{Y}_T, \mathcal{S}_T|z;\theta) = f(y_0, s_0|z;\theta)\prod_{t=1}^{T} f(y_t, s_t|y_{t-1}, s_{t-1}, z;\theta)$$

$$= f(y_0|s_0, z;\theta)P(s_0)\prod_{t=1}^{T} f(y_t|s_t, y_{t-1}, s_{t-1}, z;\theta)P(s_t|y_{t-1}, s_{t-1}, z;\theta)$$

$$= f(y_0|s_0;\gamma)P(s_0)\prod_{t=1}^{T} f(y_t|s_t, y_{t-1};\gamma)P(s_t|s_{t-1}, z;\mu),$$

where $P(s_t|s_{t-1}, z;\mu)$ are elements of the transition probability matrix. The third line makes use of the following facts: P's do not depend on lagged y, they only depend on parameters in μ, conditional on the current state s the likelihood of y does not depend on the past states, and it only depends on parameters in γ. We take the initial distribution of states to be equal to the $P(s_0) = (1/2, 1/2,)$.

The above expression is referred to as complete-data likelihood function because to be evaluated it requires the knowledge of the history of y's as well as the history of states. Following Diebold at al 1994 it can be written in terms of indicator functions as follows.

$$\begin{aligned}
L(\mathcal{Y}_T, \mathcal{S}_T|z;\theta) =& (I(s_0 = 1)f(y_0|s_0 = 1;\gamma_1)\rho_1 + I(s_0 = 2)f(y_0|s_0 = 2;\gamma_2)\rho_2) + \\
&\times \prod_{t=1}^{T}\Big\{ f(y_t|s_t = 1, y_{t-1};\gamma_1)I(s_t = 1, s_{t-1} = 1)p_{11}(z, y_{t-1};\mu_1) + \\
&f(y_t|s_t = 2, y_{t-1};\gamma_2)I(s_t = 2, s_{t-1} = 1)p_{12}(z, y_{t-1};\mu_1) + \\
&f(y_t|s_t = 1, y_{t-1};\gamma_1)I(s_t = 1, s_{t-1} = 2)p_{21}(z, y_{t-1};\mu_2) + \\
&f(y_t|s_t = 2, y_{t-1};\gamma_2)I(s_t = 2, s_{t-1} = 2)p_{22}(z, y_{t-1};\mu_2)\Big\}.
\end{aligned}$$

The log likelihood is then given by

$$\begin{aligned}\log L(\mathcal{Y}_T, \mathcal{S}_T|z;\theta) =& I(s_0=1)\log(f(y_0|s_0=1;\gamma_1)\rho_1)+\\ & I(s_0=2)\log(f(y_0|s_0=2;\gamma_2)\rho_2)+\\ +\sum_{t=1}^{T}\Big\{ & \\ & I(s_t=1)\log f(y_t|s_t=1,y_{t-1};\gamma_1)+\\ & I(s_t=2)\log f(y_t|s_t=2,y_{t-1};\gamma_2)+\\ & \\ & I(s_t=1,s_{t-1}=1)\log p_{11}(z,y_{t-1};\mu_1)+\\ & I(s_t=2,s_{t-1}=1)\log p_{12}(z,y_{t-1};\mu_1)+\\ & \\ & I(s_t=1,s_{t-1}=2)\log p_{21}(z,y_{t-1};\mu_2)+\\ & I(s_t=2,s_{t-1}=2)\log p_{22}(z,y_{t-1};\mu_2)\Big\}.\end{aligned} \tag{L}$$

This log-likelihood function cannot be evaluated without the knowledge of the history of states.However an incomplete-data log-likelihood function can be obtained by summing over all possible state histories. This function could then be maximized numerically to find the ML estimate of θ. In practice however, this procedure would be extremely computationally demanding. An alternative way to estimate θ is by a variant of the EM algorithm. See Hamilton (1994).

The algorithm iterates on two steps until convergence is attained. The limit of the iteration can be show to be the ML estimate.

The algorithm starts with a guess of the vector of parameters $\hat{\theta}_0$. Given this guess we can form inference about the state history, i.e. we can calculate probabilities of $s_t = 1$ and $s_t = 2$ for every t. This is done combining the information from $f(y_t|s_t, z; \hat{\theta}^0)$ and the transition probabilities $p_{ij}(z; \hat{\theta}^0)$ (see Hamilton 1994) and it simply tells us what is the probability that an observation y_t was generated by a given state if the parameters of the process are $\hat{\theta}^0$. Denote by $\hat{P}(s_t = j|\mathcal{Y}_\tau; \hat{\theta}^0)$ the inference about s_t based on observations on y through period τ. If we use the entire sample to infer state sequence the resulting probabilities $\hat{P}(s_t = j|\mathcal{Y}_T; \hat{\theta}^0)$ are called smoothed probabilities of the state history. We can the replace the indicator functions in the complete-data likelihood above by the smoothed probabilities and evaluate an *expected* log-likelihood function. For example

$$\begin{aligned} I(s_t=1) &= \hat{P}(s_t=1|\mathcal{Y}_T, z; \hat{\theta}^0) \\ I(s_t=1, s_{t-1}=2) &= \hat{P}(s_t=1, s_{t-1}=2|\mathcal{Y}_T, z; \hat{\theta}^0) \end{aligned} \tag{8}$$

We can then maximize this expected log-likelihood to find an updated estimate of the parameter vector $\hat{\theta}^1$.[20] Theses steps are repeated starting with $\hat{\theta}^1$. The iterations are continued

[20] The ML estimates of γ are linear ML estimates on data weighted by a function of the smoothed proba-

until a chosen convergence criterion is met.

C.2 Multiple countries and four regimes

The model estimated in the paper allows for four regimes and uses data on multiple countries. The estimation strategy is identical to the one above. The complete data log-likelihood for country k in terms of indicator functions is given by

$$\begin{aligned}\log L_k(\mathcal{Y}_{kT}, \mathcal{S}_{kT}|z_k;\theta) =& I(s_{k0}=1)\log(f(y_{k0}|s_{k0}=1;\gamma_1)\rho_1)+ \\ & I(s_{k0}=2)\log(f(y_{k0}|s_{k0}=2;\gamma_2)\rho_2)+ \\ & I(s_{k0}=3)\log(f(y_{k0}|s_{k0}=3;\gamma_3)\rho_3)+ \\ & I(s_{k0}=4)\log(f(y_{k0}|s_{k0}=4;\gamma_4)\rho_4)+\end{aligned} \tag{Lk}$$

bilities (see Hamilton 1996). The estimates of μ cannot be expressed in a closed form and must be obtained by solving numerically a system of nonlinear equations.

$$
\begin{aligned}
\sum_{t=1}^{T} \Big\{ & \\
& I(s_{kt} = 1) \log f(y_{kt} | s_{kt} = 1, y_{kt-1}; \gamma_1) + \\
& I(s_{kt} = 2) \log f(y_{kt} | s_{kt} = 2, y_{kt-1}; \gamma_2) + \\
& I(s_{kt} = 3) \log f(y_{kt} | s_{kt} = 3, y_{kt-1}; \gamma_3) + \\
& I(s_{kt} = 4) \log f(y_{kt} | s_{kt} = 4, y_{kt-1}; \gamma_4) + \\
& \\
& I(s_{kt} = 1, s_{kt-1} = 1) \log p_{11}(z_k, y_{kt-1}; \mu_1) + \\
& I(s_{kt} = 2, s_{kt-1} = 1) \log p_{12}(z_k, y_{kt-1}; \mu_1) + \\
& I(s_{kt} = 3, s_{kt-1} = 1) \log p_{13}(z_k, y_{kt-1}; \mu_1) + \\
& I(s_{kt} = 4, s_{kt-1} = 1) \log p_{14}(z_k, y_{kt-1}; \mu_1) + \\
& \\
& I(s_{kt} = 1, s_{kt-1} = 2) \log p_{21}(z_k, y_{kt-1}; \mu_2) + \\
& I(s_{kt} = 2, s_{kt-1} = 2) \log p_{22}(z_k, y_{kt-1}; \mu_2) + \\
& I(s_{kt} = 3, s_{kt-1} = 2) \log p_{23}(z_k, y_{kt-1}; \mu_2) + \\
& I(s_{kt} = 4, s_{kt-1} = 2) \log p_{24}(z_k, y_{kt-1}; \mu_2) + \\
& \\
& I(s_{kt} = 1, s_{kt-1} = 3) \log p_{31}(z_k, y_{kt-1}; \mu_3) + \\
& I(s_{kt} = 2, s_{kt-1} = 3) \log p_{32}(z_k, y_{kt-1}; \mu_3) + \\
& I(s_{kt} = 3, s_{kt-1} = 3) \log p_{33}(z_k, y_{kt-1}; \mu_3) + \\
& I(s_{kt} = 4, s_{kt-1} = 3) \log p_{34}(z_k, y_{kt-1}; \mu_3) + \\
& \\
& I(s_{kt} = 1, s_{kt-1} = 4) \log p_{41}(z_k, y_{kt-1}; \mu_4) + \\
& I(s_{kt} = 2, s_{kt-1} = 4) \log p_{42}(z_k, y_{kt-1}; \mu_4) + \\
& I(s_{kt} = 3, s_{kt-1} = 4) \log p_{43}(z_k, y_{kt-1}; \mu_4) + \\
& I(s_{kt} = 4, s_{kt-1} = 4) \log p_{44}(z_k, y_{kt-1}; \mu_4) \Big\}.
\end{aligned}
$$

The complete-data of the entire sample of K countries is given by

$$
\log L(\mathcal{Y}_T, \mathcal{S}_T | Z; \theta) = \sum_{k=1}^{K} \Big\{ \log L_k(\mathcal{Y}_{kT}, \mathcal{S}_{kT} | z_k; \theta) \Big\}. \tag{9}
$$

The initial distribution of states is assumed to be $(1/4, 1/4, 1/4, 1/4)$ and the EM algorithm is used to find the ML estimate of θ in a way analogous to the simple case described above.

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