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What makes growth sustained?

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We identify structural breaks in economic growth in 140 countries and use these to define "growth spells": periods of high growth preceded by an upbreak and ending either with a downbreak or with the end of the sample. Growth spells tend to be shorter in African and Latin American countries than elsewhere. We find evidence that growth duration is positively related to: the degree of equality of the income distribution; democratic institutions; export orientation (with higher propensities to export manufactured goods, greater openness to FDI and avoidance of exchange rate overvaluation favorable for duration); and macroeconomic stability. The findings of this paper back the notion that "inclusive" economic transformations are more likely to lead to sustained growth than reforms that go along with rises in income inequality.

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INTRODUCTION

Perhaps the most important question confronting policy-makers in low-income and emerging market countries is how to *sustain* economic growth. Until recently, however, the economics literature provided little guidance on this issue. To be sure, since the early 1990s, a body of work centred on cross-country growth regressions has aimed to explain differences in long-term growth between, say, the miracle episodes in Asia and the stagnation in sub-Saharan Africa and Latin America. However, this work ignored a fundamental property of growth in developing countries, namely, its lack of persistence. If developing-country output paths look more like mountains, cliffs and plains than the steady "hills" observed in the industrial world, then looking for an explanation of *average* cross-country growth differences can lead to misleading results (Pritchett, 2000). Furthermore, such an approach will not shed light on the critical question, from a developing-country perspective, of why some growth episodes tend to end more quickly and abruptly, or why some downturns may be relatively protracted.[2]

A more promising approach may involve exploiting the information in *turning points* in countries' growth performance. If an economy has been falling off a cliff for a number of years and then turns itself around and starts climbing a mountain, it makes sense to ask what is going on around the time of the transition, and during the growth episode, to uncover any useful patterns. Likewise, if a country has been growing well for a number of years, but suddenly changes course for the worse, it would be useful to know what the path out of growth looks like, perhaps so that other countries can take a different fork in the road. Papers that attempt to uncover the informational content of growth transitions – inspired by Pritchett (2000) and related work, such as Easterly et al. (1993) Ben-David and Papell (1998) and Aguiar and Gopinath (2007) – include Rodrik (1999), Hausmann, Pritchett, and Rodrik (2005), Jones and Olken (2008), Pattillo, Gupta, and Carey (2005), Jerzmanowki (2006), Hausmann, Rodriguez, and Wagner (2006) and Reddy and Minoiu (2007).

The results from this literature have been mixed. They partly confirm some of the elements that were thought to be important based on the cross-country approach, such as the importance of institutions. However, the papers also suggest that growth transitions remain largely a mystery, in that the "usual suspects" explain only a small fraction of what is going on during a transition. More specifically, currency depreciations and political regime changes seem to be correlated with growth accelerations (Hausmann, Pritchett and Rodrik, 2005), while collapses in investment play a role in downbreaks.[3] Growth decelerations are found to be associated with macroeconomic instability, conflict and export collapses (Hausmann, Rodriguez and Wagner, 2006). Hence, one tentative conclusion from this literature is that what matters for getting growth going may be different from what is important to keep it going.

[2] Panel regressions shed some light on these issues, but may not capture turning points well, and are mis-specified if the growth dynamics are not captured in a stable linear relationship with a set of fundamentals.
[3] Whether investment booms correlate with upbreaks is less clear, however (Jones and Olken, 2008). This is a critical issue for "big push" views of development. Massive scaling up of aid flows to finance capital deepening in poor countries has recently been proposed by Sachs and others. Long before, the development literature focused heavily on investment as the vehicle for generating sustained growth in poor countries (see Rosenstein-Rodan (1943), Nurkse (1953), and Murphy and others (1989)). The finding that investment is not a strong correlate of upbreaks would appear to cast doubt on these views.

The present paper contributes to this literature by focusing squarely on the second issue, namely the predictors of growth *duration*. Closing the per capita income gap with rich countries requires long periods of fast growth in the developing world. Surges in growth are in fact relatively common in the developing world, even in regions that have done very badly over the past few decades (for example, sub-Saharan Africa). What really sets poor-performing regions apart is that their growth spells have tended to end relatively soon (for instance, in comparison with East Asian or industrial countries). The question of how to forestall the end of growth spells is thus critical, especially for the large number of developing countries that have recently been enjoying strong growth.

We approach the topic somewhat differently than the literature that precedes us. Focusing on the before-and-after of a deceleration episode misses a great deal of potential information because it does not tell us what a country (or its environment) was "doing right" *prior* to its deceleration. Studies that focus on deceleration events are not well placed to draw lessons from the fact that some decelerations are preceded by much longer periods of high growth than others. We attempt to capture this information by moving the object of inquiry to *duration per se*: that is, by studying the determinants of the length of growth spells. We do so by applying duration analysis techniques that are common in medical or microeconomic applications (for example, studies that examine the length of unemployment spells). A further advantage is that the duration approach can easily take account of censored observations. It can exploit the information contained in growth spells that are still ongoing, inferring a protective effect for a covariate that is higher in long continuing spells than in shorter spells that end in-sample.

The object of our analysis is the "growth spell": the period between a growth acceleration and a deceleration. To identify accelerations and decelerations we combine both statistical structural break tests and economic criteria. Relying exclusively on ad hoc economic criteria may not be the best approach if year-to-year volatility in the underlying growth series differs substantially across countries, as is indeed the case; we would risk identifying too many spurious breaks, particularly in countries with higher growth volatility. But relying exclusively on statistically determined structural breaks in growth may not be enough, because some statistically significant breaks in growth may be too small to be of much interest economically.

Having identified growth spells, we explore the potential correlates of their duration by estimating a proportional hazard model with time-varying covariates. This model relates the probability that a growth spell will end to a variety of economic and political variables. In doing so, we distinguish between "initial conditions" in place at the time of an acceleration, and changes that take place during a growth spell. The latter are particularly relevant for the question of what policies can extend the life of an ongoing growth spell.

Within the literature on growth transitions, our approach relates most closely to recent papers by Hausmann, Rodriguez and Wagner (2006) and Jerzmanowki (2006). While Hausmann, Rodriguez and Wagner (2006) also use duration analysis, they focus on the length of *stagnations* rather than that of growth spells. Another difference with respect to the present paper is that they identify stagnations using only an economic criterion, without reference to the question of whether these breaks are statistically significant. Jerzmanowki (2006) is easily the most ambitious paper in this literature, and perhaps the most faithful to the Pritchett (2000) idea that developing country growth can be classified into structurally different regimes. He estimates a Markov-switching model of growth with four such regimes: miracle growth; stable growth; stagnation; and crisis. These four regimes and the 16 transition probabilities between regimes are estimated simultaneously. However, the approach is so informationally demanding that it can examine only one potential determinant of transition probabilities at a time. In contrast, our paper identifies just two regimes using structural break analysis and then, in a second step, investigates the probability of a regime switch (from growth to stagnation) using duration analysis. In doing so, we study many potential factors influencing the probability that a growth spell might end.

Our main findings confirm some previous results in the literature: external shocks and macroeconomic volatility are negatively associated with the length of growth spells, while good political institutions predict longer growth spells. We also have some more surprising findings. Trade liberalisation seems to not only be associated with getting growth going, as emphasised by previous authors, but also with sustaining it – particularly when combined with competitive exchange rates, current account surpluses and an external capital structure weighted towards foreign domestic investment. Furthermore, we find that export composition matters. We find that the manufacturing share in exports and, more generally, export product sophistication tend to predict prolonged growth. Most strikingly, we find that the duration of growth spells is strongly related to income distribution: more equal societies tend to sustain growth longer. [4] On the whole, these results share some of the flavour of recent work on the political economy of growth and development, as briefly discussed in Section 3 and in our conclusions.

[4] Berg and Ostry (2011) discuss this result, look at historical episodes of ends of spells to compare the narrative with the regression results, and examine some possible interpretations and policy implications.

1. STRUCTURAL BREAKS AND "GROWTH SPELLS"

We apply a variant of a procedure proposed by Bai-Perron (1998, 2003) to test for multiple structural breaks in time series when both the total number and the location of breaks are unknown. Our approach differs from the Bai-Perron approach in that it uses sample-specific critical values that take into account heteroskedasticity and sample size as opposed to asymptotic critical values, and in that it extends Bai-Perron's algorithm for sequential testing of structural breaks, as described below. Antoshin, Berg and Souto (2008) describe these extensions in more detail and show that they improve both the power and size properties of the test in applications such as ours.[5]

Identifying structural breaks in economic growth

At the outset, we must decide on the minimum "interstitiary period", that is, the minimum number of years, h, between breaks.[6] Imposing a long interstitiary period means that we could be missing true breaks that are less than h periods away from each other, or from the beginning or end of the sample period. However, allowing a short interstitiary period implies that some structural break tests may have to be undertaken on data subsamples containing as few as $2h+1$ observations. In these circumstances, the size of the test may no longer be reliable, and the power to reject the null hypothesis of no structural break on the subsample may be low. Moreover, we hypothesise that breaks at shorter frequencies may have different determinants, and in particular may embody cyclical factors that we are less interested in here. Balancing these factors, we set h either equal to 8 or to 5.

We next employ an algorithm that sequentially tests for the presence of up to m breaks in the GDP growth series. The first step is to test for the null hypothesis of zero structural breaks against the alternative of 1 *or more* structural breaks (up to the pre-set maximum m). The location of potential breaks is decided by minimising the sum of squared residuals between the actual data and the average growth rate before and after the break. Critical values are generated through Monte Carlo simulations, using bootstrapped residuals that take into account the properties of the actual time series (that is, sample size and variance). We choose these critical values so as to reject true nulls at the 10 per cent level.[7]

Table 1 and Chart 1 summarise the results from applying these tests to income per capita growth series in 140 countries for which internationally comparable output data are available since at least the 1970s. Our data source is version 6.2 of the Penn World Tables, extended

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[5] Of the various alternatives presented in Antoshin, Berg and Souto (2008), the sequential procedure with heteroskedasticity correction performs best for time series with low-to-medium autocorrelation and is thus employed here.

[6] Given a sample size T, the interstitiary period h will determine the maximum number of breaks, m for each country: $m = int(T/h)-1$. For example, if $T = 50$ and $h = 8$, then $m = int(6.25)-1 = 5$. In practice, we set $m = int(T/h)-2$ to avoid occasional anomalies.

[7] The sample size is often small when we reject true nulls 10 per cent of the time. In the on-line appendix, we provide a full set of results for tests of 25 per cent size. Most of the results presented below hold here as well. Several, however, are weaker for the h = 5 and p = 25 sample, suggesting to us that this sample may be excessively contaminated by business cycle effects.

from 2004 to 2006 using the IMF's World Economic Outlook database.[8] Table 1 shows the number of upbreaks and downbreaks, at the 10 per cent significance level and minimum interstitiary periods (h) of 5 and 8 years, respectively, by region and decade.[9]

[8] We prefer to use the Penn World Tables because it has been the standard data set in the literature, using the IMF's data only because it is available more recently. On some of the issues with the Penn World Tables for growth data and a comparison with other data sources, see Johnson et al. (2009).

[9] We also ran the algorithm using higher p-values to give us a chance to detect more breaks (albeit at the expense of more "false positives") in countries in which the year-to-year volatility of output is high. This increases the total number of breaks identified, but does not substantially affect the distributions of upbreaks and downbreaks across regions and time periods (available in on-line appendix).

Table 1: Growth breaks by decade and region

Region	Minimum segment = 5							Minimum segment = 8					
	No. of countries	Total	Average break size	50s-60s	70s	80s	90-00s	Total	Average break size	50s-60s	70s	80s	90-00s
Total *upbreaks*	140	137	7.9%	33	29	34	41	78	5.0%	17	13	21	27
Industrial countries[1]	37	25	7.0%	9	5	6	5	11	5.6%	5	0	3	3
Emerging Asia	22	27	5.5%	6	8	5	8	19	6.0%	4	6	4	5
Latin America and Caribbean	28	33	6.1%	8	7	12	6	20	9.4%	3	4	8	5
Africa and Middle East	53	52	10.9%	10	9	11	22	28	6.9%	5	3	6	14
Total *downbreaks*	140	150	-7.2%	20	59	43	28	96	-6.3%	7	48	30	11
Industrial countries[1]	37	38	-6.0%	0	23	5	10	21	-5.3%	0	15	1	5
Emerging Asia	22	20	-7.4%	4	6	7	3	15	-6.0%	0	7	5	3
Latin America and Caribbean	28	34	-6.1%	7	10	13	4	23	-5.5%	1	11	11	0
Africa and Middle East	53	58	-9.1%	9	20	18	11	37	-7.8%	6	15	13	3

[1] Includes Japan, Korea, Singapore, Hong Kong SAR and Taipei China
Source: Author calculations based on data from the Penn World Tables 6.2 and the IMF World Economic Outlook database.

With $h = 5$, our algorithm identifies a total of 280 breaks – 140 upbreaks and 140 downbreaks. That is, a little more than one upbreak and one downbreak per country on average. This is dramatically higher than the total number of breaks (74) that the standard Bai-Perron algorithm identifies using the same data, p-value and interstitiary period, and is consistent with the findings reported in Antoshin, Berg and Souto (2008). Upbreaks tend to be most common in the 1950s and 60s, driven by Europe and Latin America, and in the 1990s, driven by Africa. Downbreaks are particularly concentrated in the 1970s. For the high-income countries the first half of the 1970s stands out. For Latin America, it is the period between 1978 and 1983, and for Africa it is the 1970s and the first half of the 1980s.

Setting $h = 8$ substantially reduces the total number of breaks. We find 174 breaks: 78 upbreaks and 96 downbreaks (the standard Bai-Perron approach identifies only 64 breaks in total). The fact that setting $h = 8$ leads to 40 per cent fewer breaks shows that the interstitiary period matters, but it does not tell us which approach is better. With $h = 5$ we may be picking up some breaks in long-term growth that we might be missing when we require breaks to be at least 8 periods apart. However, we may also be picking up abrupt output movements at shorter frequencies that reflect volatility, business cycles, or short-lived commodity price booms or busts. These are more likely to be filtered out by setting $h = 8$. On balance, we prefer to focus on the $h = 8$ case. For robustness, we also look at the $h = 5$ case.

From structural breaks to growth spells

The period following a growth upbreak can be thought of as a "growth spell" – a time period of higher growth than before, ending either with a downbreak or with the end of the sample. However, it is sometimes the case (after periods of very high growth) that high growth continues, albeit at a lower level. In this case, one would not want to say that a growth spell has ended. Conversely, it is sometimes the case that an upbreak follows a period of sharply negative growth, leading to a period in which growth is still negative (or positive but very small). In this case, one would not want to say that a growth spell is under way.

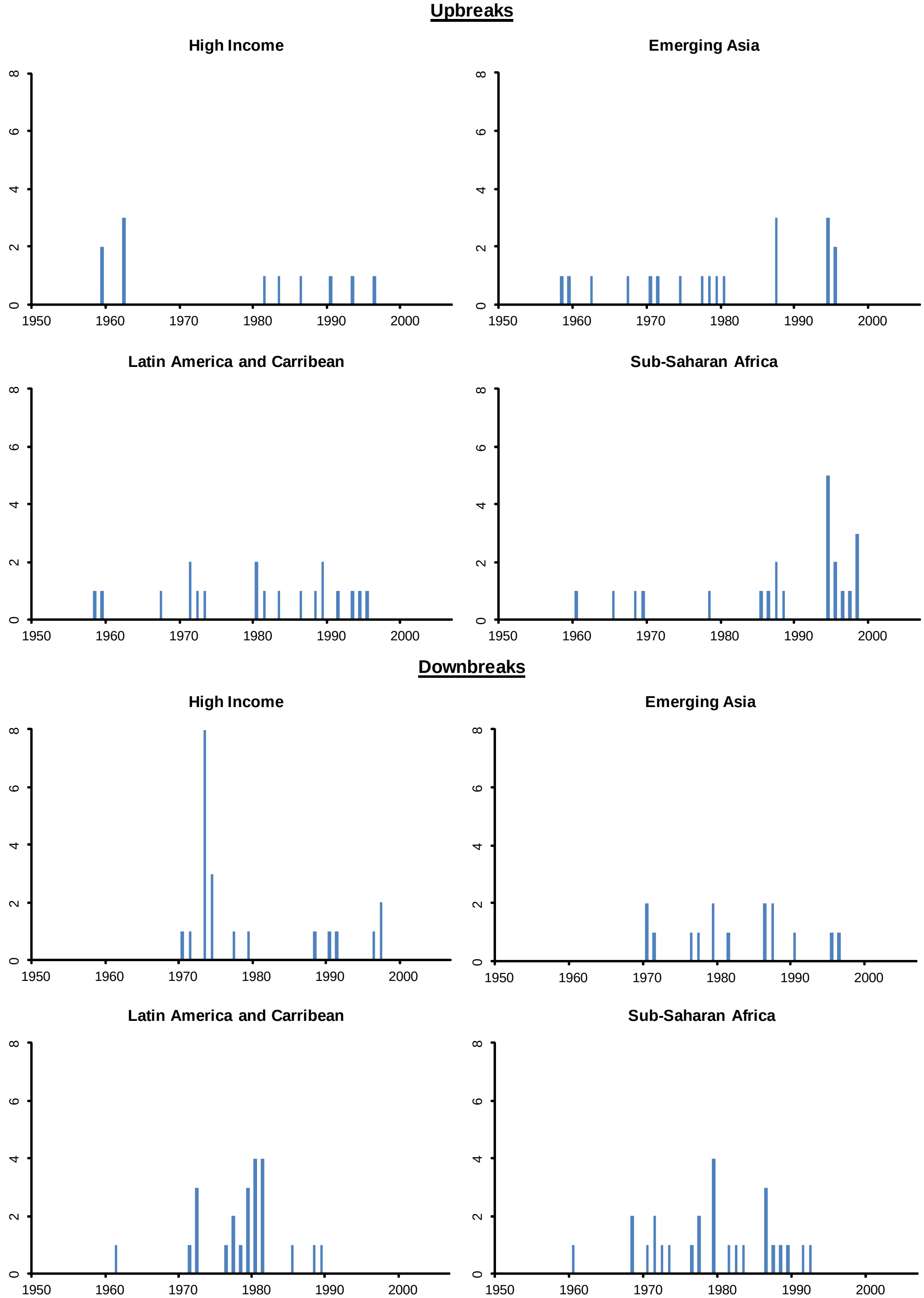
In short, if the objective is to understand the determinants of *desirable* growth spells, the statistical criteria discussed in the previous section need to be supplemented by an economic criterion. We hence define growth spells as periods of time:

- *beginning* with a statistical upbreak followed by a period of *at least g* per cent average growth; and
- *ending* either with a statistical downbreak followed by a period of *less* than g per cent average growth ("*complete*" growth spells) or with the end of the sample ("*incomplete*" growth spells).

Since growth in our definition means per capita income growth, growth of as low as 2 per cent might be considered a reasonable threshold. We used $g = 2$, $g = 2.5$ and $g = 3$, with similar results, and focus on the $g = 2$ case below.[10]

[10] It could be argued that, in defining spells, an additional economic criterion might be applied to the size of the growth break, in addition to that imposed on the level of growth before and after the break. For example, each break might be required to represent a change in growth of at least two percentage points. On balance, we believe that such a requirement is inappropriate. If growth is very smooth in a particular country, such that even a small growth break of say 1 percentage points stands out statistically, then we should try to understand the determinants of this break. However, we have investigated the properties of the set of spells, and resulting duration regressions that results from the application of this additional minimum break size criterion and report briefly on them below.

Chart 1: Number of upbreaks and downbreaks, by region and year



Note: Based on minimum spell length of 8.
Source: Authors' calculations.

We now characterise the growth spells that result from applying these criteria to the structural breaks summarized in Table 1, using g = 2, from several angles.[11]

Duration of spells

Regions do not differ much in terms of the *frequency* of growth spells. Table 2 presents the number of growth spells by region together with some rudimentary information about the distribution of the length of these spells. There have been a total (both complete and incomplete) of 64 spells for the h = 8 case and 104 for h = 5. A little under half of the spells identified at each level correspond to Latin America and Africa, about in line with the fraction of Latin American and African countries in the sample. Hence, in spite of the potential bias against finding growth spells in these countries as a result of their high year-to-year volatility, Latin America and Africa do not, on average, appear very unusual with respect to their ability to *get growth going*.

Instead, the real problem in these regions seems to be their inability to *sustain* growth over long periods. Irrespective of which minimum interstitiary period and p-level we choose, the mean length of growth spells is always much shorter – by up to a half – for Latin America and Africa compared with the industrial countries and emerging Asia.

The table also shows an interesting asymmetry between complete and incomplete growth spells for Africa and Latin America. Latin America had a fair number of (albeit short) growth spells in the past, but it has few ongoing growth spells. In contrast, in Africa a large number of countries have been enjoying an ongoing growth spell. Most of these were initiated in the mid to late 1990s, which is why they are still short on average. It is too early to say whether the global crisis of 2008/2009 has changed this picture.[12]

[11] In the definition above, growth spells are required to begin with a *within-sample* upbreak. But there are many country cases in which there are no upbreaks in the first 20 years or so because growth started out high. This growth period could reasonably be regarded as a growth spell initiated by an upbreak outside the sample period. It would be useful to extend the output series backwards, or use information about economic history, to roughly "time" the beginnings of these early growth spells.

[12] We have tried imposing an additional economic criterion that each break have a minimum size of 2 percentage points (not shown). This turns out to leave the total number of breaks unchanged. The result is a slightly different set of breaks (and spells). The effect on average break size is negligible (for example, the average change in growth associated with a downbreak increases in absolute value from -7.2 to -7.5 per cent.). These differences matter very little for our regression results (not shown).

Table 2: Frequency and duration of growth spells

	No. of countries	Minimum length of spell: 5 years: No. of spells	Mean duration	% of spells lasting at least 10 years	16 years	Minimum length of spell: 8 years: No. of spells	Mean duration	% of spells lasting at least 10 years	16 years
				Complete spells					
Industrial countries[1]	37	9	12.7	67	11	2	13	100	0
Emerging Asia	22	6	21.3	83	67	3	18	33	33
Latin America and Caribbean	18	11	9.9	27	18	5	14.4	60	40
Africa and Middle East	43	11	5.7	0	0	3	8.3	0	0
Other developing[2]	20	12	8.6	17	8	7	10.7	43	14
				Incomplete spells					
Industrial countries[1]	37	11	25.5	91	73	9	26.9	100	78
Emerging Asia	22	14	20.4	71	50	13	25.6	100	62
Latin America and Caribbean	18	3	22.7	100	67	2	19	100	50
Africa and Middle East	43	19	14.2	68	21	15	14.6	80	27
Other developing[2]	20	8	20.1	75	63	5	17.4	100	60
				Total					
Industrial countries[1]	37	20	19.8	80	45	11	24.4	100	64
Emerging Asia	22	20	20.7	75	55	16	24.2	88	56
Latin America and Caribbean	18	14	12.6	43	29	7	15.7	71	43
Africa and Middle East	43	30	11.1	43	13	18	13.6	67	22
Other developing[2]	20	20	13.2	40	30	12	13.5	67	33

[1] Includes Japan, Korea, Singapore, Hong Kong SAR and Taipei China.
[2] Middle East, North Africa, Cyprus, Turkey and Caribbean countries.
Source: Authors' calculations.

Growth before, during and after growth spells

In addition to the incidence and duration of growth spells, overall growth performance will of course depend on growth levels both during and between spells. Table 3 examines whether there are systematic differences across regions in this regard, and also looks at growth immediately before and after growth spells to see whether there is any suggestion that growth spells begin or end with economic crises.

Table 3: Average growth before, during and after growth spells

	Minimum length of spell: 5 years					Minimum length of spell: 8 years				
	Average growth			3 years …		Average growth			3 years …	
	before	during	after	before start	after end	before	during	after	before start	after end
					Complete spells					
Industrial countries[1]	0.6	7.9	-0.6	0.2	-1	3.3	6	1.2	2.6	3.4
Emerging Asia	-1.5	7	-1.3	-1.3	-1.6	-0.7	9.1	1.4	1.4	1.9
Latin America and Caribbean	0.6	4.7	-0.1	0	-0.1	1.1	4.8	0.2	1.3	-1.3
Africa and Middle East	-0.9	9.5	-3.2	-3.1	-3.7	-2.7	9.9	-4	-10.6	-6.5
Other developing[2]	-1.8	6	-2.3	-1.5	-2.5	-1.6	5	-0.9	-1.4	-2
					Incomplete spells					
Industrial countries[1]	-0.7	5.9		-1.6		0.1	5.6		-0.7	
Emerging Asia	-0.6	4.9		-0.8		-0.2	5		0.1	
Latin America and Caribbean	-2	3.2		-3.9		-1.3	3.4		-3	
Africa and Middle East	-5.1	7.5		-7.8		-4.3	5.6		-7.2	
Other developing[2]	-2.9	5.9		-5.4		-2.8	4.9		-4.6	

[1]Includes Japan, Korea, Singapore, Hong Kong SAR, and Taiwan Province of China.
[2]Middle East, North Africa, Cyprus, Turkey, and Caribbean countries.
Source: Authors' calculations.

In general, there are no big differences in growth levels *during* spells across regions (the main exception is Latin America, where growth spells that began in our sample period have tended to be somewhat less vigorous than in other countries). In contrast there are big differences with respect to growth after spells ended. In the advanced countries and Asia, growth spells have on average ended with (relatively) "soft landings" – growth rates between -1 and 3 per cent – while African spells have tended to end with deep collapses, with average growth rates between -3 and -6 per cent. The remaining developing countries occupied an intermediate position, with growth rates between -1 and -3 per cent.

There are also interesting differences in growth before the onset of growth spells, particularly for spells that are currently incomplete. Asian and high income countries tend to start their spells from per capita growth rates that are positive or very slightly negative. In contrast, growth spells in the remaining developing country regions tend to begin with crises. In these regions, average interstitiary rates prior to the last round of growth spells were between -1 and -5 per cent, with even lower rates immediately prior to the onset of growth spells.

2. ANALYSING THE DURATION OF GROWTH SPELLS

We would like to relate the expected duration of growth spells – or equivalently, the probability that a spell will continue beyond a specific length – to the economic and political conditions prevailing at the beginning of the growth spell, and to policies undertaken during the growth spell.

Empirical strategy

We face two main challenges. The first concerns model selection. The approach of this paper is atheoretical in the sense that we do not base our modelling priors on a particular theory of why growth is more sustained in some cases than in others. Instead, our priors are influenced by a variety of ideas from the existing literature. While these ideas give us a bit of structure that helps us think about model selection, they also point to a very wide range of potential determinants of growth duration and to possible interactions among those determinants.

So far, this does not sound very different from the standard model selection problem in empirical growth analysis, which has received significant attention in recent years (for example, Fernandez et al. (2001), Sala i Martin et al. (2004), Hoover and Perez (2004) and Hendry and Krolzig (2004)). It is greatly complicated in our case, however, by data constraints that preclude the application of a general-to-specific modelling approach. The problem is that in order to analyse growth spells that began as far back as the 1950s for 119 countries, we require data for many countries over very long time periods. Few long data series are available for many countries. Furthermore, the sample of growth spells that we start out with is small. As a result, running any growth spells regression that includes the main "usual suspects" – to say nothing of a broader regression that includes a number of other variables or interactions – will shrink degrees of freedom to uncomfortably low levels.

The lack of data leads us to the following approach. We sequentially test the relevance of particular regressors of interest, while including some minimal controls. In the empirical section below, we begin by running regressions of duration on various proxies for external shocks, controlling only for per capita income levels. This is acceptable if external shocks are not correlated with other (for example, institutional and policy) variables that may be correlated with growth spells. Finding that some of these shocks matter, we then control for them while sequentially testing first for the relevance of some institutional variables and income distribution, and then for a variety of health- and education-related variables, variables related to trade and competitiveness, and macroeconomic policy. This sequence is motivated by the idea that external shocks, institutions and social heterogeneity may affect the economy both directly and through policies. Hence, omitting policies in a model that accounts for shocks, institution and inequality/heterogeneity merely changes the interpretation of the results (as effects of shocks/institutions/heterogeneity are combined), but does not necessarily mis-specify the model. At the end, we summarise by showing the results of a few parsimonious regressions that control for all or most of the variables that were found to matter during the sequential testing process.

The second challenge relates to the distinction between initial conditions at the beginning of the spell and changes in determinants of duration as the spell proceeds, and to how potential reverse causality can be addressed in that context. In many cases, we will be studying potential determinants of spell length that changes over the course of the spell. This indicator needs to be regarded as endogenous in the sense that its level may depend on whether the country is in a growth spell or not. At the same time, however, it might be amenable to policy actions while a spell is ongoing. Hence, it would be desirable to understand not only how initial conditions affect duration, but also how ongoing changes in particular variables influence the probability that a spell will end.

We seek to address the issue of endogeneity by distinguishing, for most variables, between the initial level of the variable at the beginning of the spell, and changes since the beginning of the spell. Reverse causality is addressed by estimating the effect of these time-varying variables on the expected duration of a spell *conditional on its current length* (that is, conditional on being in an ongoing spell). As explained in more detail below, this is achieved through a survival model with time-varying covariates that can be viewed as roughly analogous to a panel estimation in which the right-hand-side variables are predetermined (though not strictly exogenous). While this will not eliminate all sources of endogeneity (for example, endogeneity through expectation that the end of a spell is imminent), it should prevent bias through standard feedback from the end of a spell to potential determinants (for example, from a growth collapse to higher inflation, rather than the reverse).

Regression methodology[13]

Let t denote "analysis time" (time since growth accelerated) and T duration (the length of a growth spell), a random variable. Thus $t = 1$ denotes the first year in a growth spell. $X(t)$ is a vector of random variables that may influence the probability that a growth spell ends; x_t the realisation of $X(t)$ at time t; and z a vector of non-time varying variables that may also have an impact on length of a growth spell. z could contain realisations of $X(t)$ before the beginning of a growth spell (that is, x_t , $t < 1$) and also variables that have no time dimension at all, such as geographical variables. We want to estimate the effect of $X(t)$ and z of interest on T.

Duration is usually modelled by parameterising the *hazard rate* (the conditional probability that the spell will end in the next period) and estimating the relevant parameters using maximum likelihood. The most popular approach is to assume a "proportional hazard model" – in effect an assumption that the time dependence of the hazard, called the "baseline hazard", is multiplicatively separable from its dependence on other variables $X(t)$ and z – and to parameterise it by assuming that the relationship between the hazard and these other variables is log linear and that the "baseline hazard" takes a particular functional form:

(1) $$\lambda(t) = g(X(t), z)\lambda_0(t) = \exp(\beta[X(t), z])\lambda_0(t)$$

[13] For details, see Woolridge (2002), chapter 20.

where $\lambda_0(t)$ is assumed to obey a specific distribution whose parameters can be estimated along with the coefficient vector β.

One potential problem in estimating (1) arises from the feedback of duration to the covariates *X*, that is, the fact that *X* might depend on whether a spell has ended or is still ongoing. As shown by Woolridge (2002), (1) can be estimated consistently if we can assume that the hazard at time *t* conditional on the covariates at time *t* depends only on the lagged realisations of those covariates, that is, when it depends neither on future realisations of the covariates nor on unobserved covariates.

Intuitively, we are making three important assumptions. First, we rule out contemporaneous feedback from the end of a growth spell to the time-varying covariates within the current time period. Second, we must assume that duration is conditionally independent of censoring. This is automatically satisfied in our sample, since we have fixed censoring (all growth observations end in 2006). Third, and as usual, we must not omit relevant variables from the regression. Given the data availability constraints discussed at the end of the last section, this is potentially the most serious problem.

The nature of duration dependence itself – that is, the effect of time in spell on the hazard – is of some intrinsic interest. Do spells tend to become more sustainable over time, or is there a sense in which there is a natural spell-length? Of course, we would like to say that we have explained such behaviour through the evolution of other variables included in the regression, so in a sense significant duration dependence is a sign of modelling failure. At a minimum, though, it is important to know if our other results are sensitive to assumptions about the nature of duration dependence.

We have used as a baseline specification the assumption that $\lambda_0(t)$ follows a Weibull distribution, that is, $\lambda_0(t) = pt^{p-1}$. The parameter p, which is estimated, determines whether duration dependence is positive (p>1) or negative. In the robustness section below, we also look at a number of alternative functional forms, including some that allow duration dependence to be non-monotonic. The main results are robust to alternative distributional assumptions.[14]

A final methodological issue is that we treat our dependent variable (the length of the spell) as known, when in fact it is estimated and thus observed with error. This problem, which is a general affliction of this and related literatures, is not easy to solve. Abrevaya and Hausman (1999) and Lancaster (1985) show that hazard estimates using the Weibull distribution are consistent even with measurement error in the dependent variable. However, our setup does not meet the requirements for this result (most notably, it applies only to non-censored data). We have conducted some simulations in an attempt to gauge the direction and magnitude of

[14] We use the Stata command Streg with the accelerated-time-to-failure option. To take account of the fact that a downbreak, by construction, cannot happen until five (or eight) years into a spell at the earliest (a consequence of our interstitiary period), we created a dummy variable defining the notional start of the spell as the true start year plus four years.

the bias that may be associated with this measurement error.[15] These exercises suggest that, for our baseline regression and data, there is indeed likely to be some attenuation of the estimated association between the hazard and its correlates – the estimated magnitude of β in equation (1) – relative to the true value, due to the measurement error induced by the fact that the growth breaks and spells are estimated rather than directly observed. This result provides some comfort that our results are "conservative" in that, if we find a significant correlation, it would likely be stronger if we could directly observe the growth spells with certainty.

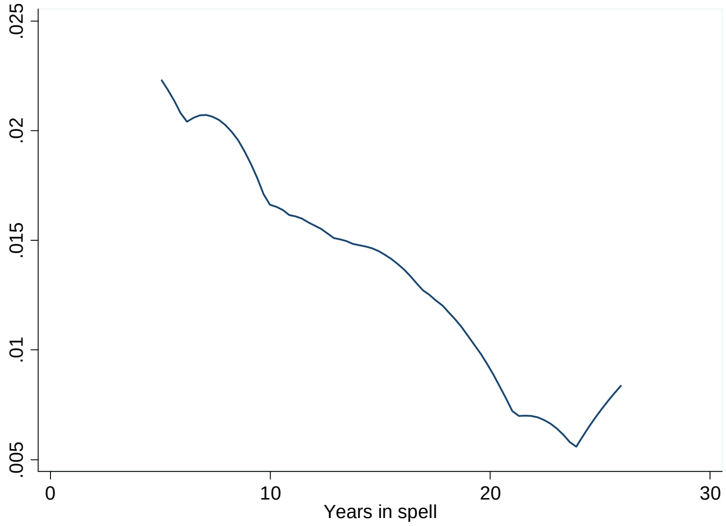
Results

We start by characterising the unconditional hazard rate or the probability that a spell will end after a given number of years, conditional only on the fact that it has already lasted up to that point. We then examine the role of external shocks, then of institutions and variables related to social conflict (income distribution and ethnic heterogeneity), and then a variety of other, policy-related indicators, using some of the previous variables as controls.[16]

Unconditional hazard

Chart 2 presents the unconditional hazard for spells defined with a minimum interstitiary period of eight years. This hazard is calculated simply by looking at all the spells that have lasted at least a given length and calculating how many end in the next period (then smoothing). This hazard declines with time, implying that spells that have already lasted longer have a lower hazard of ending.[17] We will now examine how spell duration is correlated to various determinants of interests. Armed with this analysis, we can return to the question of whether, controlling for the evolution of these covariates, there is any intrinsic time effect on the hazard.

[15] These exercises involve: (i) simulating growth data that resemble the growth data we use in our regressions and which include growth spells whose hazard by construction follows a conditional Weibull distribution such as that estimated in one of our benchmark regressions; (ii) estimating hazard regressions on the growth spells in this simulated data, using either (a) the true breaks from the simulated data or (b) the breaks in the simulated data as estimated by our modified Bai-Perron procedure; and (iii) comparing the estimates in 2a and 2b. These results are available on request.
[16] Table 1 in the Appendix provides summary statistics for all the regressors.
[17] A similar picture obtains for h = 5, though with a suggestion that the hazard is flat after falling for the first few years.



Notes: Based on weighted kernel smoother of the empirical hazard rate, for minimum interstitial period of five years, using data from 64 spells with minimum length of eight years.
Source: Authors' calculations.

External shocks

We focus on two external shocks: changes in the terms of trade and changes in nominal US interest rates. We include terms of trade shocks (measured as year-to-year percentage changes) and contemporaneous and first lags for US interest rate changes. Table 4 shows the results from running these models on our two samples: interstitiary periods of eight and five years with breaks identified at the p=0.1 level.[18]

The table shows *exponentiated* regression coefficients. These can be interpreted as "time ratios": the factor by which the time to failure is multiplied as a result of increasing the value of the regressor by one unit. For example, a time ratio of 0.9 means that a unit change in the regressor decreases the expected time to failure by 10 per cent. A time ratio of 1 means there is no effect and a time ratio greater than one denotes a protective effect. The p-values shown adjacent to the time ratios refer to the probability that the true time ratio equals 1. We use the convention that time ratios that are significantly different from 1 at the 5 per cent level or less are denoted in **bold**; time ratios significant at the 10 per cent but not 5 per cent level are in ***bold and italics***.

As expected – given Rodrik (1999) and related work – external shocks are associated with a higher risk that growth spells will end. For the terms of trade, a time ratio of 1.03-1.04 means that a one percentage point improvement in the terms of trade will increase the expected length of the spell by 3-4 per cent. We also find a very large and significant association of US interest rate changes with duration: depending on the sample, a one percentage point (100 basis point) increase in US rates in the previous year is estimated to reduce the predicted spell length by up to 56 per cent. Qualitatively similar (though less precise) results obtain if a 0-1 dummy variable for large hikes in the US federal funds rate is used instead of continuous changes in US market rates (as in Becker and Mauro, 2006).

[18] Results for breaks identified at the p=0.25 level are available in the on-line appendix.

Table 4: External shocks and boom size[1]

Model	Variable	8-year minimum spell		5-year minimum spell	
		time ratio	*p* value	time ratio	*p* value
1	Terms of trade growth[2]	***1.04***	***0.10***	***1.03***	***0.08***
	US interest rate change[3]	1.16	0.46	1.07	0.60
	First lag of the US interest rate change	***0.44***	***0.01***	***0.68***	***0.01***
	Spells/failures	57/19		88/46	

[1]All regressions control for initial income per capita.
[2]Expressed in percentage points; increase means terms of trade improvement.
[3]Change in the average annual three-month treasury bill rate, in percentage points.
Source: Authors' calculations.

Political and economic institutions

There is a well-established link between long-run growth and political institutions, in particular the extent to which they achieve political accountability and constrain the executive.[19] Whether this link operates via more vigorous growth or more sustained growth spells, or both, is not obvious. One channel through which weaker institutions could lead to shorter growth spells is by making societies deal less effectively with external shocks (Rodrik, 1999). Another is that poor institutions breed economic and political problems which make countries more crisis-prone, and growth more volatile (Acemoglu et al. (2003)).

Table 5 shows the relationship between institutions and the length of growth spells in our data. The standard "polity2" measure of democratic institutions, measured on a scale of -10 (most autocratic) to +10 (most democratic) shows a "protective" relationship. A one point improvement in the polity score is associated with an increase in the expected duration of a growth spell by 10–12 per cent (model 1). This holds for both cross-sectional differences in the polity of societies at the beginning of a growth spell, and for changes in the polity score within a growth spell. Since the coefficient on these "initial level" and "change within spell" variables are similar, one can collapse them and simply control for the contemporaneous level of the polity variable, with the effect that the precision of the estimate is somewhat improved (see model 2, where the increase in predicted duration associated with a one point increase in the polity score is 12 per cent).

Models 3 and 4 in Table 5 show that the strong relationship between the polity variable and the time ratio is driven by both of its main subcomponents, namely, separate assessments of "democracy" and "autocracy", which are both measures on a 0-10 point scale ("polity" is defined as the democracy score minus the autocracy score). Models 5-7 examine three "concept variables" in the polity database on which both the "democracy" and "autocracy" scores are based to varying degrees, namely, "executive recruitment" (that is, how governments come to power, scored between 1 and 8, where larger means more democratic); "executive constraints" (that is, the presence of checks and accountability, scored between 1 and 7); and "political competition" (for example, the relevance of parties and civil society

[19] See, for example, Acemoglu, Johnson and Robinson (2001, 2005); Sokoloff and Engerman (2000); and Rodrik, Subramanian and Trebbi (2004).

organisations, scored between 1 and 10). The results are all robust and go in the expected direction.

Table 5: Institutions[1]

Model	Variable	8-year minimum spell time ratio	8-year minimum spell *p* value	5-year minimum spell time ratio	5-year minimum spell *p* value
1	"Polity2" (Polity IV database)				
	Initial level	***1.12***	***0.10***	***1.10***	***0.01***
	Change within spell	***1.11***	***0.07***	***1.10***	***0.02***
	Spells/failures	46/17		66/35	
2	Polity 2 (Polity IV database)	***1.12***	***0.04***	***1.12***	***0.00***
	Spells/failures	51/17		72/37	
3	Democracy (Polity IV database)	1.17	0.11	***1.22***	***0.00***
	Spells/failures	51/17		72/37	
4	Autocracy (Polity IV database)	***0.77***	***0.01***	***0.80***	***0.00***
	Spells/failures	51/17		72/37	
5	Executive recruitment (Polity IV database)	***1.42***	***0.02***	***1.35***	***0.00***
	Spells/failures	51/17		72/37	
6	Executive constraints (Polity IV database)	***1.35***	***0.07***	***1.42***	***0.00***
	Spells/failures	51/17		72/37	
7	Political competition (Polity IV database)	***1.26***	***0.05***	***1.23***	***0.00***
	Spells/failures	51/17		72/37	
8	Investment profile (ICRG)	1.64	0.29	***1.36***	***0.08***
	Spells/failures	34/4		46/16	

[1]Regressions control for terms of trade shocks, US interest changes and initial income.
Source: Authors' calculations.

What about the role of narrower, "economic institutions"? These might also matter; for example, even countries with autocratic systems might be able to develop institutions that provide a growth-friendly climate by protecting the rights of investors and entrepreneurs, or property rights more generally. The problem is that direct measures of these institutions are not available over long time periods. The longest available series appear to be those compiled by the *International Country Risk Guide* (ICRG), beginning in 1984. The eighth model in Table 5 includes an ICRG measure that describes economic, as distinct from political, institutions: "investment profile", which codes contract enforcement, profit repatriation and payment delays on a 0-12 point scale.[20] The results are consistent with a highly "protective" effect, with a one point increase (improvement) in investor protection associated with an increase in the expected spell length of 36-64 per cent. However, the estimates are imprecise.

Inequality and fractionalisation

Do more homogenous societies – either in terms of income distribution, or in terms of ethnic of religious composition – have longer growth spells? This may be the case if growth ends as a result of social or political conflict; or if more homogeneous societies (just like societies with better institutions) are more capable of adapting to shocks. Controlling for terms of trade shocks and US interest shocks, we examine the effect of two measures of heterogeneity: economic, proxied by the Gini coefficient, and social, proxied by a measure of ethnic heterogeneity (Table 6).

Table 6: Duration regressions: inequality and fractionalisation[1]

		8-year minimum spell		5-year minimum spell	
Model	Variable	time ratio	*p* value	time ratio	*p* value
1	Inequality (Gini coefficient)				
	Initial level	***0.87***	***0.02***	***0.85***	***0.00***
	Change within spell	1.08	0.31	0.94	0.28
	Spells/failures	22/6		32/14	
2	Inequality (Gini coefficient)	***0.89***	***0.03***	***0.89***	***0.00***
	Spells/failures	31/11		45/21	
3	Ethnic fractionalisation (Alesina et al. (2003))	0.99	0.41	0.99	0.40
	Spells/failures	56/19		86/45	
4	Ethnic fractionalization (Alesina et al. (2003))	***0.96***	***0.02***	***0.98***	***0.10***
	Inequality (Gini coefficient)	***0.91***	***0.03***	***0.89***	***0.00***
	Spells/failures	31/11		45/21	

[1]Regressions control for terms of trade shocks, US interest changes and initial income.
Source: Authors' calculations.

The main result is that there is a large and statistically significant association between income inequality and duration. A one percentage point higher Gini is associated with an expected duration of the growth spell that is lower by between 11 and 15 per cent. Since the cross-sectional standard deviation of the Gini in our sample in 2000, for example, was over 10 percentage points, this is an enormous effect. Note that, unlike democratisation, all the action comes from cross-sectional differences in initial levels of the Gini; "within spell" changes are estimated very imprecisely (which is perhaps not surprising, given the high persistence of the

[20] Go to www.prsgroup.com/ICRG_Methodology.aspx.

Gini over time), and do not have statistically significant effects.[21] Model 2 shows that the relationship is preserved if one simply includes the contemporaneous Gini into the model, rather than distinguishing between Ginis at time zero and changes in the Gini. This is important because controlling only for the contemporaneous Gini allows us to work with a large sample that includes a number of extra spells for which initial Ginis were not available.

In contrast, measures of ethnic, linguistic or religious heterogeneity – available as cross-sectional variables only – did not seem to have a robust significant association with the length of growth spells. Model 3 shows results based on one such variable, namely, an ethnic fractionalisation measure compiled by Alesina et al. (2003). It is small in magnitude and insignificant. Related measures by Easterly and Levine (1997) and Fearon (2003) led to even weaker effects. Model 4 shows the estimated time ratios for the Alesina et al. measure, while controlling for income distribution. The estimated time ratio is now significantly below unity. When we repeated the regressions using identical subsamples without controlling for inequality we obtained very similar results (not shown), indicating that the differences between models 3 and 4 are driven by the samples, and not by the use of income inequality as a control.

Finally, we investigated the relationship between the duration of growth spells and direct measures of violent conflict – such as wars and internal strife – taken from the Uppsala Conflict Data Program/International Peace Research Institute (UCDP/PRIO) armed conflict dataset (Gleditsch et al. (2002)). Surprisingly, we did not find strong robust associations.

There are two interpretations for this. First, high violent conflict, at least according to the UCDP/PRIO scoring, is not as obviously correlated with low growth as one might expect. Simple cross-country correlations indicate a negative but not statistically significant correlation between average internal conflict and average growth, and a surprising statistically significant positive correlation between external conflict and growth. Second, it is possible that violent conflicts depress growth primarily through their effects after a growth spell has already ended, rather than by ending a growth spell.

Social and physical indicators

We next examine indicators related to education, health and physical infrastructure, while continuing to control for the effects of terms of trade shocks, US interest rate changes and initial income. Table 7 shows that a number of indicators are significant, though unevenly across samples. The most robustly significant variable is within-spell improvement in primary education, where the estimated coefficients are very high: a one-*month* improvement raises predicted duration by some 25-70 per cent. Both the initial level and increases in child mortality reduce the predicted duration of a spell, with significance only in the larger sample, when h=5.

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[21] Year-to-year Gini proxies were obtained by linearly interpolating levels from the WIDER 2a database of worldwide income inequality (June 2005). The potential mis-measurement resulting from this linear interpolation may be another reason why within-spell changes in the Gini appear to have no effect.

Finally, the time ratio associated with an indicator of physical infrastructure development—telephone mainlines per capita, model 5—is higher than unity as expected, with an increase of one telephone per 100 people associated with a 1 percent increase in the expected spell duration, again only significantly so when h=5.

Table 7: Duration regressions: social and physical indicators[1]

Model	Variable	8-year minimum spell		5-year minimum spell	
		time ratio	*p* value	time ratio	*p* value
1	Primary education (Barro-Lee; years)				
	Initial level	0.78	0.67	1.16	0.61
	Change within spell	***9.19***	***0.04***	***4.06***	***0.01***
	Spells/failures	24/10		47/25	
2	Secondary education (Barro-Lee; years)				
	Initial level	1.03	0.98	2.49	0.32
	Change within spell	20.43	0.12	1.92	0.42
	Spells/failures	24/10		47/25	
3	Adult mortality (males; deaths per 100)				
	Initial level	1.04	0.55	0.97	0.20
	Change within spell	0.96	0.65	1.00	0.98
	Spells/failures	44/10		71/34	
4	Child mortality (deaths per 100; WDI)				
	Initial level	0.96	0.74	***0.87***	***0.04***
	Change within spell	0.78	0.23	***0.68***	***0.00***
	Spells/failures	48/13		74/35	
5	Telephone mainlines per 100 people (WDI)	1.01	0.23	***1.01***	***0.02***
	Spells/failures	46/12		71/31	

[1]Regressions control for terms of trade shocks, US interest changes and initial income.
Source: Authors' calculations.

Financial development

Many economists argue forcefully that financial development is a critical part of the growth process for many reasons.[22] We find some significant associations between various measures of higher financial development and the duration of growth spells, particularly when h = 5 (Table 8). We find that an increase in the ratio of bank deposits to GDP, or of private credit to GDP, of one percentage point is associated with 3 to 4 per cent longer spells. The level also seems to have a positive correlation with duration. To maximise the sample size and save degrees of freedom, we look just at contemporaneous (lagged) level effects (models 3 and 4) and find similar results.

[22] See, for example, Levine (1997) for a review.

Table 8: Duration regressions: financial development[1]

Model	Variable	8-year minimum spell time ratio	8-year minimum spell *p* value	5-year minimum spell time ratio	5-year minimum spell *p* value
1	Bank Deposits (per cent of GDP)				
	Initial level	1.04	0.33	***1.03***	***0.04***
	Change within spell	1.05	0.13	***1.04***	***0.06***
	Spells/failures	37/13		48/22	
2	Private credit (per cent of GDP)[2]				
	Initial level	1.05	0.21	1.03	0.12
	Change within spell	1.07	0.11	***1.03***	***0.03***
	Spells/failures	37/13		48/22	
3	Bank deposits (per cent of GDP)	1.03	0.20	***1.02***	***0.03***
	Spells/failures	53/19		72/34	
4	Private credit (per cent of GDP)	1.01	0.40	***1.02***	***0.03***
	Spells/failures	53/19		72/34	

1Regressions control for terms of trade shocks, US interest changes and initial income.
2Private credit by deposit money banks and other financial institutions.
Source: Authors' calculations

Globalisation

Trade integration and openness have long been linked to growth performance through links such as market size and competition. In contrast, the relationship between financial integration and growth is more controversial and less robust.

Table 9 shows the relationship between trade integration and financial integration proxies and the duration of growth spells. We find a significant and large correlation with *trade liberalisation* – measured by the Wacziarg-Welch dummy variable. Roughly speaking (and bearing in mind that we are controlling only for external shocks and initial income at this point), countries that have liberalised trade appear to enjoy a spell that is 3-8 *times* longer. This effect carries over to *openness*, though it is significant only with h = 8 and the relationship is weaker.[23] The tension between these results may indicate that the Wacziarg-Welch dummy variable might be a proxy for reforms that go beyond just trade liberalisation, as argued in Rodriguez and Rodrik (2000).

[23] Following Pritchett (1996), the measure used here adjusts for cross-country differences in size, access to the sea, distance to export markets, and whether the country is an energy producer. That is, openness is measured as the residual in a regression of the sum of exports and imports, as a share of GDP, on these structural characteristics. However, results are similar with unadjusted openness.

Table 9: Duration regressions: financial development[1]

Model	Variable	8-year minimum spell		5-year minimum spell	
		time ratio	*p* value	time ratio	*p* value
1	Trade liberalisation (Wacziarg-Welch dummy variable)				
	Initial level	2.83	0.21	***6.56***	***0.00***
	Change within spell	***6.76***	***0.02***	***7.88***	***0.00***
	Spells/failures	38/16		61/33	
2	Trade openness (based on PWT data, adjusted for structural characteristics)				
	Initial level	***1.04***	***0.03***	1.01	0.33
	Change within spell	***1.04***	***0.01***	1.01	0.15
	Spells/failures	51/15		76/35	
3	Financial integration (sum of external assets and liabilities[2])				
	Initial level	1.01	0.54	1.00	0.87
	Change within spell	1.01	0.52	1.00	0.60
	Spells/failures	29/7		40/18	
4	External debt liabilities[2]				
	Initial level	1.00	0.90	1.00	0.57
	Change within spell	1.00	0.92	1.00	0.18
	Spells/failures	29/7		40/18	
5	FDI liabilities (Lane and Milesi-Ferretti database[2])				
	Initial level	1.00	0.99	1.03	0.27
	Change within spell	1.05	0.22	***1.11***	***0.02***
	Spells/failures	29/7		40/18	

[1] Regressions control for terms of trade shocks, US interest changes and initial income.
[2] Lane and Milesi-Ferretti (2007).
Source: Authors' calculations.

The effects of financial integration on growth – measured as the sum of external assets and liabilities, expressed, like trade openness, as a share of GDP – are weak or imprecisely estimated. However, a disaggregation of the financial integration turns out to be important. Debt liabilities accumulation may be associated with shorter spells, although the effect is small and not significant. In contrast, FDI flows are a significant predictor of longer spells, at least in the h = 5 sample, with an increase in FDI liabilities by 1 per cent of GDP in the recipient country over the course of the spell associated with an increase in the expected duration of a growth spell by 5-11 per cent. This provides support for the idea that the benefits of financial integration depend on the structure of the assets and liabilities that are exchanged, consistent with the findings in Dell'Ariccia et al. (2008).

The current account, competitiveness and export structure

Contrary to theories in which growth is constrained by access to capital, several recent papers find that foreign financing does not seem to deliver a growth bonus in developing countries.[24] This could be related to the capacity of developing countries to absorb capital inflows, to the macroeconomic consequences of capital inflows, which can lead to overvalued exchange rates which undermine growth in the manufacturing sector, or to the notion that low domestic savings is a sign of poor domestic property rights institutions.

The second interpretation – that reliance on foreign financing is bad because it hurts the development of a manufacturing sector – suggests that the *structure* of exports (or more generally production) might matter for future growth. Hausmann, Rodriguez and Wagner (2006) suggest a measure of the sophistication of goods that an economy could *potentially* produce – namely, sophistication weighted by a measure of proximity to the current export basket, based on the frequency with which particular pairs of goods are exported by the same country (see Hausman, Hwang and Rodrik (2007) and Hidalgo et al. (2007)). They argue that this measure, which they call "open forest", should capture the ease with which economies can shift to other export baskets of high sophistication and hence high growth promise, for example, in response to adverse shocks. They show that "open forest" is indeed inversely related to the length of stagnation periods. By the same token, it might be positively related to the ability of an economy to sustain growth.

Table 10 shows how the variables stressed by this literature relate to the length of growth spells. In general, the results are supportive of the view that current account surpluses, competitive exchange rates and export structure matter for growth duration.

[24] See Aizenman, Pinto and Radziwill (2004), Rajan and Subramanian (2011), and Prasad, Rajan and Subramanian (2007).

Table 10: Regressions: current account competitiveness and export structure[1]

Model	Variable	8-year minimum spell		5-year minimum spell	
		time ratio	*p* value	time ratio	*p* value
1	Current account balance (per cent of GDP, WDI and IFS)				
	Initial level	1.31	0.18	1.02	0.85
	Change within spell	***1.26***	***0.09***	1.05	0.60
	Spells/failures	24/6		29/11	
2	Domestic savings (per cent of GDP, WDI)				
	Initial level	***1.10***	***0.06***	1.03	0.24
	Change within spell	1.08	0.13	1.02	0.42
	Spells/failures	35/11		55/26	
3	Overvaluation (residual of cross-sectional regressions of price levels on PPP GDP per capita)				
	Initial level	0.99	0.23	1.00	0.61
	Change within spell	***0.98***	***0.02***	1.00	0.75
	Spells/failures	52/19		83/42	
4	Manufacturing exports/total exports (per cent, WDI)				
	Initial level	1.00	0.87	1.02	0.12
	Change within spell	***1.06***	***0.01***	***1.03***	***0.03***
	Spells/failures	29/13		43/22	
5	Sophistication of exports (Hausmann, Hwang and Rodrik, 2007)				
	Initial level	1.82	0.72	***8.11***	***0.01***
	Change within spell	7.67	0.19	***7.59***	***0.02***
	Spells/failures	39/12		60/31	
6	"Open forest" (Hausmann, Rodriquez and Wagner, 2006)[2]				
	Initial level	1.03	0.95	***1.54***	***0.03***
	Change within spell	***2.04***	***0.07***	***1.86***	***0.01***
	Spells/failures	39/12		60/31	

[1]Regressions control for terms of trade shocks, US interest changes and initial income.
[2]Sophistication of exports of other countries weighted by country "proximity" to these exports based on frequency with which good-pairs are exported by the same country.
Source: Authors' calculations.

First, increasing the *current account surplus* during a growth spell seems to raise the chance that growth will be sustained in the $h = 8$ sample, where a one-percentage-point of GDP increase in the current account deficit during the spell lowers the expected duration by 26 per cent. Similar results are obtained for domestic savings. Increases in the degree of *overvaluation* during a spell are also correlated with shorter spells in the samples with $h = 8$. On these samples, each percentage point increase in overvaluation decreases the predicted spell duration by 2 per cent.

That the current account and overvaluation measures clearly correlate with spell duration in the h = 8 sample but not in the $h = 5$ sample is consistent with the idea that the $h = 5$ sample includes spells that reflect business-cycle dynamics. For example, increasing current account deficits and overvaluation may be consistent with a demand-led boom, which could endure for perhaps about five years but would not be ultimately sustainable.

The links between export structure and growth spells are generally large and clear. *Manufacturing exports* and the length of growth spells show a particularly robust relationship. What seems to matter for sustained growth is not so much the share of manufacturing at the beginning of a growth spell, but whether manufacturing exports rise as a share of total exports during the growth spell. A one percentage point increase in manufacturing exports is associated with an increase in the expected duration of a growth spell by 3 to 6 per cent.

Measures of actual or potential *export sophistication* also seem to correlate with the duration of spells. The coefficients have the expected signs in both levels and changes during spell, and with both measures of sophistication. However, the link is particularly strong and significant for in-spell changes in the “open forest” measure proposed by Hausmann and his co-authors. The coefficients are not as easy to interpret as in the other cases because the export sophistication variables are expressed in natural logs of complex indices. However, the standard deviation of the Hausmann, Hwang and Rodrik (2007) (log) export sophistication index is just above 0.5, while the standard deviation of the Hausmann, Rodriguez and Wagner (log) “open forest” index is just above 1. Hence, the results suggest that a one standard deviation increase in export structure flexibility as measured by “open forest” roughly doubles the predicted duration of the spell in the h = 8 sample.

Macroeconomic stability

We now examine the relationship between duration and two traditional indicators of macroeconomic volatility: inflation, and nominal exchange rate depreciation. In addition, we look for a correlation between growth duration and the average growth rate during the spell. Finally, we examine fiscal performance during a spell, measured in terms of debt/GDP ratios.

For inflation and exchange rate depreciation, we use the traditional log transformation multiplied by 100 to make the time ratios easier to interpret.[25] We could have used $\ln(\pi)$ instead, which some authors (Sarel, 1996; Ghosh and Phillips, 1998) have argued is more appropriate to study the effect of inflation on growth. However, this transformation would not have worked for exchange rate depreciation (negative depreciations, that is

[25] Our inflation measure is $100*\ln(1+\pi)$, where π is the log difference of the price level. At low inflation rates, $100*\ln(1+\pi)$ is approximately linear, so that one percentage point in inflation is about the same as a one point rise in $100*\ln(1+\pi)$. Suppose, for example, that inflation rises from 5 per cent a year to 20 per cent. This is the same as a rise in $100*\ln(1+\pi)$ by about 13 points.

appreciations, being very common in our sample) and we wanted to use the same transformation for both inflation and depreciation to make the coefficients comparable; the results for inflation turn out to be insensitive to the choice of transformation in this case.

The first main result is that nominal instability – inflation or depreciation – appears to be negatively correlated with growth duration, particularly in the sample with h=8. The results for inflation in this sample suggest that a one point increase in $100*\ln(1+\pi)$ during the growth spell – which at low inflation rates is approximately equal to a one percentage point increase in the rate of inflation – is associated with a 1 per cent decrease in the predicted duration of the spell. For a depreciation in the exchange rates, the relationship is somewhat stronger and is significant in both samples.

One important question is whether the strong results for inflation and exchange rate depreciation are driven by outliers, as has been argued in the context of conventional cross-country growth regressions (Easterly, 2005). To check this, we drop all observations from the sample in which either current or initial inflation/depreciation exceeded 50 per cent per annum (this means dropping all observations in spells where inflation/depreciation at the beginning of a growth spell exceeded 50 per cent, even if contemporaneous inflation/depreciation was lower). The results (model 3 in Table 9) show that the basic result remains. At the same time, initial inflation rates now have a highly significant negative correlation with spell duration. Hence, the inflation result is not driven by hyperinflation.[26]

Our second main result on macroeconomic stability is that high average growth within spell is a significant predictor of shorter spell duration. It is not obvious that this variable belongs in the "macroeconomic stability" section, but one interpretation is that it reflects "overheating." In any event, we find (models 4-6 of Table 11) that faster growth is less sustainable. When growth is one percentage point higher, predicted spell duration falls by about 15 per cent in all samples and with or without controls for rates of inflation or depreciation.

Our third important result is that rapid growth of public debt/GDP during a spell is correlated with shorter duration, at least in the h=5 sample. The relationship is large economically – a growth of the debt/GDP ratio by 1 percentage point during a spell reduces predicted spell duration by 2 per cent (model 7).

[26] We also find some evidence (not shown) that changes in inflation may not matter when inflation is below some threshold (for example, 10 per cent), but standard errors are too large to draw firm conclusions here.

Table 11: Duration regressions: macroeconomic volatility[1]

Model	Variable	8-year minimum spell		5-year minimum spell	
		time ratio	*p* value	time ratio	*p* value
1	Log (1+inflation)				
	Initial level	1.00	0.94	1.01	0.58
	Change within spell	0.97	0.60	***0.99***	***0.02***
	Spells/failures	54/19		82/43	
2	Log(1+depreciation in the parallel exchange rate)				
	Initial level	***0.94***	***0.02***	0.99	0.12
	Change within spell	***0.96***	***0.06***	***0.99***	***0.10***
	Spells/failures	23/9		34/18	
3	Log(1+moderate inflation)[2]				
	Initial level	0.96	0.45	***0.91***	***0.00***
	Change within spell	0.98	0.64	***0.94***	***0.02***
	Spells/failures	49/19		76/42	
4	Average growth within spell	***0.84***	***0.01***	***0.86***	***0.00***
	Spells/failures	57/19		88/46	
5	Log (1+inflation)				
	Initial level	1.01	0.84	1.00	0.73
	Change within spell	0.98	0.60	***0.99***	***0.01***
	Average growth within spell	***0.81***	***0.01***	***0.86***	***0.00***
	Spells/failures	54/19		82/43	
6	Log(1+depreciation in the parallel exchange rate)				
	Initial level	0.98	0.36	***0.99***	***0.06***
	Change within spell	***0.97***	***0.04***	***0.98***	***0.01***
	Average growth within spell	***0.64***	***0.00***	***0.85***	***0.00***
	Spells /failures	23/9		34/18	
7	Debt/GDP change within spell				
	Average growth within spell	0.97	0.20	***0.98***	***0.05***
	Log (1+inflation)	***0.67***	***0.09***	***0.81***	***0.02***
	Initial level	1.01	0.88	1.00	0.93
	Change within spell	1.00	0.96	***0.99***	***0.02***
	Spells /failures	33/8		44/18	

[1]Regressions control for terms of trade shocks, US interest changes and initial income.
[2]Observations with inflation in excess of 50 per cent per annum replaced by missing values.
Source: Authors' calculations.

This relationship is less robust absent controls for inflation and average growth (not shown), perhaps not surprisingly in view of the mechanisms that may link these variables, but also suggesting that the increase in debt is working through other mechanisms than the effects on aggregate demand or inflation.

Of course, it is plausible that many of the correlates of spell duration that we have identified are themselves correlated with each other. In the next section, we attempt, within the constraints of scarce data, to disentangle the independent effects of our various regressors.

A summary view

Having concluded our tour of the main covariates that can be usefully analysed with our data, it is important to see whether the effects hold up if they are jointly included in the model. Many of the variables that we have identified as potential correlates of growth spell duration – for example, more equal income distributions and better political institutions – are correlated. The question is whether these variables have independent power to predict longer growth spells.

Data scarcity limits the extent to which we can examine the covariates of growth spells jointly. However, it is possible to include at least some variables from each of the groups examined in a way that maintains a reasonable sample size. The results are shown in Table 12, for two versions of the model: one which uses “Overvaluation” among the variable from the competitiveness/export structure group, and the other that uses Hausmann’s “open forest”. In both versions we also control for terms of trade shocks, US interest rates and initial income per capita. As in the earlier regressions, a Weibull distribution was assumed.

As expected, the joint inclusion of many variables weakens some of the individual results. Most variables, however, retain their statistical and economic significance at least on one sample.[27] Among the statistically significant variables, the time ratio estimates are for the most part similar to the coefficients examined before, though they tend to be less stable across subsamples. The external shocks variables tend to lose significance, though the signs remain consistent with Table 4. Income inequality is among the most robust predictors of duration. Autocracy (or equivalently polity2,not shown) is also important, depending on the sample and other covariates. Several external variables retain their economic and statistical significance in at least one model. Export sophistication as measured by “open forest” is among the most robustly significant. The ratio of manufacturing in total exports turned out not to be significant in the presence of income distribution and democratisation (perhaps lending support to the political economy interpretation of this variable by Johnson, Ostry and Subramanian (2006, 2010).

[27] The financial development variables are an exception; they are either completely insignificant or have the wrong sign in all cases (not shown).

Table 12: Summary regressions

Model	Variable	8-year minimum spell		5-year minimum spell	
		time ratio	*p* value	time ratio	*p* value
1	Log (1+inflation) (per cent, change within spell)	0.99	0.60	***0.99***	***0.04***
	Inequality (Gini coefficient)	***0.86***	***0.01***	***0.91***	***0.00***
	Autocracy (Polity IV database)	***0.79***	***0.01***	0.90	0.12
	Trade liberalisation (Wacziarg-Welch dummy variable)	1.78	0.39	0.91	0.84
	Overvaluation	0.99	0.16	1.00	0.91
	External debt liabilities	1.00	0.24	1.00	0.31
	FDI liabilities (Lane and Milesi-Ferretti database[2])	***1.04***	***0.09***	1.01	0.23
	Terms of trade growth	1.02	0.29	1.02	0.12
	First lag (US interest rate change)	0.80	0.31	**0.81**	**0.10**
	Initial level of income percapita	***0.67***	***0.02***	0.87	0.12
	P[1]	1.35	0.301	1.42	0.12
	Spells/failures	27/11		36/17	
2	Log (1+inflation) (percent, change within spell)	1.00	0.95	***0.99***	***0.00***
	Inequality (Gini coefficient)	***0.90***	***0.00***	***0.93***	***0.00***
	Autocracy (Polity IV database)	***0.93***	***0.02***	0.98	0.79
	Trade Liberalization (Wacziarg-Welch Dummy Variable)	1.11	0.71	1.18	0.64
	Open forest (Hausmann Rodriquez and Wagner 2006)	***2.50***	***0.00***	***2.02***	***0.00***
	External debt liabilities 2/)	***1.00***	***0.09***	1.00	0.69
	FDI liabilities (Lane and Milesi-Ferretti database 2/)	***1.04***	***0.00***	1.01	0.42
	Average growth within spell	***0.82***	***0.02***	***0.82***	***0.06***
	Terms of trade growth	1.01	0.12	1.02	0.25
	First lag (US interest rate change)	0.95	0.34	***0.83***	***0.06***
	Initial level of income percapita	***0.73***	***0.00***	***0.83***	***0.03***
	P1/	***6.04***	***0.00***	***1.91***	***0.01***
	Spells/failures	26/10		33/16	

1P is the shape parameter in the Weibull distribution $h_t = pt^{p-1}$. The p-value is for the null hypothesis that p=1 (implying that the hazard is duration independent
Source: Authors' calculations.

For the macroeconomic stability variables, significance becomes somewhat more elusive with the inclusion of the other covariates (average growth during spell is a robust exception). Inflation retains significance in half the samples. This reduction in significance may be due to the corresponding reduction in sample size and degrees of freedom, but it could also lend some credence to the argument in Acemoglu et al. (2003) to the effect that macroeconomic volatility may reflect deeper factors rather than acting as an independent cause of poor performance. Debt/GDP is not significant (not shown), possibly reflecting the especially sharp decline in sample size that its inclusion provokes.

A common thread is that low initial income is a significant and important predictor of longer spells (not shown). This has two important implications. First, growth downbreaks may be part of the (conditional) convergence process. Thus, as countries approach the frontier, the end of the growth boom may come suddenly. Second, this constitutes indirect evidence against the poverty traps hypothesis. Hausmann et al. (2005) find that poor countries are in general at least as likely as others to experience growth upbreaks, and we saw some flavour of that in noting that sub-Saharan African countries have had their share of upbreaks. Here we see that poor countries are more likely, ceteris paribus, to see their growth spells endure.

Equipped with these summary regressions, we can now return to the question of duration dependence. We know from earlier that the unconditional hazard falls with time. But, controlling for the correlates we have examined, do growth spells have a natural dynamic pattern? This could be interpreted either as intrinsic – how the hazard of growth ending would evolve over time if all covariates were kept constant – or as reflecting time-varying omitted variables (for example, the hazard might rise over the life of a spell as political pressures that tend to bring about an end to the spell build up). In the Weibull specification assumed to date, the baseline duration dependence – $\lambda_0(t)$ in equation 1 – is monotonic and depends on the estimated parameter p, growing with time for $p>1$, falling for $p<1$, or remains constant if $p=1$. We find that in most specifications the estimated value of p is greater than 1, sometimes statistically significantly so (as in model 2 in Table 12), suggesting that the baseline hazard rises with time, controlling for the evolution of the covariates.

Goodness of fit

Do the regressions explain a large share of the variation in growth spell duration? In general, this is a hard question to answer, due to the nature of the duration specification with censored observations time-varying determinants of duration. For example, we would like to calculate the expected spell duration and compare to the actual. However, unless we assume strict exogeneity, the end of the spell itself will likely change the trajectory of the determinants of duration. Thus, we cannot integrate through all (future) time to calculate expected spell duration. Here, we examine various indicators of goodness-of-fit.

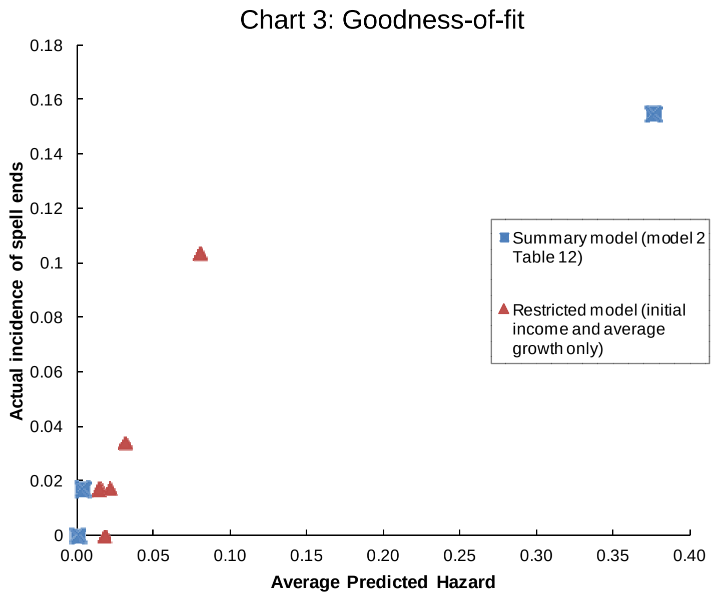
First, we examine the overall statistical performance of our summary model from Table 12 against a series of nested models that have only the most basic covariates or indeed none at all (Table 13). The likelihood-ratio tests imply that the full model fits the data significantly better. As indicated by the high values for the associated chi-squared statistics, these tests reject the full set of zero restrictions implicit in the smaller models at extremely small p-values (less than 0.01). Along the same lines, we can get a rough sense of the explanatory power of the model by examining a likelihood-based pseudo-R2 likelihood ratio statistic measuring goodness of fit (Woolridge, 2002). Overall, the covariates seem to have substantial explanatory power in this sense.

Table 13: LR-tests and pseudo *R*-squared

Model	log likelihood	LR test Chi-squared[1]	p-value	pseudo *R*-squared[2]
h = 5				
Full model 2, Table 12	-19.37			0.50
Only average growth within spell and initial income p.c	-36.85	**34.96**	**(0.00)**	0.04
Only initial income per capita	-38.54	**38.34**	**(0.00)**	0.00
None (pure duration model)	-38.54	**38.34**	**(0.00)**	…
h = 8				
Full model 2, Table 12	-0.55			0.98
Only average growth within spell and initial income p.c.	-25.46	**49.82**	**(0.00)**	0.09
Only initial income per capita	-27.40	**53.68**	**(0.00)**	0.02
None (pure duration model)	-27.99	**54.87**	**(0.00)**	…

[1]Test comparing full model 2 with smaller nested models. Bold indicates rejection of nested models at the 1 per cent level.
[2]Defined as 1 - L1/L0, where L1 is the log likelihood of the corresponding model and L0 of the pure duration model.

Second, we can give a more informal feel for the economic significance of our results. Chart 3 relates the predicted hazard to the actual incidence of spell failures. To create this chart, we divide all the observations into five, equal-sized groups, with the first group having the lowest predicted hazard and the fifth group having the highest predicted hazard. For each group we calculate the average predicted hazard, based on model 2 of Table 12. We can also measure the fraction of observations in each group that represent actual ends of spells. The scatter of the second number against the first represents a picture of "goodness-of-fit". We also carry out a similar exercise for a restricted model with the same Weibull hazard model but only per capita income and average growth as predictive variables. We see this figure as suggesting that predicted hazards vary over a wide range – much more so for the summary model – and are reasonably good predictors of the actual frequency of spell failures. This demonstrates that the summary model has substantial explanatory power, much more so than the restricted model.



Note: Each data point represents one-fifth of the observations in the sample, ordered by the average predicted hazard. For the summary model, three such groups have zero actual and essentially zero predicted hazard, so they overlap in the figure.
Source: Authors’ calculations.

3. ROBUSTNESS

In the previous section we examined the robustness of the results with respect to alternative data samples that differed with respect to their definition of breaks in growth, and hence growth spells. We also looked at how different combinations of potential predictive variables affected the results. This section takes robustness analysis one step further, examining (i) alternative distributional assumptions about the duration of growth spells; and (ii) omitted variables and unobserved heterogeneity.

Alternative distributional assumptions

The results presented until now have assumed the Weibull distribution for the hazard model. The models presented in the previous section can be re-estimated using a variety of distributional forms. This gives a sense of the robustness of the coefficients of the model to alternative distributional assumptions. It also allows us to examine whether the robustness of the increasing baseline hazard we observed in the previous section, for example whether allowing for a non-monotonic baseline hazard, yields different results. A simple way of generalising the Weibull distribution is to allow the duration parameter p to be itself a linear function of time as in $p = a + bt$. This supports a hazard that initially grows with time (p>1) then falls (p<1), or vice versa. Similarly, other distributional forms, such as the log-normal, log-logistic, or gamma, will allow hazards that first grow and then fall.

Table 14 shows the results. The columns labelled “Weibull” merely repeat the results for model 2 of Table 12 for reference. The remaining columns estimate the same model using alternative distributions. Unfortunately, the Weibull with ancillary time parameter could only be estimated for the samples with five-year minimum spell (the estimation would not converge for the other samples using this distribution).

Table 14: Duration dependence and robustness with respect to functional form[1]

	8-year minimum spell			5-year minimum spell			
Variable	Weibull	Log-logistic	Log-normal	Weibull w. anc. param.	Weibull	Log-logistic	Log-normal
Log (1+inflation)	1.00	1.00	1.00	**0.99**	**0.99**	**0.99**	***0.99***
	0.95	0.83	0.79	**0.01**	**0.00**	**0.04**	***0.08***
Inequality	**0.90**	**0.90**	**0.91**	**0.94**	**0.93**	**0.94**	**0.93**
	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**
Autocracy score	**0.93**	**0.93**	***0.92***	0.99	0.98	1.02	1.03
	0.02	**0.05**	***0.06***	0.80	0.79	0.78	0.70
Trade liberalisation	1.11	0.95	0.87	**1.59**	1.18	1.13	0.96
	0.71	0.89	0.71	**0.04**	0.64	0.79	0.93
Open forest	**2.50**	**2.69**	**2.75**	**1.74**	**2.02**	**2.23**	**2.13**
	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**
External debt liabilities	***1.00***	**1.00**	**1.00**	1.00	1.00	1.00	1.00
	0.09	**0.04**	**0.02**	0.68	0.69	0.92	0.55
FDI liabilities	**1.04**	**1.04**	**1.05**	**1.01**	1.01	1.01	1.01
	0.00	**0.00**	**0.00**	**0.02**	0.42	0.49	0.33
Av. growth within spell	**0.82**	**0.84**	**0.85**	**0.79**	***0.82***	0.81	***0.77***
	0.02	**0.03**	**0.05**	**0.00**	***0.06***	0.11	***0.09***
Terms of trade change	1.01	1.01	***1.02***	1.01	1.02	1.02	1.03
	0.12	0.12	***0.09***	0.34	0.25	0.26	0.15
U.S. interest rate change	0.95	0.95	0.93	0.90	***0.83***	***0.78***	***0.76***
	0.34	0.46	0.41	0.12	***0.06***	***0.06***	***0.06***
Initial income per capita	**0.73**	**0.71**	**0.68**	**0.81**	**0.83**	0.85	0.86
	0.00	**0.00**	**0.00**	**0.00**	**0.03**	0.11	0.17
Constant	**0.03**	**0.01**	**0.01**	0.57	0.17	0.02	0.07
	0.05	**0.02**	**0.01**	0.81	0.60	0.30	0.56
Ancillary parameter (1)[2]	**6.04**	**0.14**	**0.30**	**0.06**	**1.91**	**0.45**	0.85
p value[3]	**0.00**	**0.00**	**0.00**	**0.03**	**0.01**	**0.00**	0.43
Ancillary parameter[4]				0.36			
p value				0.17			
Spells/failures		26/10			33/16		

[1]Re-estimation of model 2 from Table 12. Time ratios and p-values shown, except for Cox, where hazard ratio is presented.

[2]Refers to time coefficient *b* of function ln(*p) = a*+*b*t for Weibull with ancillary time parameter; to shape parameter *p* for standard Weibull; to scale parameter □ for log-logistic, and to standard deviation □ for lognormal.

[3]Refers to test that time coefficient *b* = 0 in case of Weibull with time parameter; that shape parameter *p* = 1 in case of standard Weibull; that □ = 1 in case of log-logistic; and that standard deviation □ = 1 in case of lognormal.

[4]Refers to intercept *a* of function ln(*p) = a*+*b*t for Weibull with ancillary time parameter; p-value refers to test that *a* = 0.

Source: Authors' calculations.

Table 14 shows that the coefficient estimates for the economic covariates are not very sensitive to the assumed distributional form, and that their statistical significance often (though not always) is similar across distributions.

With respect to duration dependence itself, as we saw before, when monotonicity is imposed in the Weibull specification, the estimations suggest that the hazard is a rising function of time, with a null of constant hazard (p=1) rejected in model 2 of Table 12 but not in model 1. What happens when monotonicity is not imposed? For model 2, the ancillary time parameter itself is not significant in the augmented Weibull specification, suggesting that we cannot reject monotonicity and thus that the baseline Weibull may be adequate. (The parameter point estimates are consistent with a rising baseline hazard). The parameter estimates for the log-normal and log-log distributions suggest rising baseline hazards with time for the h=5 sample and rising then roughly flat baseline hazards for the h=8 sample, though with considerable uncertainty about the exact shape. Overall, there is some underwhelming evidence for a rising baseline hazard.

Unobserved heterogeneity and robustness to omitted variables

One potential source of bias in the coefficients estimated in the summary models in Table 12 is an incorrectly specified set of economic covariates. In a strict sense, we know that this must be the case; clearly, it would be a remarkable coincidence if either of the two summary models were exactly right. The best we can hope for is that the specification error that is necessarily present does not greatly affect the coefficient estimates of the variables on which we focus.

But how can this be tested? One approach that is easy to implement (but does not set the bar very high, as we shall see) is to assume that the models are right except for the presence of unobserved heterogeneity (also referred to as “frailty”) in the form of a multiplicative stochastic term υ_i which is added to the proportional hazard model presented in Section 3.B:

$$\lambda(t) = \upsilon_i \exp(\beta[X(t), z])\lambda_0(t)$$

υ_i is assumed to follow a specific distribution (such as the gamma, or inverse Gaussian). Depending on what the index *i* pertains to, υ_i can either be interpreted as a random term modifying the hazard conditional on *t* and *X*(*t*) for each observation, or as specific to sets of observations (“shared frailty”), for example, across all observations pertaining to a specific country. In this case, υ_i is analogous to a random effects term in a panel regression context.

Table 15: Frailty regressions

(Time ratios and p-values shown)

Variable	8-year minimum spell			5-year minimum spell		
	Log-logistic	Log-logistic with frailty (observation level)	Log-logistic, shared frailty (country level)	Log-logistic	Log-logistic with frailty (observation level)	Log-logistic, shared frailty (country level)
Log (1+inflation)	1.00	1.00	1.00	**0.99**	**0.99**	***0.99***
	0.83	0.83	0.79	**0.04**	**0.04**	***0.08***
Inequality	**0.90**	**0.90**	**0.91**	**0.94**	**0.94**	**0.93**
	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**
Autocracy score	**0.93**	**0.93**	***0.92***	1.02	1.02	1.03
	0.05	**0.05**	***0.06***	0.78	0.78	0.70
Trade liberalisation	0.95	0.95	0.87	1.13	1.13	0.96
	0.89	0.89	0.71	0.79	0.79	0.93
Open forest	**2.69**	**2.69**	**2.75**	**2.23**	**2.23**	**2.13**
	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**
External debt liabilities	**1.00**	**1.00**	**1.00**	1.00	1.00	1.00
	0.04	**0.04**	**0.02**	0.92	0.92	0.55
FDI liabilities	**1.04**	**1.04**	**1.05**	1.01	1.01	1.01
	0.00	**0.00**	**0.00**	0.49	0.49	0.33
Av. growth within spell	**0.84**	**0.84**	**0.85**	0.81	0.81	***0.77***
	0.03	**0.03**	**0.05**	0.11	0.11	***0.09***
Terms of trade change	1.01	1.01	***1.02***	1.02	1.02	1.03
	0.12	0.12	***0.09***	0.26	0.26	0.15
US interest rate change	0.95	0.95	0.93	***0.78***	***0.78***	***0.76***
	0.46	0.46	0.41	***0.06***	***0.06***	***0.06***
Initial income per capita	**0.71**	**0.71**	**0.68**	0.85	0.85	0.86
	0.00	**0.00**	**0.00**	0.11	0.11	0.17
Constant	**0.01**	**0.01**	**0.01**	0.02	0.02	0.07
	0.02	**0.02**	**0.01**	0.30	0.30	0.56
Scale parameter γ	**0.14**	**0.14**	**0.30**	**0.45**	**0.45**	0.85
p value 1/	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.43
Spells/failures		26/10			33/16	

[1]Refers to test that γ = 1.
Source: Authors' calculations.

Table 15 shows the effect of adding a "frailty" term to the log-logistic version of summary model 2. As can be seen from the table, this barely has an impact on the regression coefficients and significance levels, regardless of whether frailty is modelled at the observation level or at the country level.[28]

[28] We used the log-logistic distribution because attempts to estimate frailty models using the baseline Weibull distribution failed (no convergence). In addition, we tried frailty based on a lognormal distribution, with similar results as in Table 15.

One potential problem with the frailty regressions in Table 15 is that they assume that frailty term is uncorrelated with the economic covariates in our model (see Woolridge, 2002). To the extent that unobserved heterogeneity arises because a relevant economic covariate has been omitted from the model, this assumption is likely to be violated. An alternative approach to exploring the robustness of the coefficient estimates that is not susceptible to this problem is to add additional variables to the X - matrix of covariates that may be proxying for potential omitted variables. In light of the striking differences in the duration of growth spells across regions (see Section 2), good candidates for such variables are regional dummies. Alternatively, one can examine the idea that the sample is heterogeneous by dropping observations that are suspected to be different in ways that are not controlled for by X from the regression, and checking how this affects the results.

Table 16 undertakes these exercises. The top panel reproduces the results from model 2 (Table 12) for reference purposes. The next panel shows how the results are affected by adding regional dummies for Latin America and sub-Saharan Africa to the model. These were two regions of the world that stood out for having relatively short growth spells. The results are reasonably encouraging: the Latin America dummy is significant in one sample (and suggests some omitted variable correlated with shorter spells), but the sub-Saharan Africa dummy and the Latin America dummy in the other sample are insignificant (and the point estimates suggest spells are unusually long in those continents/samples.) Moreover, the main results from the summary regressions are largely unaffected.

Finally, the next panel drops all Asian observations from the model, to ensure that our main results – for example, with respect to the effect of low income inequality and/or export "connectedness" (open forest) – do not simply capture the differences between Asia and the remainder of the sample. This results in a significantly smaller sample. However, the coefficients (and even their statistical significance levels) turn out to be remarkably similar to those in the other two panels.

Table 16: Robustness to regional dummies and to dropping Asian observations[1]

Model	Variable	8-year minimum spell time ratio	8-year minimum spell *p* value	5-year minimum spell time ratio	5-year minimum spell *p* value
Model 2 (reproduced from Table 12)	Log (1+inflation) (per cent, change within spell)	1.00	0.95	**0.99**	**0.00**
	Inequality (Gini coefficient)	**0.90**	**0.00**	**0.93**	**0.00**
	Autocracy score (scale 0 to 10)	**0.93**	**0.02**	0.98	0.79
	Trade liberalisation (0-1 dummy)	1.11	0.71	1.18	0.64
	Open forest	**2.50**	**0.00**	**2.02**	**0.00**
	External debt liabilities (per cent of GDP)	***1.00***	***0.09***	1.00	0.69
	FDI liabilities (per cent of GDP)	**1.04**	**0.00**	1.01	0.42
	Average growth within spell (per cent)	**0.82**	**0.02**	***0.82***	***0.06***
	Terms of trade change (per cent)	1.01	0.12	1.02	0.25
	US interest rate change (points)	0.95	0.34	***0.83***	***0.06***
	Initial income per capita (in thousands)	**0.73**	**0.00**	**0.83**	**0.03**
	Spells/failures	26/10		33/16	
Model 2 with regional dummies	Log (1+inflation) (per cent, change within spell)	***1.01***	***0.07***	**0.99**	**0.01**
	Inequality (Gini coefficient)	**0.93**	**0.00**	**0.92**	**0.00**
	Autocracy score (scale 0 to 10)	**0.95**	**0.03**	0.97	0.60
	Trade liberalisation (0-1 dummy)	1.37	0.22	1.27	0.53
	Open forest	**2.62**	**0.00**	**2.34**	**0.00**
	External debt liabilities (per cent of GDP)	1.00	0.34	1.00	0.56
	FDI liabilities (per cent of GDP)	**1.03**	**0.00**	1.01	0.33
	Average growth within spell (per cent)	**0.70**	**0.00**	0.85	0.17
	Terms of trade change (per cent)	**1.02**	**0.00**	1.02	0.24
	US interest rate change (points)	0.99	0.77	0.85	0.11
	Initial income per capita (in thousands)	**0.78**	**0.00**	**0.81**	**0.02**
	Latin America (dummy)	**0.58**	**0.02**	1.39	0.54
	Sub-Saharan Africa (dummy)	1.60	0.18	1.96	0.40
	Spells/failures	26/10		33/16	
Model 2 w/o Asian observations	Log (1+inflation) (per cent, change within spell)	1.00	0.76	**0.99**	**0.00**
	Inequality (Gini coefficient)	**0.92**	**0.00**	**0.94**	**0.00**
	Autocracy score (scale 0 to 10)	0.96	0.43	0.98	0.79
	Trade liberalisation (0-1 dummy)	0.91	0.72	0.88	0.76
	Open forest	**2.55**	**0.00**	***1.80***	***0.06***
	External debt liabilities (per cent of GDP)	**1.00**	**0.01**	1.00	0.97
	FDI liabilities (per cent of GDP)	**1.04**	**0.00**	1.00	0.64
	Average growth within spell (per cent)	***0.87***	***0.07***	***0.83***	***0.06***
	Terms of trade change (per cent)	**1.02**	**0.05**	1.02	0.22
	US interest rate change (points)	0.99	0.94	***0.82***	***0.08***
	Initial income per capita (in thousands)	**0.73**	**0.00**	0.92	0.54
	Spells/failures	19/9		25/13	

[1]Regressions control for terms of trade shocks, US interest changes and initial income.
Source: Authors' calculations.

4. CONCLUSION

This paper builds on the emerging literature on growth transitions by moving the object of inquiry to the duration of growth spells. Using an extension of Bai and Perron's (1998, 2003) approach to testing for multiple structural breaks, we identified a rich set of structural breaks in economic growth paths around the world, and used these to define "growth spells". We then employed survival analysis to explore the role of a large number of economic factors that might be influencing the length of growth spells.

The paper identified a handful of economic and political characteristics that predict sustained growth: more equal income distribution, democratic institutions, openness to trade and foreign direct investment, and an export or production structure that favours relatively sophisticated exports. We also found that stable macroeconomic environments, with lower inflation rates and fewer instances of high depreciation and slower accumulation of debt predict longer growth spells.

The associations and regularities identified in this paper seem consistent with several themes that have been prominent in the literature on economic development in the last 20 years. These include the view that less equal and cohesive societies experience lower and more volatile growth, perhaps because social conflict breeds populist policies (Sachs, 1989) or because they have weaker institutions and a reduced capacity for managing external shocks (Rodrik, 1999; Easterly, Ritzen and Woolcock, 2006). The results are also consistent with the notion that export orientation may help growth by building constituencies in favour of better institutions (Rajan and Zingales, 2006; Johnson, Ostry and Subramanian, 2006, 2010); and the idea that current export or production structures matter for future growth because they favour innovation and allow economies to react more flexibly to shocks (Hausmann, Hwang and Rodrik, 2007; Hausmann, Rodriguez and Wagner, 2006). Exploring, differentiating and testing these channels remains a challenge for future work.

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Appendix Table 1: Summary Statistics for Regressors

Description	Source	Unit of measurement	Obs	Mean	Std. Dev.
Terms of Trade	WEO	Ratio of export prices to import prices (2000=100)	603	0.48	13.20
US interest rate	FED 3 month Treasury bill	Percent change	635	-0.02	1.52
Initial level of income	PWT 6.2	USD per capita	720	3.23	4.47
Polity 2	Polity IV	Scale from -10 (autocratic) to 10 (democratic)	560	1.22	6.87
Autocracy	Polity IV	Scale from 0 to 10 (most autocratic)	560	2.97	3.18
Democracy	Polity IV	Scale from 0 to 10 (most democratic)	560	4.20	3.89
Executive recruitment	Polity IV	Scale from 1 (rulling by inheritance) to 8 (democratic elections)	560	5.77	2.26
Executive constraints	Polity IV	Scale from 1 (unlimited executive authority) to 7 (executive parity of subordination)	560	4.22	2.14
Political competition	Polity IV	Scale from 1 (repressed competition) to 10 (open electoral participation)	560	5.53	3.29
Investment profile	ICRG	Scale from 2 (high risk) to 12 (low risk)	398	7.52	2.22
Income inequality	Wider 2.a	Gini coefficient (the higher the coefficient the higher inequality is)	411	38.47	7.36
Ethnic fractionalization	Alesina et al. (2003)	One minus the sum of ethnic group shares in country and multiplied by 100	692	44.16	25.56
Primary Education	Barro and Lee	Average years of primary schooling in the total population over age 25	395	2.10	1.21
Secondary Education	Barro and Lee	Average years of secondary schooling in the total population over age 25	395	0.63	0.54
Adult mortality	WDI	Deaths per 100	502	32.78	11.81
Child mortality (deaths per 100; WDI) - initial level	WDI	Deaths per 100	515	8.56	4.49
Telephone infrastructure	WDI	Mainlines per 100 people	448	107.98	154.43
Bank deposits	Beck et al. 2000	Ratio of deposit money bank assets to GDP, in percent	302	29.83	34.48
Private credit	Beck et al. 2000	Ratio of private credit by deposit money banks to GDP, in percent	302	26.14	28.95
Trade Openness	PWT 6.2	Exports plus Imports divided by GDP, percent	570	6.69	44.27
Financial Integration	Lane and Milesi-Ferretti, 2003	Sum of total foreign assets and liabilities (net of the value of derivatives) as a ratio of GDP.	242	134.41	136.38
External debt liabilities	Lane and Milesi-Ferretti, 2003	External debt liabilities from IMF's (WEO) and World Bank's Global Development Finance database	242	53.81	50.61
FDI liabilities	Lane and Milesi-Ferretti, 2003	Data on foreign assets and liabilities of banks and other banking institutions reported by IFS	242	16.35	21.52
Sophistication of exports	Hausmann Hwang and Rodrik 2006	Weighted sum of the productivity levels associated to each exported good	414	8.37	0.38
Current Account Balance	WDI and IFS	Percent of GDP	210	-3.37	6.27
Domestic Savings	WDI	Percent of GDP	350	15.37	12.56
Manufacturing exports/Total exports	WDI	Ratio of manufacturing goods exports to total exports	315	26.07	25.65
Log(1+CPI inflation)	IFS	Percent	630	12.87	23.10
Log(1+CPI inflation) restricted to moderate	IFS	Percent	574	6.32	7.74
Depreciation	Reinhart-Rogoff 2004	Log(1+depreciation in the parallel exchange rate)	459	8.06	21.25
"Open Forest" measure of export sophistication	Hausmann and Klinger 2006	Distance-adjusted level of income associated with all potential new export goods, where the distance is measured between each new potential good and the economy's present export basket	554	13.35	0.98
Trade Liberalization	Wacziarg-Welch 2003	Indicator = 1 if current year is greater than the year of trade liberalization and no reversal of the trade policy reforms have occurred, and 0 otherwise.	484	0.66	0.47
Overvaluation of income by price level	PWT 6.2	log (PPP over GDP divided by the exchange rate times 100)	641	-18.74	38.10

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