Freie Universität Berlin
Fachbereich Wirtschaftswissenschaft

Essays on Economic Growth – A Medium-Term Perspective

Inaugural-Dissertation zur Erlangung des akademischen Grades eines Doktors der Wirtschaftswissenschaft des Fachbereichs Wirtschaftswissenschaft der Freien Universität Berlin

vorgelegt von Diplom-Volkswirtin Monika Kerekes

aus

Hannover

Berlin, 2015

Erstgutachter: Professor Dr. Dr. Giacomo Corneo

Zweitgutachter: Professor Irwin Collier Ph. D.

Tag der Disputation: 04.12.2015

Vorveröffenlichungen

Die nachfolgende Liste enthält die gemäß § 10 Abs. 4 der Promotionsordnung zum Dr. rer. pol. des Fachbereichs Wirtschaftswissenschaft der Freien Universität Berlin vom 13. Februar 2013 als Sonderdruck einzureichenden Vorveröffentlichungen.

Kapitel 2:
Kerekes, M. (2007). Analyzing Patterns of Economic Growth: A Production Frontier Approach. Diskussionsbeiträge des Fachbereichs Wirtschaftswissenschaft der Freien Universität Berlin. Volkswirtschaftliche Reihe. 2007/15.

Hinweis: Eine deutlich überarbeitete Version des Papiers wurde zur Resubmission im *Journal of Macroeconomics* akzeptiert, konnte dann aber aus Zeitgründen nicht erneut eingereicht werden.

Kapitel 3:
Kerekes, M. (2009). Growth Miracles and Failures in a Markov Switching Classification Model of Growth. Diskussionsbeiträge des Fachbereichs Wirtschaftswissenschaft der Freien Universität Berlin. Economics. 2009/11.

Kerekes, M. (2012). Growth Miracles and Failures in a Markov Switching Classification Model of Growth. *Journal of Development Economics 98*, 167–177 (http://dx.doi.org/10.1016/j.jdeveco.2011.06.012). Hinweis: Die Literaturhinweise wurden angepasst, soweit im Artikel zitierte Working Paper inzwischen in Zeitschriften veröffentlicht sind.

Acknowledgements

I would like to express my gratitude to everyone who supported me in writing this thesis. Finishing this thesis has been more challenging than I had ever imagined. I am sincerely grateful to my thesis advisor Prof. Giacomo Corneo not only for his guidance, critical dispute and support, but also for his patience and the confidence that I would one day complete my studies. I would also like to express my gratitude to Prof. Irwin Collier, who agreed to co-superwise my work and thereby helped me at a time of unexpected difficulties. In addition, I am grateful to Prof. Mathias Trabandt, Prof. Tim Bönke and Holger Lüthen for their interest in my work and for sitting in my thesis committee.

I worked on this thesis over many years, first as an employee at the Eastern European Institute of the Freie Universität Berlin, then as an employee at the Confederation of German Employers' Associations (BDA) and the Federal Ministry for Economic Affairs and Energy. Everywhere I had met supportive collegues and I would like to thank them, for being there and encouraging me to continue at times when I needed just that.

Finally, I am deeply indebted to my family and family-in-law for keeping me in their thoughts and for not begrudging me my frequent lack of time over the years. However, I would not have finished this thesis without my husband's support. Not only did he listen, read and discuss the thesis with me when I felt it was necessary, but he has also made true on his promises and stood by me for better for worse as a whole new reality has rocked our world.

Berlin, 21.02.2016

Contents

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Motivation

Quoting Lucas (1988, p.5), the consequences of economic growth and productivity improvements on human welfare are staggering and "make it hard to think about anything else". Accordingly, many economists have worked on uncovering the driving forces of economic growth, both theoretically and empirically. From the theoretical point of view, the emergence of endogenous growth theory has represented major progress. Endogenous growth theory attempts to explain the evolution of technological progress or population growth within the growth model and thus endogenizes those exogenous factors that make sustained growth possible in the neoclassical growth model (Solow, 1956; Swan, 1956). By implication and unlike in the neoclassical model, policy is no longer irrelevant for long-term growth (Barro and Sala-i Martin, 2004, chap. I.4). Three broad classes of endogenous growth models can be distinguished (Thompson, 2008): idea-based growth models (Aghion and Howitt, 1992; Romer, 1990), human capital-based growth models (Lucas, 1988) and models with convex technologies, but conditions that bind the marginal returns to capital somewhere above zero (Jones and Manuelli, 1990; Rebelo, 1991). What all models have in common are non-convexities or other assumptions that guarantee that one reproducible factor in the economy asymptotically features non-decreasing marginal returns, which makes perpetual growth at a constant rate sustainable even in the absence of exogenous population growth or technological progress.[1]

The emergence of endogenous growth theory in combination with the availability of large datasets has also spurred a lot of empirical work intended to understand the reasons why growth rates differ across countries and which policy measures can be used to effectively raise growth (Temple, 1999). The workhorse of empirical growth research are formally or informally derived growth regressions (Barro, 1991; Mankiw et al., 1992). Typically, the average growth rate of income per capita over several decades and for a large number of countries is regressed on set of possible growth determinants and initial income per capita. A statistically significant negative coefficient on initial income is taken as proof of conditionally converging income levels across countries. Statistically significant coefficients on other growth determinants are interpreted as evidence that these growth determinants are suitable policy measures to influence either steady state or transitional growth. This approach has subsequently been extended to panel regressions (Islam, 1995), which allows using the variation of growth rates over time within countries in addition to the variation of growth rates across countries. Thereby the number of observations is multiplied and more sophisticated estimation techniques such as the generalized method of moments estimator can be applied (Caselli et al., 1996). Moreover, panel estimation offers some possibilities to control for omitted variables, a frequently voiced concern in the specification of traditional cross-country growth regressions (Durlauf et al., 2005; Temple, 1999).

While some important insights have been generated using the growth regression framework,[2] a major difficulty of growth regressions is their inherent instability: depending on the exact specification of the model with regard to sample period, sample coverage and growth correlates, the results tend to differ (Levine and Renelt, 1992; Sala-i-Martin et al., 2004; Sala-i-Martin, 1997).

[1] In addition to endogenous growth theory, some alternative approaches that pay more attention to the evolutionary element of the growth process, to structural and to demand issues have been formulated. A nice overview from the viewpoint of poverty reduction is presented in Gore (2007).

[2] At the very least, it has been recognized that growth differences are closely linked to differences in total factor productivity levels and growth rates thereof, as well as to national policies. Despite this, there is little consensus about the relative importance of different policy measures (Easterly and Levine, 2001).

One likely reason for the observed instability of growth regressions is the instability of the growth rates themselves. While the country characteristics used in growth regressions are typically quite stable over time, Easterly et al. (1993) show that the correlation of growth rates across decades is rather low. Most correlation coefficients vary between 0.1 – 0.3 depending on the sample coverage and the period under consideration. Pritchett (2000) illustrates that growth rates are particularly unstable and volatile in developing countries; these countries are plagued by large and abrupt changes of their average growth rates. In terms of growth regressions this implies that trying to explain the average growth rate over time periods of arbitrary length cannot lead to robust results because the average growth rate itself becomes to some extent an arbitrary measure: In the presence of large structural breaks it depends on the exact time periods chosen for the analysis. Hence, in order to learn more about economic growth, it is essential to take seriously the observed instability of growth rates and to focus more on the patterns of economic growth rather than on the average growth rate itself.[3]

As a result of this fundamental critique of growth regressions, a new strand of literature has started to emerge. It acknowledges that most countries experience both periods of successful and periods of failing growth and hence change between different growth regimes (Jones and Olken, 2008). Viewed this way, understanding long-run growth essentially means understanding how and why countries switch from one regime to another (Jerzmanowski, 2006). As a prerequisite to studying growth transitions, it is necessary to identify the points in time that mark a regime change. Usually, structural breaks in average growth rates are identified by applying either a filter-based or a statistical approach. The former relies on subjectively defined rules, the latter uses statistical methods to test for the presence of structural breaks (Kar et al., 2013).[4] Given the subjective element in the choice of the approach and in the definition of rules, it is perhaps not surprising that the discussion on how to appropriately define

[3]Another strand of literature emphasizes the model uncertainty that is intrinsic in growth regressions and that arises from the open-endedness of growth theories. This complementary literature uses Bayesian model averaging techniques to identify the most relevant explanatory variables (Durlauf et al., 2005, 2008). This approach is not considered in this thesis.

[4]In addition, some authors have applied a so-called episodic approach, which restricts attention to longer and sometimes informally derived growth spells. Cf. Chapter 2.

growth regimes is far from settled.[5] In a second step, most studies attempt to exploit the information hidden in the identified turning points by either searching for noticeable changes in growth determinants before the onset of a new growth episode or by assessing the ability of growth determinants to predict the duration of a growth spell. The methods of analysis are mostly discrete choice and duration models. Hausmann et al. (2005) is the seminal contribution for the first approach whereas Berg et al. (2012) is the standard reference for the second one.[6]

While definite results are still scarce, one important insight from this literature is that changes in growth regimes are frequent. This is true for all countries including the African ones, which are often associated with dismal growth behavior. The insight does not hinge on the chosen method to identify growth transitions and it is equally true for accelerating and decelerating growth rates.[7] This observation is highly related to a second important insight: igniting growth and sustaining it appear to be two distinct endeavors.[8] Even though the majority of countries is able to ignite growth at some point in time, only a minority can sustain it long enough to lastingly catch up with the leading economies. Most growth spurts lose momentum over time and quite often improved living standards as a result of growth accelerations are reversed by growth collapses. In such an environment policy makers will be interested to obtain answers to three questions in particular: what should they do to get growth started, what should they do to sustain it and what should they not do in order to avoid choking it off. Unfortunately, the insights on these issues are still rather limited: despite much effort to identify responsible factors for growth regime changes, they remain poorly understood. Traditional growth regressors - whether in levels or in changes - appear to do a very poor job of predicting regime changes.[9]

[5] Cf. Jones and Olken (2008) as a seminal contribution for the statistical and Hausmann et al. (2005) as one for the filer-based approach.

[6] However, Berg et al. (2012) were not the first to apply duration analysis in the context of growth transitions. The first analysis to do so appears to be Hausmann et al. (2006).

[7] This observation is in one way or another documented in all studies cited above.

[8] This conclusion features prominently e.g. in Rodrik (2005) who bases his conclusion to a large extent on Hausmann et al. (2005).

[9] Hausmann et al. (2005) note this explicitly and this result is a recurrent theme in many other cited contributions.

The limited success to explain large changes in observed growth rates leaves ample opportunities to contribute to this important research agenda. One underexplored area of research relates to the mechanical sources of growth. Whereas growth accounting exercises are ubiquitous in standard growth empirics,[10] they are rare in combination with growth regime changes. Yet, if it is of interest to know whether average growth rates are driven by factor accumulation or technological progress, it is certainly of interest, too, to learn which elements matter for growth regime changes. A second starting point for new insights is to focus on *patterns* of growth instead of focusing on the breaks in average growth rates themselves. Patterns of growth are determined by the sequence of switches between growth regimes. Hence, such an approach essentially by construction distinguishes between proximate causes of growth that result in short-term growth events and growth fundamentals that determine the aforementioned patterns. Finally, triggers for growth regime changes need to be identified. Given that traditional growth determinants have proved to be of limited use in this context, growth narratives and "unorthodox" growth determinants are an obvious starting point. In general, finding that changes in one of these "unorthodox" determinants are systematically related to growth regime changes considerably strengthens the credibility of their growth impact in traditional growth regressions, too, and can give policy makers specific guidance as to how to increase economic well-being. The dissertation contributes to the literature along the illustrated lines.

1.2 Outline

The first essay in Chapter 2 deals with the sources of economic growth across growth transitions. Whereas it is well-accepted that long-run economic growth is intimately linked to technological progress, many growth theories predict an important role for factor accumulation in the short and medium run.[11] This

[10] For early contributions, cf. e.g. Jorgenson and Griliches (1967) and Solow (1957); Young (1995) is an example for a study that has generated considerable debate on the sources of growth in East Asia.

[11] This is obvious in the standard Solow model (Solow, 1956; Swan, 1956).

understanding is also at the root of government-led development policies that attribute an important role to large-scale government investments in escaping poverty (Lin, 2011; UN Millennium Project, 2005). However, this view has been challenged by Jones and Olken (2005, 2008). Using growth accounting, they document that growth expansions and growth collapses are hardly associated with factor accumulation. This is the starting point of the first essay: It analyzes to what extent this conclusion holds when confronted with a different methodology. After identifying statistically significant shifts in average growth rates of income per capita in a large cross-section of countries over the years 1950 – 2007, the proximate sources of growth are derived using a nonparametric growth accounting framework. Nonparametric growth accounting rests on milder assumptions than its parametric counterpart and disentangles the parametric residual "total factor productivity changes" into changes in technology and changes in efficiency. Hence, it is well suited to provide a robustness test of Jones and Olken (2005, 2008) while at the same time revealing more about the process of medium-term growth itself.[12]

Chapter 2 confirms Jones and Olken (2005)'s results that growth transitions are frequent with factor accumulation playing a surprisingly limited role. Medium-term growth rate changes are closely linked to changes in total factor productivity, which in the majority of cases represent changes in the efficiency of production. Accordingly, accelerating growth rates in middle and low income countries are to four-fifth or more the result of efficiency improvements. Growth accelerations in high income countries are an exception to this rule. In these countries technological progress, too, is an important element of growth rate increases. In fact, its contribution to growth is larger than the contribution of efficiency improvements. While the sources of growth accelerations depend on the income levels of the respective economies, the sources of growth decelerations are less sensitive in this respect. They are mostly the result of deteriorating productive efficiency, regardless of the state of development. However, factor accumulation explains almost one quarter of the decline in growth rates over decelerations and thus a noticeably larger fraction of the

[12]Non-parametric growth accounting has been introduced into the macroeconomic literature by Kumar and Russel (2002).

growth rate change than over accelerations.

Overall, the results indicate that models of economic growth and empirical growth research should account carefully for the efficiency of production as a major source of growth. Moreover, emphasizing the efficiency of production in the growth context offers a natural answer as to why igniting growth is different from sustaining it. If growth is initially ignited by simply improving the efficiency of production, it follows naturally that this source of growth will ultimately be reaped and has to be replaced by a combination of innovations and factor accumulation. Hence, the challenge of sustained growth could ultimately be described as the challenge of switching from growing on the intensive margin to growing on the extensive one.

In Chapter 3 the focus is not on the growth breaks themselves, but rather on the patterns of growth over time. More specifically, a country's observed growth process is interpreted as a result of multiple transitions between different growth regimes.[13] Growth regimes are states of nature which are characterized by a specific behavior of economic growth and which are common to all countries. The long-run growth rate and its pattern, however, are country-specific because they depend on the time spent in each growth regime. And this behavior is governed by transition probabilities which determine how frequent and how lasting a switch to a certain regime is. The paper aims at identifying countries with similar transition probabilities and thus similar dynamics of growth. These clusters are used in a second step to derive possible determinants thereof. According to the logic of the model, transition probabilities are more likely to depend on medium- or long-term conditions (often referred to as growth fundamentals) whereas short-term events manifest themselves in switches of the growth regimes.

Formally, a Markov switching classification model is estimated for the growth rate of GDP per capita in a sample of 84 countries over the period 1962 – 2003. The countries' observed growth patterns are the result of the time spent in each

[13] The basic idea in this chapter – formulating the growth process as a Markov switching model – is taken from Pritchett (2003) and Jerzmanowski (2006).

of the four following distinct growth regimes: steady growth around two percent, very fast growth, economic stagnation and extreme growth events. The resulting country clusters represent successful countries that are characterized by long periods of steady or fast growth, moderately successful countries that alternate between periods of stagnation and steady growth and countries referred to as growth failures because these countries spend most of their time either in stagnation or extreme growth states. An analysis of growth fundamentals across country clusters reveals interesting differences. A distinctive feature of successful countries is the prevalence of good quality institutions. Neither moderately successful nor failing countries are characterized by a similar quality of institutions. Compared to failing countries, moderately successful ones benefit from more favorable geographic conditions and better policies. The latter manifest themselves in more educated workforces, more infrastructure investments, earlier trade liberalization and more macroeconomic stability. This is true even though institutions are of comparable quality in both country groups. The encouraging consequence for many countries is that even though good institutions are important, a lack of them does not necessarily translate into dismal growth behavior.

Chapter 4 focuses on policy determinants of growth transitions, or more specifically of growth accelerations. It relies on the idea that successful growth strategies should be able to change the growth path of a country to the better. In the framework of traditional growth regressions a growth strategy is usually deemed successful as soon as it has a statistically significant positive impact on the average growth rate, even if the magnitude of the impact is negligible. Contrary to that, in the growth acceleration framework a successful growth strategy has to be systematically related to reasonably long-lasting episodes of noticeably higher average growth than before. It follows directly that what is successful using the first criterion is not necessarily equally successful according to the second one and vice versa. However, a growth strategy that is successful in both frameworks has a lot to go for it.

Recently and in particular as a result of the Chinese growth miracle, the notion to jump-start growth by aiming for competitive, i.e. undervalued real exchange rates has gained widespread popularity and makes the real exchange rate a candidate for an "unorthodox" growth determinant.[14] Therefore, this chapter analyzes whether sustained real depreciations and notably those resulting in real undervaluation are systematically related to accelerating growth rates. In fact, a curious aspect of the existing literature is that the association between real depreciations and growth accelerations has frequently been claimed even though there is no corresponding empirical evidence.[15] Chapter 4 intends to provide the evidence and to complement it by further information regarding the role of the associated real exchange rate levels.

The sample used in Chapter 4 covers 107 countries over the years 1950 - 2007. For the analysis, the data is reorganized around turning points: Episodes of fast and sustained growth in the vein of Hausmann et al. (2005) are related to episodes of modest, but sustained real depreciations using a binary choice model. The paper does not support a general and robust link between the initiation of growth accelerations and real depreciations. Real depreciations are not regularly accompanied by growth accelerations, neither on average nor when the subset of the most likely growth-conducive real depreciation events is considered. Rather, the uncovered association appears sensitive and fragile, which is the result of distinct and often offsetting effects of real depreciation events depending on the concomitant level of the real exchange rate and on the time period under consideration. Whereas prior to 1980 sustained real depreciations of overvalued currencies had the potential to initiate growth accelerations, in

[14]The notion that real overvaluation harms growth but real undervaluation actually promotes it has reemerged recently following in particular the seminal contribution by Rodrik (2008). Empirical efforts to prove this point usually rely on the documentation of positive marginal growth effects in the estimation of growth regressions. However, given that the growth effect of undervalued real exchange rates is thought to be particularly relevant in the context of poor countries – which are frequently characterized by erratic movements of the growth rates – additional evidence is required for all the reasons mentioned in Section 1.1.

[15]Examples are Couharde and Sallenave (2013), Frenkel and Rapetti (2008), Glüzmann et al. (2012), Nouira and Sekkat (2012), Rapetti et al. (2012), Razmi et al. (2012). From a theoretical point of view, several potential reasons for the positive effect of depreciated real exchange rates on growth have been suggested. The most important lines of reasoning are the existence of positive externalities in the tradeable sector, the existence of more severe market failures in the tradeable compared to the non-tradeable sector, investment-increasing redistributive effects and the relaxation of foreign exchange constraints (Dooley et al., 2003; Levy-Yeyati et al., 2013; Montiel and Serven, 2008; Rapetti et al., 2012; Razmi et al., 2012; Rodrik, 2008).

more recent times this applies to sustained depreciations of already undervalued currencies. Nevertheless, growth accelerations remain largely unpredictable. They have become even more so in recent times due to the dwindling importance of some traditionally influential determinants. Hence, somewhat ironically even the determinants of breaks in economic growth may be subject to structural breaks.

Chapter 2

Analyzing Patterns of Economic Growth: A Nonparametric Production Frontier Approach

Abstract: Economic growth is best understood as a combination of high growth and low growth episodes. This paper analyzes the sources of growth when economies shift from one regime of growth to another. To that end the derivation of structural breaks in growth rate series is combined with nonparametric growth accounting, which allows the decomposition of productivity changes into technological progress and changes in the efficiency of production. Growth regime changes in the medium run are mainly the result of productivity changes. Growth spurts due to technological progress happen only in developed countries. Growth spurts in developing countries are catch-up growth episodes based on efficiency improvements. Factor accumulation is of minor importance.

Keywords: Growth, Structural Breaks, Data Envelopment Analysis

JEL Classification: O11, O47

2.1 Introduction

Growth rates in virtually all countries are highly unstable over time (Easterly et al., 1993; Pritchett, 2000). Acknowledging this important fact, a new empirical literature on economic growth is emerging that emphasizes the existence of and the reasons for major *turning points* in growth rates series instead of restricting the analysis to differences in long-run average growth rates. The present paper contributes to this literature: it identifies statistically significant shifts in the average growth rates of income per capita for a large number of countries and explores the relative importance of factor accumulation, efficiency changes and technological changes as proximate causes for the observed transitions.

The starting point for this paper is the analysis by Jones and Olken (2005), who employ growth accounting to investigate the proximate causes for statistically significant transitions between high growth and low growth episodes.[1] Whereas it is widely accepted that long-run differences in income levels and growth rates are the result of major differences in total factor productivity levels and growth rates (Caselli, 2004; Easterly and Levine, 2001; Hall and Jones, 1999; Prescott, 1998), the relative importance of factor accumulation versus total factor productivity for medium run growth spells is less clear. There are indications, however, that factor accumulation should play a greater role in the medium term than in the long run: For instance, in the neoclassical growth models an increase in the saving and investment rate can unleash higher transitional, i.e. medium run growth rates, but not higher steady state growth rates (Barro and Sala-i Martin, 2004; Solow, 1956). Formal models that attempt to explain the divergent income levels between developed and developing countries (e.g. poverty trap models) typically feature nonconvexities that ultimately limit capital accumulation and thereby growth (Acemoglu and Zilibotti, 1997; Azariadis and Drazen, 1990; Azariadis and Stachurski, 2005; Murphy et al., 1989; Sachs et al., 2004). Models on industrialization, arguably a first step in the development and growth of nations, also emphasize the role of capital accumulation (Azariadis and Stachurski, 2005; Galor and Moav, 2004; Porter, 1990).

Yet, in their analysis Jones and Olken (2005) find that factor accumulation plays a surprisingly small role in growth transitions and that its impact is asymmetric.

[1] The working paper has subsequently been published as a note in *The Review of Economics and Statistics* in a shortened version that omits the details of growth accounting and hence the main link to this paper. Cf. Jones and Olken (2008).

Factor accumulation explains less than ten percent of the differences in growth rates in the event of an acceleration and about thirty percent in the event of a deceleration. The main driver of growth transitions appear to be major shifts in total factor productivity. The dominant role of total factor productivity changes for medium run growth rate changes and the observed asymmetric impact of factor accumulation that most growth models cannot explain is at the very least surprising and warrants further investigations as to how robust this result is to the use of different methodologies.

Therefore, this paper reassesses the findings by Jones and Olken (2005). It applies nonparametric instead of traditional parametric growth accounting and thus renders unnecessary implicit assumptions inherent in the latter such as a Cobb-Douglas production technology or fully competitive markets. Only mild assumptions like free disposal or constant returns to scale are needed. As a further advantage nonparametric growth accounting makes allowance for inefficiencies in production, thereby enabling the further decomposition of changes in total factor productivity into changes in the efficiency of production and technological changes. This paper adds to the existing literature on nonparametric growth accounting by reporting confidence intervals for changes in efficiency, technology and factor accumulation in the absence of technological regress. With regard to Jones and Olken's (2005) original contribution further refinements are made: First, a different variant of the Bai-Perron procedure is used to derive the structural breaks that allows to more reliably distinguish between situations with or without breaks (Bai and Perron, 2006). Second, each growth episode is required to last for at least eight years at a minimum to ensure that growth transitions are not confounded with business cycles. Such a confusion may occur in Jones and Olken (2005) because growth spells are allowed to be as short as two years. Third, production is specified on a per worker basis instead of a per capita one, which is a more natural representation of the production process and may change the relative importance of factor versus productivity changes. In addition, data coverage is increased by using the Penn World Tables version 6.3. A final contribution of this paper is the implementation of the Bai-Perron procedure as a new Stata command.

Despite the differences in methodology, this paper, too, finds a multitude of growth transitions and confirms the minor role of capital accumulation therein. The average growth acceleration results from efficiency improvements with only limited contributions of technological change and capital accumulation. Strictly speaking, however, this pattern is only a good description of growth accelerations in middle and low income countries. Growth accelerations in high income countries are special in that they are driven to a large extent by technological changes. As in Jones and Olken (2005) growth decelerations are different from accelerations in that they are more strongly affected by the formation of capital. Yet, deteriorations in the efficiency of production remain the key cause for the breakdown of growth. Unlike in the case of accelerations, the proximate causes of growth decelerations do not hinge on the level of development of the respective countries. These results survive a number of robustness tests.

The remainder of the paper is organized as follows. The related literature is surveyed in Section 2.2. The methodology is discussed in Section 2.3. Results and robustness tests are presented in sections 2.4 and 2.5. Section 2.6 concludes.

2.2 Related Literature

The research program for analyzing growth transitions is closely linked to Pritchett (2000). Pritchett argues that traditional growth regressions in the style of Barro (1991), Kormendi and Meguire (1985), Islam (1995) or Mankiw et al. (1992) are largely uninformative because highly unstable growth rates are regressed on highly persistent explanatory variables. As a consequence, the results are not robust to slight alterations of the estimation framework and only limited policy conclusions can be drawn.[2] According to Pritchett (2000), a more promising way to uncover determinants of growth is to shift the focus to episodes of growth that share similar characteristics and ask what happens before growth accelerates or decelerates, what happens to growth if major policy reforms are undertaken or what distinguishes the reactions of successful countries from those of less successful ones in the presence of similar economic shocks. The resulting literature on growth transitions has so far quite strictly adhered to this program.

When analyzing growth transitions, a definition of growth spells, i.e. periods during which the growth rate remains reasonably stable, is required. Three different approaches have been suggested in the literature: the filter-based approach, the

[2] Similar criticism has been raised by Easterly et al. (1993) and Levine and Renelt (1992), but the research program is attributable to Pritchett (2000).

episodic approach, and the statistical approach.[3] The filter-based approach relies on subjectively defined, but objectively verifiable rules (e.g. through calculations). In general, successive years are classified as high or low growth spells if the average growth rate during these years exceeds or falls below a previously defined threshold. Usually, growth rates are averaged over periods of four to eight years (Aizenman and Spiegel, 2010; Arbache and Page, 2010; Hausmann et al., 2005; Imam and Salinas, 2008; Jong-A-Pin and de Haan, 2011). The episodic approach focuses on longer periods like decades. Similar to the filter-based approach it uses subjective classification rules, but these rules need not be objectively verifiable. For instance, episodes might be selected relying on "common knowledge", e.g. by dividing time series into the periods prior and post 1975 in order to capture the growth slowdown in the 1970s (Rodrik, 1999; Sahay and Goyal, 2006). In the statistical approach growth episodes are derived using well defined statistical testing procedures that allow for one (Ben-David and Papell, 1998) or several structural breaks (Jones and Olken, 2005, 2008). Some authors also apply combinations of the different approaches, in particular of the filter-based and statistical approach (Berg et al., 2012; Kar et al., 2013).[4]

Based on the identified growth spells, some authors apply regressions akin to cross-country growth regressions to uncover the reasons for countries' apparently different resilience to shocks (Rodrik, 1999). Others employ correlation analysis to single out factors that are different across good and bad growth spells (Sahay and Goyal, 2006). The most common approach, however, is to use discrete choice models in an attempt to identify events after which a growth transition is likely in a statistical sense. While there is evidence that terms of trade shocks, economic reforms, financial liberalization and policy changes play some role, the ultimate reasons for growth transitions remain largely a mystery. There are numerous contributions to this literature, among others Aizenman and Spiegel (2010), Arbache and Page (2010), Becker and Mauro (2006), Bluedorn et al. (2014), Dovern and Nunnenkamp (2007), Hausmann et al. (2005), Hausmann et al. (2006), Jong-A-Pin and de Haan (2011) and Kali et al. (2013). Berg et al. (2012) and Hausmann et al. (2006) extend this literature and look directly at the duration of growth spells employing duration analysis.

[3] Sahay and Goyal (2006) use a similar classification but assign the existing literature somewhat differently to the categories. Kar et al. (2013) only distinguish between the filter-based and statistical approach.

[4] Jerzmanowski (2006) and Kerekes (2012) take a different approach and interpret the observed instability of growth rates within a Markov switching model of growth.

Jones and Olken (2005) contribute to the preceding literature in that they apply the statistical approach to detect growth episodes. After the identification of growth spells, however, they use growth accounting to explore the contribution of factor accumulation and total factor productivity changes, respectively, to growth transitions. In order to gain more insight into total factor productivity changes, a further decomposition into technological and efficiency changes is desirable. One analytical tool to determine the relative importance of the two components is data envelopment analysis (DEA), which dates back to Farrell (1957) and which has been introduced into macroeconomic productivity analysis by Färe et al. (1994).[5] Kumar and Russel (2002) show that income changes can be decomposed into changes in efficiency, technology and factor accumulation if one is willing to assume constant returns to scale. They use this nonparametric growth accounting to analyze the contribution of each factor to the emerging bimodal distribution of labor productivity across countries.

DEA in macroeconomics has subsequently been extended into three directions: First, the Kumar-Russel type of analysis has been applied to extended time periods or specific regions, increasingly taking into account additional production factors (Badunenko, 2013; Badunenko et al., 2013, 2008; Badunenko and Tochkov, 2010; Growiec, 2012; Henderson and Russell, 2005; Salinas-Jimenez et al., 2006). Second, two-stage approaches have become popular that derive efficiency scores nonparametrically in a first step and relate them parametrically to other covariates in a second step (Christopoulos, 2007; Delgado-Rodríguez and Álvarez Ayuso, 2008; Grosskopf and Self, 2006).[6] As a third development, the statistical properties of the DEA estimators have increasingly been taken into account,[7] albeit this development has largely been restricted to studies focusing on the decomposition of productivity, only (Enflo and Hjertstrand, 2009; Henderson and Zelenyuk, 2007). Recently, however, Badunenko et al. (2014) have employed nonparametric growth accounting with statistical inference.

In terms of the reviewed literature this paper can be integrated as follows: The statistical approach is used to determine episodes of high and low growth. After

[5]In principle, an alternative to DEA would have been stochastic frontier analysis. However, as explained in footnote 11, stochastic frontier analysis is not suited for an analysis in the presence of multiple structural breaks.

[6]For a critique of this approach cf. Simar and Wilson (2007).

[7]These have been developed in a series of papers by Simar and Wilson. Cf. section 2.3.2.1.

that, nonparametric growth accounting is applied to derive the proximate causes of growth transitions, which includes the derivation of confidence intervals.

2.3 Methodology

2.3.1 Identification of Structural Breaks

Consider the following model for the growth rate of GDP per capita:

$$g_t = \beta_i + u_t, \; t = T_{i-1} + 1, ..., T_i. \tag{2.1}$$

Within the growth regime labeled i the annual growth rate g_t equals the regime-specific mean growth rate β_i plus a stationary error term u_t, which may have a different distribution across regimes. Suppose it is known that the growth rate series contains m structural breaks points denoted by $(T_1, ..., T_m)$ and that each of the $m+1$ growth regimes is required to last for at least $h > 1$ periods. In the Bai-Perron (BP) procedure (Bai and Perron, 1998, 2003a,b, 2006) the coefficients $\hat{\beta} = (\hat{\beta}_1, ..., \hat{\beta}_{m+1})$ are estimated by minimizing the total sum of squared residuals S_T for the m-partition $(T_1, ..., T_m)$, which is given by

$$S_T = \sum_{i=1}^{m+1} \sum_{t=T_{i-1}+1}^{T_i} [g_t - \beta_i]^2. \tag{2.2}$$

The break points $(\hat{T}_1, ..., \hat{T}_m)$ are estimated such that S_T with the associated least-squares estimate $\hat{\beta}$ is minimized over all conceivable m-partitions while taking account of the minimum duration requirement h for each regime.[8,9]

In order to derive the required number of breaks, Bai and Perron (1998) suggest a sequential testing procedure based on the $\sup F_T$ test statistic. Intuitively, the $\sup F_T(\ell|\ell+1)$ testing procedure tests the null hypothesis of $m = \ell$ breaks against

[8] Appendix 2.A reviews the empirical implementation of the BP procedure in more detail.

[9] This paper follows Jones and Olken (2005) and assumes that the log of GDP per capita is integrated of order one. Whether GDP follows a deterministic or stochastic trend remains an unsettled question for the time being (Cuestas and Garratt, 2011; Darné, 2009; Murray and Nelson, 2000; Nelson and Plosser, 1982; Perron, 1989; Zivot and Andrews, 1992). Therefore, it might be worthwhile to apply the Kejriwal-Perron testing procedure in future work, which is valid for investigating structural breaks both in the presence of I(0) and I(1) errors (Kejriwal and Perron, 2010).

the alternative hypothesis of $m = \ell + 1$ breaks and rejects the null if the additional break point reduces the total sum of squared residuals by a sufficiently large amount. Starting with the null hypothesis of $m = 0$ breaks, the number of breakpoints is increased one by one until the $\text{supF}_T(\ell+1|\ell)$ test fails to reject the null hypothesis of ℓ breaks. The critical values are simulated and depend on ℓ and a so-called trimming parameter ε.

One drawback of this testing procedure is the frequently low power of the first test, i.e. the test zero against one break point, if more than one break is present. Since the power of the double maximum test, which tests the null hypothesis of $m = 0$ breaks against the alternative hypothesis of an unknown number of breaks up to M (i.e. $1 \leq m \leq M$), is almost as high as if the null were tested against the true number of breaks, Bai and Perron (2006) suggest to adapt the first step of the sequential testing procedure. Instead of testing zero against one break point, the double maximum test should be applied in the first step, thus testing the null of $m = 0$ against the alternative of $1 \leq m \leq M$. If the null hypothesis is rejected, testing should be continued using the $\text{supF}_T(\ell|\ell + 1)$ testing procedure. This alternative is referred to as the udmaxL testing procedure in the following.

2.3.2 Nonparametric Growth Accounting

A nonparametric approach to growth accounting is used in this paper to evaluate the relative contributions of changes in factor accumulation, in the efficiency of production and in technology to the observed growth rate changes during growth transitions. Unlike standard growth accounting (Solow, 1957), this approach does not need an assumption about the form of the production function and the form of technological progress (except for the returns to scale), nor does it require the implicit assumptions of perfect competition and constant factor shares.[10] Since it explicitly allows

[10]In parametric growth accounting usually a Cobb-Douglas production function and constant factor shares are assumed. Often the capital share is set to 1/3 for all countries. For a critique of the Cobb-Douglas assumption cf. e.g. Duffy and Papageorgiou (2000). For a discussion on how to appropriately measure factor shares and on whether the assumption of constant factor shares is warranted cf. among others Bentolila and Saint-Paul (2003), Crafts (2003), Gollin (2002) and Krueger (1999). The effect of imposing a constant elasticity of substitution between capital and labor equal to one via the assumed Cobb-Douglas production function is reviewed in Nelson (1973) and Rodrik (1997). If growth accounting were to be based on an alternative production function than Cobb-Douglas, the question of factor-augmenting technological progress would have to be addressed (Acemoglu and Autor, 2010). Both types of growth accounting rely on aggregate production functions, a concept

for the possibility of non-efficient production, it can distinguish between catch-up growth due to efficiency improvements and growth due to real (technological) innovations. Nonparametric growth accounting is based on data envelopment analysis (DEA) and Malmquist productivity indices. The following exposition draws on Färe et al. (1994), Kumar and Russel (2002) and Ray (2004, chap. 2) unless otherwise noted.[11]

2.3.2.1 Data Envelopment Analysis

Each country j ($j = 1, ..., J$) in period t produces the single output aggregate GDP (Y_t^j) using aggregate capital (K_t^j) and aggregate labor (L_t^j) as inputs. Assuming a convex technology with constant returns to scale, free disposability of inputs and outputs, and ruling out technological regress,[12] the production possibility set of the world in period t ($\mathcal{T}_t$) encompasses all convex combinations of ever observed input-output bundles until period t. Formally:

$$\begin{aligned}\mathcal{T}_t = \{(Y,K,L) \in \mathbb{R}^3 : K \geq \sum_{\tau \leq t}\sum_j \mu_\tau^j K_\tau^j \wedge L \geq \sum_{\tau \leq t}\sum_j \mu_\tau^j L_\tau^j \\ \wedge Y \leq \sum_{\tau \leq t}\sum_j \mu_\tau^j Y_\tau^j, \mu_\tau^j \geq 0 \ \forall j,\tau\}.\end{aligned} \tag{2.3}$$

The upper boundary of this production possibility set represents the (observed) world technology frontier. Each country's actual output is related to the world technology frontier by means of the distance function, which is defined as follows:

$$D_t^j(K_t^j, L_t^j; Y_t^j) = \min\left\{\phi_t^j : \left(K_t^j, L_t^j; \frac{Y_t^j}{\phi_t^j}\right) \in \mathcal{T}_t\right\}. \tag{2.4}$$

The inverse of the distance function indicates by how much output could be increased with the chosen input mix and still remain technologically feasible. In this sense,

---

subject to considerable debate (Felipe and Fisher, 2003).

[11] Growth accounting based on stochastic frontier analysis was considered as an alternative. Like the DEA approach, it allows the decomposition of total factor productivity changes into efficiency and technological changes. Unlike DEA, it incorporates a stochastic error term. However, in a long panel like in this article technological change and time-varying efficiency levels have to be allowed for. In the context of stochastic frontiers, this is only possible by severely restricting the evolution of the efficiency term such that the time path is either equal across countries or smooth over time (Kumbhakar and Lovell (2000)). Neither assumption is suited for an analysis that focuses on the behavior of growth components in the presence of structural breaks.

[12] In order to rule out technological regress, the formulation suggested by Henderson and Russell (2005) and based on Diewert (1980) is used.

it indicates the efficiency of production and will also be referred to as the efficiency score.[13] Clearly, for feasible production $D_t(\bullet) \leq 1$ must be true, with $D_t(\bullet) = 1$ meaning that production takes place on the world technology frontier and is thus fully efficient.

The world technology frontier is not directly observable, but has to be estimated from the observed input-output combinations. DEA analysis is a popular technique to do so. It essentially wraps the data in the "tightest fitting convex cone" (Kumar and Russel, 2002, p. 530) and constructs the best-practice frontier as the boundary of this set. Formally, for each country the distance functions for each point in time are estimated by solving the linear programming problem in (2.5). The estimated distance functions uniquely determine the estimated world technology frontier.

$$\begin{aligned} D_t^j(K_t^j, L_t^j; Y_t^j) = \min\ \phi_t^j \text{ subject to } & \frac{Y_t^j}{\phi_t^j} \leq \sum_{\tau \leq t} \sum_j \mu_\tau^j Y_\tau^j, \\ & K_t^j \geq \sum_{\tau \leq t} \sum_j \mu_\tau^j K_\tau^j, L_t^j \geq \sum_{\tau \leq t} \sum_j \mu_j^\tau L_\tau^j, \\ & \mu_\tau^j \geq 0\ \forall j, \tau. \end{aligned} \tag{2.5}$$

2.3.2.2 Tripartite Decomposition

In order to decompose income changes between two periods into changes attributable to changes in the efficiency of production, technological changes and capital accumulation, two features of the DEA framework are exploited. First, each country's production in period t is expressed in terms of distance functions times the world technology frontier, and second, aggregate inputs and output are converted into input and output per worker using the constant returns to scale assumption. Let GDP per worker be denoted by $\tilde{y}_t$ and capital per worker by $\tilde{k}_t$. Given the distance functions from above, dropping country superscripts and using $D_t = \phi_t$, output per worker $\tilde{y}_t$ at capital intensity $\tilde{k}_t$ is related to the world technology frontier of period t ($\tilde{\mathbf{y}}^t(\tilde{k}_t)$) via $\tilde{y}_t(\tilde{k}_t) = \phi_t \tilde{\mathbf{y}}^t(\tilde{k}_t)$.

With some rearranging the growth factor of output per worker from t to $t+1$ can

[13] Efficiency of production refers to *proportional* changes of inputs and outputs. Hence, efficient production in DEA does not necessarily imply Pareto-efficiency.

be expressed as

$$\frac{\tilde{y}_{t+1}(\tilde{k}_{t+1})}{\tilde{y}_t(\tilde{k}_t)} = \frac{\phi_{t+1}}{\phi_t} \frac{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^t(\tilde{k}_{t+1})} \frac{\tilde{\mathbf{y}}^t(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^t(\tilde{k}_t)}. \tag{2.6}$$

According to equation (2.6) changes in output per worker as measured by the growth factor are the result of changes in efficiency (first term), changes in technology measured at the second-period capital intensity (second term) and changes in the capital intensity measured in relation to the first-period world technology frontier (third term). Geometrically speaking, the first term represents a change in the distance from the frontier, the second term an outward shift of the frontier and the third term a movement along the estimated frontier.[14] Of course, changes in technology could be measured at the first-period capital intensity and changes in capital intensity could be measured using the second-period world technology frontier. There is no compelling reason for either alternative, but the decompositions yield different results unless technical progress happens to be Hicks-neutral. This ambiguity is usually solved by employing the Fisher ideal decomposition, i. e. by taking the geometric average of the two measures. Since the structural breaks are derived in terms of GDP per capita, the proposed decomposition is extended to incorporate changes in the labor force participation rate (*lfp*) using $y_t = \tilde{y}_t \cdot lfp_t$. The final decomposition thus becomes

$$\frac{y_{t+1}}{y_t} = \frac{\phi_{t+1}}{\phi_t} \left(\frac{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^t(\tilde{k}_{t+1})} \frac{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_t)}{\tilde{\mathbf{y}}^t(\tilde{k}_t)} \right)^{1/2} \left(\frac{\tilde{\mathbf{y}}^t(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^t(\tilde{k}_t)} \frac{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_t)} \right)^{1/2} \frac{lfp_{t+1}}{lfp_t}. \tag{2.7}$$

All components of (2.6) can be expressed solely in terms of distance functions and observed inputs and outputs, and therefore resemble Malmquist productivity indices.[15] However, it is necessary to know the efficiency of production in period t relative to the world technology frontier of period $t+1$ and vice versa. These counterfactual distance functions are obtained by appropriately adjusting the reference technology in the linear program (2.5). As a result, two additional linear programs per country and period have to be solved over and above the standard

[14] Changes in capital intensity (i.e. capital per worker) can happen due to changes in the aggregate capital stock and due to changes in the number of workers. The suggested decomposition reports the aggregate effect, only. A more detailed decomposition similar to the "quadripartite" decomposition suggested by Henderson and Russell (2005) is delegated to Appendix 2.F. The extended decomposition distinguishes between the effects of capital deepening and capital widening.

[15] The standard Malmquist productivity index measures productivity change as the ratio of two distance functions, which are representations of technologies based on input and output data, only. Cf. Caves et al. (1982) and Färe et al. (1994).

linear programs.[16]

2.3.2.3 Inference

The statistical properties of DEA estimators are derived under the assumption that all observed input-output combinations are technically attainable so that no allowance is made for measurement errors. Under this assumption the estimated efficiency scores are consistent and their rate of convergence in the two-inputs-one-output case is comparable to that of parametric estimates. Nevertheless, the calculated efficiency scores are upward-biased estimates of the true efficiency scores because they are derived in relation to the best-practice, i. e. observed, world technology frontier. The observed world technology frontier, however, is likely to lie below the true world technology frontier because some more efficient input-output-combinations shaping the latter frontier are likely to be missed due to the sample being finite (Simar and Wilson, 2000). Since DEA makes no allowance for measurement errors and since the world technology frontier is effectively determined by the small subset of efficient observations, the method is sensitive to outliers. Therefore, results should always be checked for robustness (Simar and Wilson, 2008).

Even though asymptotic sampling distributions for the DEA estimators have been derived, statistical inference in practice requires using bootstrap methods (Kneip et al., 2008). However, naive bootstrapping does not consistently mimic the data generating process due to the bounded nature of the efficiency estimates.[17] Therefore, to date inference in DEA models usually relies on the smoothed bootstrap procedure introduced by Simar and Wilson (1998). This method bootstraps on the estimated efficiency scores ϕ, i.e. efficiency scores and not the original data (input-output bundles) are resampled. To overcome the problems related to the bounded nature of the efficiency scores, the bootstrap efficiency scores are not drawn from their original distribution, but from a *smoothed* one, which is based on kernel density estimation and the Silverman reflection method.[18] When bootstrapping change

[16]Cf. Appendix 2.C for the counterfactual linear programs and the tripartite decomposition based on distance functions.

[17]The distribution of efficiency scores has a positive probability mass at $\phi = 1$ because there is always at least one observation that is fully efficient (Simar and Wilson, 2000).

[18]The method assumes that efficiency scores are homogeneously distributed over the input-output space. The homogeneity assumption is standard in the literature. However, it implies that there are no systematic differences in the efficiency levels of rich and poor countries. The only study addressing the validity of this assumption is, to my knowledge, Henderson and Zelenyuk (2007). This study finds that efficiency scores in developing countries are systematically lower than in developed countries. Therefore, future research and refinements

indices like the Malmquist productivity index the procedure needs to be adapted to account for the possibility of temporal correlation between efficiency scores (Simar and Wilson, 1999). Since technological regress has been ruled out, the bootstrap procedure is modified such that each bootstrapped pseudo dataset in period $t+1$ includes the previously bootstrapped observations in addition to the current ones. The bootstrap procedure returns bootstrap estimates for the distance functions which can then be used to derive the bootstrap equivalents of the terms in equation (2.6).[19]

Based on the bootstrap results, quantities of interest like the bias of the estimates, the bias-corrected estimates or the boundaries of confidence intervals can be derived for each bootstrap replication and for the bootstrap as a whole. Let $\hat{\xi}$ denote the estimated index of interest, $\hat{\xi}_b^*$ the bootstrap estimate of the quantity for replication b, $\hat{\hat{\xi}}$ the bias-corrected quantity and B the number of bootstrap replications. Then the bias and bias-corrected values are derived as

$$\widehat{bias}_B[\hat{\xi}] = \frac{1}{B}\sum_{b=1}^{B}\hat{\xi}_b^* - \hat{\xi} \text{ and} \tag{2.8}$$

$$\hat{\hat{\xi}} = 2\hat{\xi} - \frac{1}{B}\sum_{b=1}^{B}\hat{\xi}_b^*. \tag{2.9}$$

Bias-correction should only be applied if the bias-corrected estimator has a smaller mean-square error (s^2) than the original one. Formally, this requires the ratio

$$r = \frac{1/3 * (\widehat{bias}_B[\hat{\xi}])^2}{s^2} \tag{2.10}$$

to exceed unity. Confidence intervals are constructed based on the sorted differences $(\hat{\xi}_b^* - \hat{\xi})$ so that they account both for the statistical variation and the inherent bias of the estimates (Simar and Wilson, 1999).

2.4 Data and Results

2.4.1 Data

The data is taken from the Penn World Tables (PWT) version 6.3 (Heston et al., 2009). Income per capita is expressed in international prices of the year 2005 and

of the bootstrap procedure in the country context are certainly required.

[19] Cf. Appendix 2.D for details.

is based on the Laspeyeres deflator (RGDPL in PWT notation).[20] Aggregate output is obtained by multiplying income per capita with the population size (POP), aggregate investment by multiplying the investment share (ki) with aggregate output. Aggregate labor is approximated by the number of workers in each country and the labor force participation rate is taken to be the ratio of workers to total population.[21] Human capital is not taken into account because data is only available after 1960 and only for a subset of countries.[22] Following Jones and Olken (2005) the aggregate capital stock is derived using the perpetual inventory method (Nehru and Dhareshwar, 1993) with an assumed depreciation rate of seven percent.[23]

With regard to the sample the following choices are made: For each country a minimum of 30 observations is required in order to ensure a sufficient number of data points for the calculations. Moreover, only countries with at least 20 observations in PWT version 6.1 are used, because many of the additional countries introduced for the first time in version 6.2 or later suffer from implausibly high historical levels of income (Heston et al., 2006a). Only countries with a population exceeding one million in the final year of available data are included to avoid biased DEA estimates due to the prevalence of an "atypical" production structure. Since there are not enough data points for United Germany, data for the former West Germany is included. These rules leave 107 countries for the analysis.

2.4.2 Structural Breaks

The structural breaks are derived using the udmaxL testing procedure. The minimum duration of a growth regime is set to 8 years in order to strike a balance between too long a duration requirement that would make it likely to miss breaks and too

[20] In order to mitigate the substitution bias inherent in long time series that are deflated by a Laspeyres index, it would be preferable to use RGDPCH, which is a chain index number for income per capita (Schreyer, 2004; Summers and Heston, 1991). Unfortunately, the investment share needed for the derivation of the capital stock is only available in terms of the Laspeyres index.

[21] The number of workers equals $RGDPCH * POP/RGDPWOK$ in PWT notation. For Sweden, the labor force participation rate in 1950 is set equal to the rate in 1951.

[22] Since the human capital stock evolves very slowly, human capital is unlikely to have large impacts for short- and medium-term growth events. Therefore, losing a large number of observations is too high a price to pay for its introduction. Cf. Jones and Olken (2005) who also find negligible effects of human capital.

[23] The initial capital stock is calculated using the geometric mean of the investment rate in the first ten years of the data series to approximate the growth rate before the initial observation. In case of a negative investment rate, a rate of zero is assumed.

short a duration requirement that would reduce the power of the testing procedure too much (Berg et al., 2012).[24] Moreover, a maximum of three breaks is allowed.[25] Separate covariance matrices are calculated for each growth regime to control for potential heteroscedasticity. Breusch-Godfrey tests indicate that autocorrelation is of minor importance (Greene, 2003, chap. 12).[26] The calculations are carried out in Stata using a self-implemented command.[27]

Table 1 summarizes the results. In total, 114 breaks are detected. A break is called an upbreak or a growth acceleration if the average growth rate after the break exceeds the one before the break. Otherwise, the break is classified as a downbreak or growth deceleration. The upper part of Table 1 indicates that downbreaks are somewhat more common than upbreaks. Numerous structural breaks are observed in all regions of the world and in most regions the number of upbreaks and downbreaks more or less balances. Europe is special in that it experiences more than twice as many growth decelerations than accelerations.

Most breaks are recorded from the 1970s to 1990s. This, however, is to be expected because the number of structural breaks in the 1950s and 2000s is low or zero by construction as a result of the minimum duration requirement. The longest time series of growth rates in the dataset start in 1951 and end in 2007. Thus, the earliest admissible break point is 1958 and the latest is 1999.[28] Since 36 time series start only in 1960 or later, the admissible break points in the 1960s are also noticeably restricted. Nevertheless, the relative numbers of upbreaks versus downbreaks in the decades reveal interesting differences. The majority of recorded breaks in the 1970s are downbreaks. This ties in well with the conventional wisdom that a major productivity slowdown in particular in industrialized countries happened in that decade. As a matter of fact, the majority of decelerations during that decade

[24]The power of the testing procedure varies across countries because the minimum duration requirement in combination with time series of different lengths implies varying trimming parameters. However, if trimming parameters were kept fixed, the minimum duration of growth regimes would have to vary as is the case in Jones and Olken (2005). As a result, in their setting growth regimes may be as short as two years.

[25]This restriction is of no material consequences because the udmaxL procedure would never opt for more than three breaks even if more breaks were allowed.

[26]See Section 2.5 for a robustness test using a heteroscedasticity and autocorrelation consistent variance estimator.

[27]The ado-file is available upon request together with the introductory note presented in Appendix 2.A. The procedure has been implemented following existing implementations in RATS and GAUSS.

[28]Recall that these are the last observations belonging to the former regime.

Table 2.1: Summary Statistics for Structural Breaks

a. Structural Breaks by Region

	Total	Africa	Asia	Europe	NAmer-ica	SAmer-ica	Oceania
Total number of breaks	114	33	18	25	20	15	3
Upbreaks	54	16	9	8	11	8	2
Downbreaks	60	17	9	17	9	7	1

b. Structural Breaks by Decade

	Total	1950s	1960s	1970s	1980s	1990s	2000s
Total number of breaks	114	4	14	43	21	32	–
Upbreaks	54	3	11	8	8	24	–
Downbreaks	60	1	3	35	13	8	–

c. Structural Breaks by Initial Income

	Total	High Income	Middle Income	Low Income
Total number of breaks	114	31	22	61
Upbreaks	54	8	9	37
Downbreaks	60	23	13	24

Notes: Structural breaks are derived using the udmaxL testing procedure as described in the main text. The minimum duration requirement is set to 8 years and a significance level of 0.1 is used. The recorded break years are the final years of the previous growth regimes.
High income countries are defined as those countries whose income per capita is half the US income or more; low income countries are those countries whose income per capita is lower than half the income of the richest middle income countries. A dynamic definition is applied, i.e. the position of a country is determined in the year preceding the break.

(20 out of 35) indeed occurred in Europe and North America, i. e. in the regions where most industrialized countries are found. The situation in the 1990s is almost the opposite. In this decade there are many more growth accelerations than decelerations. African and European countries benefit the most with 16 of the 24 recorded upbreaks happening there. The European growth accelerations are related to the fall of Communism. The positive development of African economies in the 1990s and 2000s has been noted by other authors, too (Arbache and Page, 2010; Pattillo et al., 2005).

The lower part of Table 1 classifies the structural breaks according to the stage of development of the respective countries in the year preceding the break. In order to account for economic progress in the period under consideration, a dynamic definition of the state of development similar to the one suggested by Becker and Mauro (2006) is used. In each year, all countries with income per capita amounting to at least half of US per capita income are considered high income countries. The middle

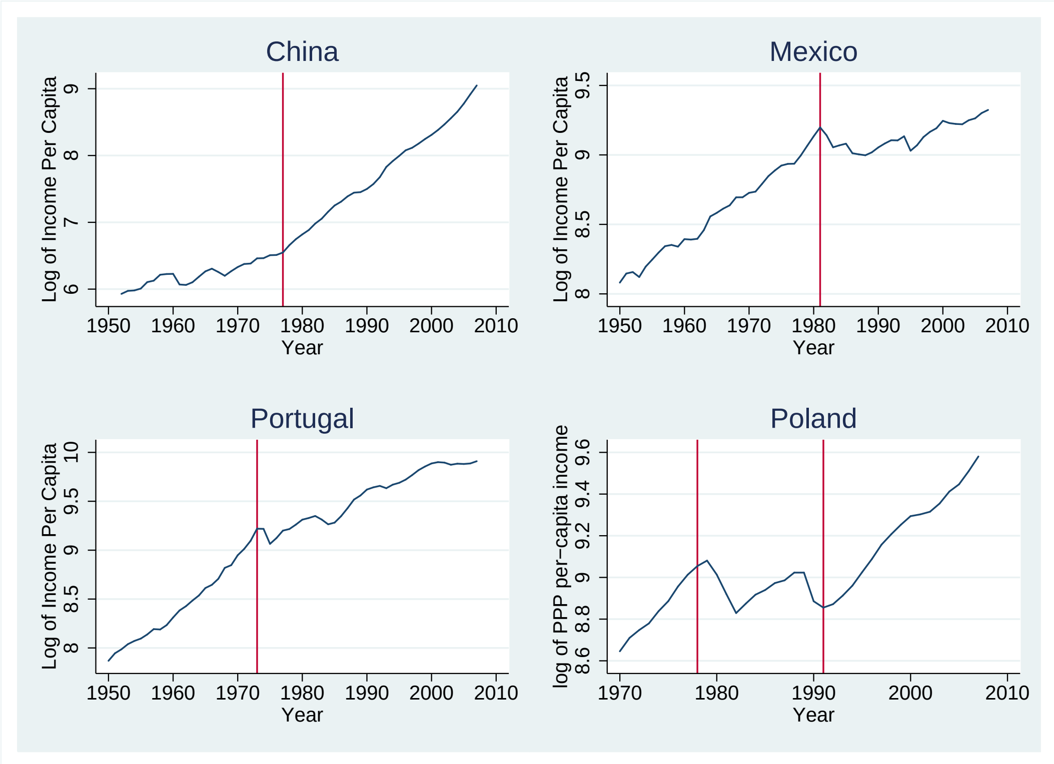


Figure 2.1: Examples of Structural Breaks

income countries are comprised of all countries with income per capita equalling at least half of the per capita income available in the leading middle income country. All other countries are classified as low income countries. An interesting pattern arises: The by far most common type of breaks in high income countries is a growth deceleration; upbreaks happen only in one quarter of the cases. The situation is more balanced in middle income countries. Even though downbreaks remain more common than upbreaks, the latter nevertheless account for 40 % of all recorded breaks. In low income countries a break is a growth acceleration in 60 % of the cases. More generally, of all observed breaks more than half happen in low income countries. In terms of upbreaks, the percentage is even higher equalling 70 %. The overall picture emanating from Table 2.1 is in line with the literature and suggests that countries are not generally locked in growth traps. Rather, poor growth performances must (at least partly) represent the failure of countries to sustain a growth acceleration once it occurs (Berg et al., 2012; Hausmann et al., 2005; Jerzmanowski, 2006; Rodrik et al., 2004).

Figure 2.1 illustrates that the calculated break points are often related to major economic or political events. For instance, in China the drift of the time series increases after 1977, which coincides with Deng Xiaoping's ascension to power and the start of economic reforms such as the liberalization of agriculture and the opening of the economy. In Mexico, the deceleration of growth after 1981 can be linked to the severe currency crisis starting in that year whereas the deceleration after 1973 in Portugal heralds the turbulent time after a bloodless military coup. In Poland, the first turning point 1978 coincides with the beginnings of the Solidarnosc Movement and severe price increases, whereas the upbreak after 1991 can be related to the economic and political reforms after the fall of communism. Poland also illustrates the trade-off introduced by imposing a minimum duration requirement for each regime: the method identifies well defined break points, but misses short-lived events that are very close to each other. In the case of Poland, the growth acceleration between 1982 and 1988 is not picked up.[29]

2.4.3 Proximate Causes of Growth Transitions

In this section the main results of nonparametric growth accounting are presented. To start with, the estimated world technology frontiers for the years 1950, 1975 and 2007 are plotted in the $(\tilde{k}, \tilde{y})$-space in Figure 2.2. It is noteworthy that the outward shift of the production frontier is much more pronounced at higher levels of capitalization than at lower one. By implication, assuming technological progress to be Hicks-neutral as in standard growth accounting is questionable in the present dataset.[30]

In order to account for the proximate sources of growth transitions, nonparametric growth accounting is carried out in the five year period before and in the five year period after each recorded break.[31] For ease of comparison with traditional growth accounting studies, growth factors are converted to the implied average yearly growth rates. These rates indicate how much of the observed per capital growth rate can be explained by efficiency changes, technological changes, capital accumulation and labor force participation changes. The sum of these individual contributions does not equal the observed income growth rate exactly since the cross products resulting from

[29]Detailed information on the countries can be found online, e.g. in the Country Studies/Area Handbook Series of the Library of Congress (Federal Research Division - Library of Congress, 2015).

[30]The DEA calculations are carried out in R using the R-Package "FEAR" (Wilson, 2008).

[31]If the break year is, say, 1960, the regime before the break comprises $g_{56}, ..., g_{60}$ and the regime after the break comprises $g_{61}, ..., g_{65}$. g_{56} denotes the growth rate from 1955 to 1956.

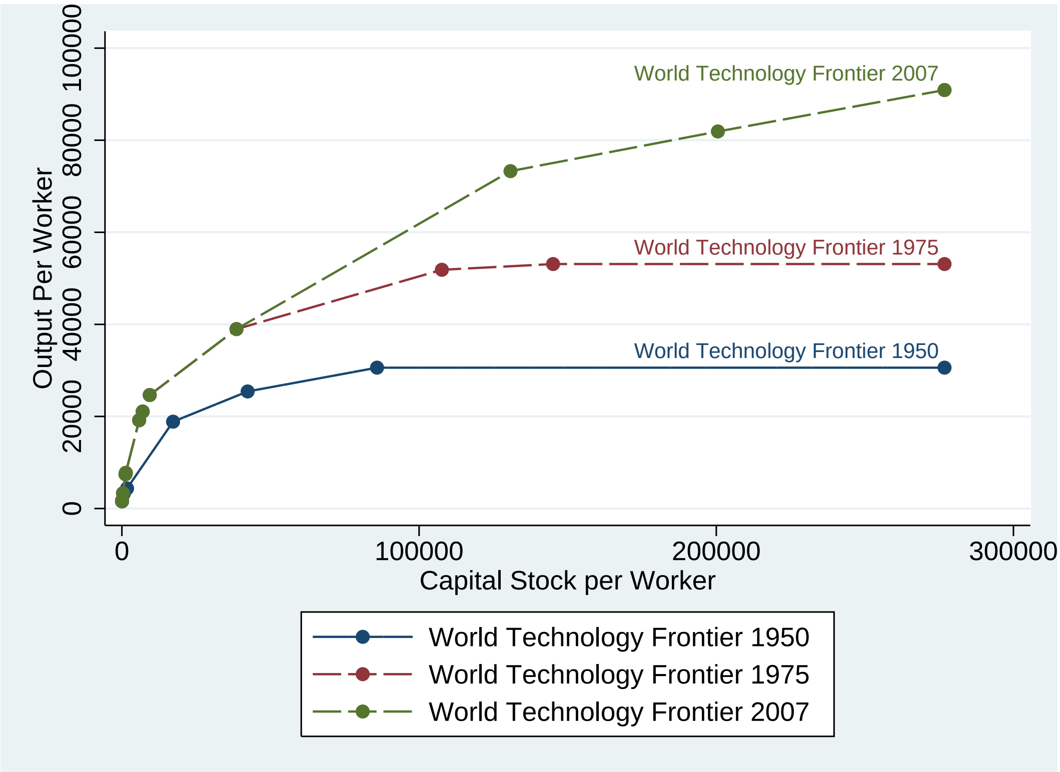


Figure 2.2: World Technology Frontiers and the Type of Technological Progress

the conversation of growth factors to growth rates are not considered. Therefore, the presented contributions indicate how much of the growth rate change can be directly attributed to the respective causes.[32] Across breaks arithmetic means are reported.[33]

Table 2.2 reports the proximate causes of growth in the five years preceding an upbreak. Col. 1 shows the percentage point contributions of all relevant components to the observed average growth rate of yearly per-capita income. Prior to an upbreak income per capital on average falls by 0.6 %. The negative sign of the growth rate can primarily be traced back to deteriorating productive efficiency. Had it no been for this component, the annual growth rate would have been 0.694 % owing to capital accumulation and an additional 1.114 % owing to technological progress. However,

[32]The average yearly growth rates of each component are derived from the geometric average of the corresponding growth factors, which themselves are calculated over the five year period under consideration. Since the Fisher type indices do not satisfy the circularity test, the results depend on the order of calculation (Coelli et al., 1998, chap. 4.5).

[33]Using arithmetic means implies that the relative weights of the economies are ignored, which is particularly problematic when the focus is on standardized magnitudes. If groups of countries are compared at a specific point in time, it therefore makes sense to use weighted averages (Henderson and Zelenyuk, 2007; Simar and Zelenyuk, 2007). However, since in this paper the behavior of economies at different points in time is summarized, there is no obvious weight that should be applied.

Table 2.2: Proximate Causes of Growth Prior to an Upbreak

	Estimate	Bias	Sigma	Bias Corrected	Lower Bound	Upper Bound
Income per Capita	−0.603					
Efficiency Change	−2.230	0.048	0.004	−2.277	-2.486	−2.075
Technological Change	1.114	−0.049	0.004	1.163	0.933	1.389
Capital Accumulation	0.694	0.001	0.001	0.692	0.623	0.763
Labor Force Participation	−0.088					
Observations	54					

Notes: Upbreaks are derived using the udmaxL procedure as described in the text. Nonparametric growth accounting is carried out in the five-year period before the break. Bias and standard errors are estimated based on 1000 bootstrap replications. The estimates are estimated average annual growth rates for the respective quantities.

on average the efficiency of production declines massively and reduces the annual growth rate by more than two percentage points. Changes in labor force participation also contribute negatively to growth although its impact is minor and it reduces the growth rate of income per capita by less than 0.1 percentage points. Col. 2 and 3 report the estimated bias and standard error for the respective estimates based on 1000 bootstrap replications. The bias of the efficiency change and technological change estimates (but not the bias of the capital accumulation estimate) exceed the respective standard errors (col. 4) by a sufficiently large amount to recommend the use of bias-corrected estimates instead of the original ones. The bias-corrected estimates are given in col. 5. Even though the actual numbers differ, the impact of bias correction on the relative contribution of the respective components to the observed growth rate is limited. Col. 6 and 7 report the bootstrapped 90 % confidence intervals with regard to the three estimated components of the decomposition. Each component makes a significant contribution to the overall growth rate since none of the confidence intervals covers zero. In the following only the bias-corrected estimates and confidence intervals are reported. The relation between the estimated bias and standard error favors this approach in the large majority of cases. Where it does not, the magnitude of the bias-correction is negligible so that bias-corrected estimates are used in these cases, too, for the sake of a uniform exposition.

Table 2.3 summarizes the decomposition results for growth around upbreaks. The first column in the upper panel of the Table depicts the proximate causes of growth preceding an upbreak and corresponds to Table 2.2. The second column presents the decomposition results for the five-year period after an upbreak. The average annual growth rate of income per capita jumps to almost 5 %. After the break

Table 2.3: Bias Corrected Contributions to Growth and Confidence Intervals: Upbreaks

	Before	After	Difference
Income per Capita	−0.603	4.744	5.347
Efficiency Change	−2.277	2.029	4.306
	[−2.486, −2.075]	[1.847, 2.225]	[4.056, 4.575]
Technological Change	1.163	0.975	-0.189
	[0.933, 1.389]	[0.794, 1.140]	[−0.462, 0.079]
Capital Accumulation	0.692	1.427	0.735
	[0.623, 0.763]	[1.352, 1.507]	[0.631, 0.837]
Labor Force Participation	−0.088	0.313	0.401
Observations	54	54	54
Differences	High Income	Middle Income	Low Income
Income per Capita	3.801	6.131	5.490
Efficiency Change	0.685	4.921	4.940
	[0.142, 1.221]	[4.702, 5.147]	[4.604, 5.304]
Technological Change	1.819	0.201	−0.718
	[1.280, 2.342]	[−0.022, 0.422]	[−1.067, −0.361]
Capital Accumulation	0.127	0.153	1.008
	[0.017, 0.242]	[0.092, 0.218]	[0.859, 1.149]
Labor Force Participation	1.115	0.788	0.153
Observations	8	9	37

Notes: Upbreaks are derived using the udmaxL procedure as described in the text. Nonparametric growth accounting is carried out for the five-year period before and after the break. Bias corrections and confidence intervals are based on 1000 bootstrap replications. The estimates are estimated average annual growth rates for the respective quantities.

all components contribute positively to the observed growth rate. Two percentage points of the growth rate can be attributed to improvements in the efficiency of production, approximately 1.4 percentage points to capital accumulation and roughly one percentage point to technological changes. In addition, changes in labor force participation rates add a further 0.3 percentage points to growth. Based on the first two columns the third one analyzes the changes over upbreaks. On average, economic growth increases by 5.3 percentage points. The difference in growth is mainly a result of improvements in the efficiency of production. Whereas before the break the efficiency of production deteriorates, efficiency improves after the break. In fact, roughly 80 % of the observed growth rate increase can be attributed to the countries no longer moving away from the world technology frontier, but moving towards it. The typical growth acceleration is also associated with an increased absolute importance of capital accumulation. Before the upbreak, capital accumulation contributes 0.7 percentage points to growth; after the upbreak this number goes up by 0.7 percentage points to 1.4 percentage points. Hence, capital accumulation accounts for approximately 13.7 % of the observed increase in per capita income growth rates. Contrary to that, technological change is no more important after the upbreak than before. The point estimate for the contribution of technological change to the growth rate change is negative, but the confidence interval indicates that it is not significantly different from zero. It should be noted, though, that even a negative estimate does not imply technological regress. Rather, it indicates that the world technology frontier no longer shifts outwards with the same speed as before the upbreak. Finally, the change in labor force participation rates explains 0.4 percentage points of the growth rate difference.

The lower part of Table 2.3 analyzes to what extent the results are sensitive to the state of development of the respective economies. The differences in income per capita growth rates and their respective sources are reported separately for high, middle and low income countries. The state of development is determined in the year preceding the upbreak. The patterns of growth rate changes differ across the three country groups. The growth rate increase is smaller in developed countries than in less developed ones (3.8 versus 6.1 and 5.5 percentage points). And even though improvements in the efficiency of production explain some part of the growth rate increase in all country groups, they are more important in middle and low income countries. In these countries efficiency changes account for 80 % or more of the growth rate change compared to 18 % in high income countries. Technological change, on the other hand, plays an important role in high income countries, only. Almost half of the observed growth rate increase in these countries can be attributed to technological change. In middle income countries the influence of technological change on the growth rate difference is not significantly different from zero whereas in low-income countries technological progress decelerates significantly. Capital accumulation contributes positively and significantly to the growth rate changes in all three country subgroups. However, in high and middle income countries the contribution in percentage points is 0.15 or less. Thus, in relative terms only 3.3 % and 2.5 % of the growth rate increase can be explained by capital accumulation, respectively. The impact of capital accumulation is more pronounced for low income countries where approximately one percentage points of the growth rate increase and thus roughly 18 % can be attributed to this component. Overall, however, capital accumulation appears to be of limited importance for medium-term growth rate changes.[34]

[34]In a previous version of this chapter data from PWT version 6.2 has been used for the calculations. While results are largely comparable across both datasets, the role of capital accumulation is somewhat different. In particular, if data from PWT 6.2 is used, capital accumulation is relatively more important in high income than in low income countries.

Table 2.4: Bias Corrected Contributions to Growth and Confidence Intervals: Downbreaks

	Before	After	Difference
Income per Capita	5.539	−1.614	−7.152
Efficiency Change	2.390	−2.618	−5.009
	[2.205, 2.590]	[−2.749, -2.484]	[−5.241, −4.773]
Technological Change	0.850	0.390	−0.460
	[0.660, 1.026]	[0.266, 0.510]	[−0.677, −0.247]
Capital Accumulation	2.240	0.573	−1.667
	[2.153, 2.329]	[0.523, 0.622]	[−1.771, −1.566]
Labor Force Participation	−0.007	0.067	0.074
Observations	60	60	60
Differences	High Income	Middle Income	Low Income
Income per Capita	−5.208	−6.560	−9.337
Efficiency Change	−3.232	−4.683	−6.889
	[−3.670, −2.786]	[−5.062, −4.324]	[−7.201, −6.546]
Technological Change	−0.588	−0.687	−0.214
	[−1.012, −0.154]	[−0.973, −0.380]	[−0.503, 0.056]
Capital Accumulation	−1.068	−1.526	−2.318
	[−1.244, −0.907]	[−1.707, −1.338]	[−2.487, −2.141]
Labor Force Participation	−0.186	0.418	0.137
Observations	23	13	24

Notes: Downbreaks are derived using the udmaxL procedure as described in the text. Nonparametric growth accounting is carried out in the five-year period before and after the break. Bias corrections and confidence intervals are based on 1000 bootstrap replications. The estimates are estimated average annual growth rates for the respective quantities.

Table 2.4 replicates Table 2.3 for downbreaks. In the typical downbreak the average yearly growth rate of income per capita decreases by more than seven percentage points from 5.5 % to −1.6 %. Approximately 70 % of this decrease is the effect of deteriorating productive efficiency. Roughly one quarter reflects the declining contribution of capital accumulation to growth. The contribution of technological progress also declines. The only component that mitigates the fall of the growth rate is labor force participation. However, with 0.074 percentage points its positive impact is drowned in the other components.

Accounting for the state of development reveals that downbreaks are more pro-

The sensitivity of results with respect to different versions of PWT is a general problem that has to be addressed more thoroughly in future growth research (Johnson et al., 2012). However, for the present essay the important thing to note is that the main conclusions (limited importance of capital accumulation for medium-term growth rate changes; relevance of technological changes for high income countries; asymmetries between upbreaks and downbreaks) are robust across both datasets.

nounced the poorer a country. In high income countries the average growth rate falls by 5 percentage points, in middle income countries by 6.5 percentage points and in low income countries by more than 9 percentage points.[35] Thus, the fall of the growth rate due to a downbreak is noticeably higher in absolute terms than the increase of the growth rate due to an upbreak in high and low income countries. Looking at the individual contributions of each component, the differences between country groups are less pronounced than over upbreaks. In all three subgroups, deteriorating productive efficiency explains the majority of the growth rate fall. And in all three subgroups, capital accumulation after the downbreak contributes less to growth than before and accounts for 20 – 25 % of the growth rate change.[36] The impact of technological change declines noticeably in high and middle income countries, only. Somewhat surprisingly, rising labor force participation rates can be observed in middle and low income countries despite the sharp fall in growth. One possible explanation is that poor households have to make up income losses at the individual level by higher participation in the labor market at the household level in order to survive.[37]

2.4.4 Discussion

The previous section confirms Jones and Olken‘s (2005) main conclusion that capital accumulation is not driving medium-term growth rate changes. Despite using a different testing procedure for structural breaks, longer time-series and the less restrictive nonparametric growth accounting framework, this paper, too, finds that capital accumulation explains only a relatively small fraction of growth rate changes around growth accelerations and decelerations (on average, 13.7 % and 23.3 %, respectively). Changes in total factor productivity are confirmed as the main source of medium-term growth rate changes, just as Jones and Olken (2005) suggest. However, the origin of total factor productivity changes differ between high income and middle and low income countries at least in the context of growth accelerations. Whereas

[35]The fall in the growth rate might appear very high for high income countries at first glance. However, countries are grouped dynamically and on income levels relative to the US, only. Therefore, the group of high income countries comprises additional countries compared to the usual set of industrialized ones or OECD members. Cf. Appendix 2.E for a classification of breaks according to income levels.

[36]To the extent that downbreaks are associated with civil unrest or wars, the numbers understate the contribution of capital accumulation since destruction of the capital stock exceeding that of normal depreciation rates is not considered.

[37]Cf. Appendix 2.F for the extended decomposition discussed in Footnote 14.

total factor productivity improvements in the latter country groups predominantly represent changes in the efficiency of production, high income countries also grow due to technological progress. Based on the asymmetric role played by capital accumulation during upbreaks and downbreaks, Jones and Olken (2005) argue that unified growth models might not be the way to go. This conclusion is reinforced in the sense that unified growth models for developed and developing countries might not be the way to go, either. As argued above, the sources of total factor productivity improvements appear to be distinct between the country groups. In addition, while the impact of capital accumulation on growth accelerations is limited in all countries, the differences in the relative contributions to the growth rate changes across subgroups of countries are noticeable and also point at potentially distinct growth processes.

Similar to Jones and Olken (2005), this paper, too, identifies a large number of growth accelerations in particular in low income countries. Therefore, poor countries do not appear to be permanently locked in poverty traps. Rather they seem to have difficulties in maintaining the accelerated growth rate once an upbreak occurs. The present framework offers a potential explanation as to why initiating growth is different from sustaining it (Rodrik, 2005). If growth accelerations in low and middle income countries initially happen mainly on the intensive margin by improving the efficiency of production, at some point these benefits will be reaped. The countries will then have to change their growth model and switch to the extensive margin of growth. For countries with low capital intensity this likely requires a combination of accumulating significantly more capital and innovating, if only e.g. by adapting existing technologies to local conditions. It is conceivable that the inability of many poor countries to sustain growth accelerations is a consequence of the countries' failure to undergo this change.

Finally, this paper also confirms that growth accelerations and decelerations exhibit important asymmetries. Not only are changes in capital accumulation a more important part of the explanation in the context of downbreaks than in upbreaks like Jones and Olken (2005) state. In addition, the differences between country groups are less pronounced. This is true for capital accumulation, which plays a non-negligible part in accounting for the fall of growth rates in all countries. However, it is also true for the origins of total factor productivity deteriorations, which not only in low and middle income countries, but in high income countries, too, largely represent a plunge in productive efficiency. Regarding the decrease of productive efficiency, the effect might be overstated, though. The calculations are based on per worker values, which themselves are constructed using labor force participation rates that do not account for unemployment or hours worked. Therefore, if unemployment during downbreaks increases or if hours worked fall, output per worker and hence efficiency is underestimated.[38] Still, the direction of the potential error is not unequivocal because the same argument implies that capital per worker is understated or lies idle, which leads to overestimated efficiency scores. Obviously, a better way to account for capacity utilization is desirable, but it is quite likely that efficiency changes will continue to play a major role.[39]

2.5 Robustness Checks

Due to the well known sensitivity of DEA analysis to atypical observations, the results of the previous section have to be checked for robustness. In this section, the underlying assumptions of the BP procedure are altered, the accounting period around growth transitions is extend, the depreciation rates used in the derivation of the capital stock are modified and frontier-defining countries are eliminated from the sample. Table 5 shows how these alterations affect the direct contributions of efficiency, technology and capital accumulation over growth transitions in high, middle and low income countries. As before, bias-corrected estimates are reported, this time based on 250 bootstrap replications.

At first, the assumptions of the BP procedure are varied. The structural breaks are derived using heteroscedasticity and autocorrelation consistent standard errors (panel HAC), requiring a minimum duration of only five years per growth spell (panel $h = 5$) and stipulating a constant trimming parameter of 0.1 (panel $\varepsilon = 0.1$), respectively. In all cases, additional breaks are identified. This conforms to expectations if the minimum duration of growth spells is reduced or if a constant trimming parameter is imposed.[40] Generally, the more break points are identified, the more important

[38] However, it might be argued that unemployment should be considered in the efficiency of production on an economy-wide level.

[39] Jones and Olken (2005) employ electricity consumption to assess capacity utilization more directly. Their results are not sensitive to this change.

[40] Notice that the latter effectively reduces the minimum duration of growth spells even further to three, four or five years, respectively, depending on the number of available observations. Three breaks had to be discarded in the growth accounting exercise because the next break happened before the the accounting period of five years has ended.

Table 2.5: Robustness Checks: Bias Corrected Contributions to Growth

		Upbreaks			Downbreaks		
		High	Middle	Low	High	Middle	Low
Base	Income per Capita	3.80	6.13	5.49	−5.21	−6.56	−9.34
	Efficiency Change	0.66*	4.95*	4.96*	−3.21*	−4.68*	−6.88*
	Technological Change	1.82*	0.19	−0.72*	−0.59*	−0.69*	−0.22
	Capital Deepening	0.15*	0.14*	0.99*	−1.09*	−1.52*	−2.32*
	Labor Force Part.	1.11	0.79	0.15	−0.19	0.42	0.14
	Observations	8	9	37	23	13	24
HAC	Income per Capita	3.78	5.94	5.98	−5.22	−6.63	−8.82
	Efficiency Change	0.45	4.75*	5.69*	−3.44*	−4.81*	−6.68*
	Technological Change	1.91*	0.03	−0.68*	−0.48*	−0.76*	−0.17
	Capital Deepening	0.21*	0.32*	0.72*	−1.00*	−1.43*	−2.04*
	Labor Force Part.	1.15	0.75	0.16	−0.17	0.45	0.10
	Observations	8	10	43	22	13	28
h = 5	Income per Capita	3.36	7.55	7.07	−5.40	−6.45	−8.71
	Efficiency Change	0.60*	6.23*	6.61*	−3.39*	−3.77*	−5.54*
	Technological Change	1.67*	0.18	−0.75*	−0.61*	−1.58*	−0.63*
	Capital Deepening	0.16*	0.36*	0.99*	−0.98*	−1.35*	−2.59*
	Labor Force Part.	0.88	0.65	0.07	−0.29	0.37	0.01
	Observations	10	8	44	22	13	28
$\varepsilon = 0.1$	Income per Capita	3.36	7.53	6.84	−5.48	−6.35	−8.78
	Efficiency Change	0.64*	6.29*	6.47*	−3.44*	−4.29*	−5.41*
	Technological Change	1.63*	0.42*	−0.78*	−0.69*	−1.23*	−0.70*
	Capital Deepening	0.17*	0.09*	0.93*	−0.98*	−1.22*	−2.74*
	Labor Force Part.	0.88	0.63	0.07	−0.23	0.47	0.03
	Observations	10	7	42	23	13	28
8 years	Income per Capita	3.16	5.39	5.33	−4.89	−5.30	−6.91
	Efficiency Change	0.88*	4.10*	4.51*	−3.14*	−3.25*	−3.80*
	Technological Change	1.32*	0.09	−0.80*	−0.54*	−1.08*	−0.71*
	Capital Deepening	0.20*	0.27*	1.24*	−1.14*	−1.22*	−2.77*
	Labor Force Part.	0.69	0.87	0.23	0.03	0.34	0.35
	Observations	8	9	37	23	13	24
regime duration	Income per Capita	2.30	5.91	5.08	−4.00	−5.17	−6.12
	Efficiency Change	0.89*	4.73*	5.75*	−2.14*	−2.84*	−2.09*
	Technological Change	0.51*	−0.30*	−1.65*	−0.74*	−1.28*	−1.13*
	Capital Deepening	−0.07	0.63*	0.13*	−1.42*	−1.83*	−3.66*
	Labor Force Part.	0.93	0.77	0.65	0.38	0.89	0.69
	Observations	8	9	37	23	13	24
$\delta = 0.1$	Income per Capita	3.80	6.13	5.49	−5.21	−6.56	−9.34
	Efficiency Change	0.71*	5.19*	4.88*	−3.45*	−4.69*	−6.48*
	Technological Change	1.65*	−0.12	−0.92*	−0.41	−0.46*	−0.22
	Capital Deepening	0.27*	0.22*	1.27*	−1.03*	−1.74*	−2.75*
	Labor Force Part.	1.11	0.79	0.15	−0.19	0.42	0.14
	Observations	8	9	37	23	13	24
$\delta = 0.05$	Income per Capita	3.80	6.13	5.49	−5.21	−6.56	−9.34
	Efficiency Change	1.25*	4.85*	4.98*	−3.14*	−4.69*	−7.18*
	Technological Change	1.34*	0.38*	−0.58*	−0.82*	−0.85*	−0.22
	Capital Deepening	0.03	0.04	0.83*	−0.94*	−1.36*	−2.00*
	Labor Force Part.	1.11	0.79	0.15	−0.19	0.42	0.14
	Observations	8	9	37	23	13	24
mild sample	Income per Capita	3.62	6.13	5.49	−4.83	−6.38	−9.34
	Efficiency Change	1.46*	5.31*	5.40*	−3.16*	−5.26*	−6.49*
	Technological Change	0.80*	−0.21	−1.26*	−0.36	−0.18*	−0.71*
	Capital Deepening	0.15*	0.16*	1.04*	−1.05*	−1.30*	−2.31*
	Labor Force Part.	1.14	0.79	0.15	−0.13	0.45	0.14
	Observations	7	9	37	21	12	24
strict sample	Income per Capita	3.62	6.13	5.49	−4.63	−6.38	−9.43
	Efficiency Change	3.09*	5.38*	4.54*	−1.93*	−4.67*	−7.76*
	Technological Change	−0.84*	−0.24*	−0.44*	−1.09*	−0.40*	−0.05
	Capital Deepening	0.16*	0.14*	1.14*	−1.35*	−1.67*	−1.69*
	Labor Force Part.	1.14	0.79	0.15	−0.15	0.45	0.14
	Observations	7	9	37	19	12	23

Notes: Col. 1 indicates the modifications compared to the base scenario. Bias corrected estimates for annual growth rates of the respective quantities are reported (250 bootstrap replications). * denotes significance at the 10-% level efficiency changes tend to become for explaining upbreaks in low income countries. In all variants, technological progress makes an important positive contribution to growth rate increases in high income countries, only. Growth accelerations in low and middle income countries continue to be dominated by efficiency changes. The contribution of capital accumulation remains most important in low income countries both in absolute and in relative terms. The patterns of downbreaks remain largely unchanged. Changes in capital accumulation continue to be more pronounced during downbreaks than during upbreaks in all country groups. Total factor productivity deteriorations are the result of both a decline in the efficiency of production and a slowdown of technological progress.

In panels $h = 5$ and $\varepsilon = 0.1$ the heightened role of capital deepening and the smaller role of efficiency changes during downbreaks in low income countries is noticeable. This feature, however, is attributable to one additionally identified downbreak in Botswana (1973), only. This downbreak is special in that it appears to be more of a consolidation rather than a crisis. Before the break the Botswanian economy grows at a rate of almost 13 %. However, efficiency during that period uncharacteristically continuously deteriorates, a feature in line with overheating of the economy. After the break economic growth slows down to a yet impressive growth rate of almost 6 %. In contrast to the typical downbreak, efficiency of production improves noticeably after the break, contributing positively (in absolute terms) to the observed growth rate change. The contribution of capital accumulation to growth declines substantially over the break.

Next, the impact of the accounting period around growth transition is analyzed. It is extended to eight years (panel 8 years) and the whole duration of a regime (panel regime accounting), respectively. Extending the accounting period to eight years somewhat increases the importance of capital accumulation and decreases the relevance of efficiency changes in explaining growth rate changes, but in terms of overall patterns it is innocuous. Regime accounting is different. Two differences stand out: The explanatory value of capital deepening decreases noticeably in high and low income countries over upbreaks, but gains importance during downbreaks. Technological progress becomes less relevant in explaining upbreaks in high income countries, but changes in the rate of technological progress become more important during downbreaks. These changes occur at the expense of efficiency changes so that, quite remarkably, efficiency changes explain less of the growth downbreak in low income countries than changes in capital accumulation. While these results can to some extent be explained within the inner logic of the modelling framework,[41] foremost they emphasize that medium-term growth rate changes are different from long-term growth rate changes.

A key difficulty in cross-country growth accounting is the need to impute economy-wide capital stocks. Calculations based on the perpetual inventory method are particularly sensitive to the assumed depreciation rates. Therefore, the following two panels ($\delta = 0.1$ and $\delta = 0.05$) analyze the effect of assuming depreciation rates of 5% and 10%, respectively. Compared to the baseline case the new depreciation rates imply vast differences: the initial capital stock for the United States ranges from approximately 75% to 132% of the base calculation. Since the imputed capital stocks enter directly into the world technology frontier, it is clear that its shape will be altered: higher (lower) depreciation rates imply lower (higher) capital stocks so that the technology frontier becomes steeper (flatter). Ceteris paribus the importance of capital accumulation should therefore increase (decrease). The relative contributions of capital deepening indeed move as expected. Not surprisingly, the relative contribution of technological change and its significance is influenced by the depreciation rate, too. After all, the steepness of the frontier also determines the rate of technological progress over time at a given capital intensity. However, overall, the results are remarkably consistent with the core conclusions, so that the imputation of capital stocks does not appear to be a major problem.[42]

Finally, to rule out that the technology frontier is an artefact of some atypical ob-

[41] The smaller contribution of capital accumulation to growth rate increases and the larger contribution to growth rate decreases to some extent follows from the marginal returns of capital. Consider capital accumulation before upbreaks: If the regime before the upbreak is a long one, capital stock per worker in the beginning of the regime will be lower than in the five or eight year period around the break. Similarly, if the regime after the upbreak prevails for a long time, capital per worker at the end of the regime will be higher than five or eight years after the break. If decreasing return to capital prevail, this implies that the growth rate change accountable to capital deepening is increased before the upbreak by regime accounting and decreased afterwards. Thus, the difference between the two becomes smaller by construction. Similar arguments apply to downbreaks. Regarding technological progress, shifts of the technology frontier at low levels of capital intensity are observed only in the beginning of the sample period (cf. Figure 2.2). Therefore, extending the accounting period will often result in a higher rate of technological progress before the first break. This explains why the deceleration of technological progress becomes more important for middle and low income countries when regime accounting is applied.

[42] Assumed depreciation rates in growth accounting studies usually lie closer to five than ten percent (Bernanke and Gürkaynak, 2001; Bosworth and Collins, 2003; Hall and Jones, 1999).

servations, the sensitivity of results to eliminating frontier-defining countries from the sample is analyzed in the last two panels. Observations are dropped according to the following rules. In the mild version, the technology frontier is calculated separately for each year. Countries that span the frontier in one particular year are dropped from the sample for that specific year, only. A more demanding definition eliminates frontier-defining countries from the sample forever.[43] Eliminating frontier-defining countries should influence the contribution of technological changes to growth rate changes, in particular. This is indeed observed in the mild sample restriction, but the thrust of the results continues to hold. Applying the strict version leads to more dramatic changes. Most notably, technological change now contributes negatively to economic growth in high income countries, turning results upside down. However, the uncovered sensitivity should not be overinterpreted. It is the result from effectively eliminating the United States of America from the sample. Given that the United States are among the countries that offer the highest quality of data and are the least likely to be outliers, the dropping rules in the strict version appear overly strict.

Summing up, the robustness tests reveal that the patterns of the proximate sources driving growth transitions are not overly sensitive to various specification changes, boosting confidence in the main results.

2.6 Conclusion

In this paper the proximate causes of significant growth rate changes within countries have been analyzed with a special focus on the relative importance of factor accumulation versus productivity changes in order to test the robustness of a recent finding by Jones and Olken (2005): namely that total factor productivity improvements do not only drive long-term growth, but also the frequently observed medium-term growth events. Methodologically, nonparametric growth accounting has been applied because this helps to avoid a number of assumptions implicit in parametric growth accounting. Moreover, productivity changes can be attributed to changes in the efficiency of production and changes in technology.

[43] This amounts to estimating the frontier for t and dropping the fully efficient countries to obtain the reduced sample $\mathcal{S}_t^{red}$. In $t+1$, the frontier is estimated using $\mathcal{S}_t^{red}$ and the observations from $t+1$. Observations from $t+1$ that lie on the frontier are dropped to generate $\mathcal{S}_{t+1}^{red}$. By this definition, past technological advances are "forgotten" if they are not replicated by other countries.

This paper confirms that growth transitions are frequent representing essentially productivity events with limited importance of capital accumulation. Depending on the income levels of the respective economies, at least two thirds of the growth rate changes can be attributed to efficiency and technological changes. The origins of productivity improvements over growth accelerations, however, depend on the state of development. Low and middle income countries almost exclusively experience improvements in productive efficiency while technological progress is an important source of growth rate changes in high income countries. Growth decelerations are different from growth accelerations in two respects. Even though productivity deteriorations explain the majority of the observed growth rate breakdowns, changes in capital accumulation are relatively more important. Moreover, compared to growth accelerations, the state of development of the respective economies is of lesser importance for the sources of growth rate changes. These results are robust to a number of specification changes.

This paper points at two avenues for further research. Given the overwhelming importance of efficiency changes in the context of growth transitions, the next logical step is to search for the sources thereof. According to the literature the sectoral composition of production, the skill composition in the economy, prevailing regulations and laws, the organization of vested interests, the integration into the world economy, the prevalence of violent conflicts and rent-seeking, the availability of a well-functioning financial system, the level of trust between market participants, attitudes and attitudinal shifts or demography are potential explanatory factors (Acemoglu et al., 2001; Edwards, 1993; Feyrer, 2009; Frankel and Romer, 1999; King and Levine, 1993a,b; Knack and Keefer, 1997; Murphy et al., 1989; Prescott, 1998; Rodrik and Subramanian, 2005). However, their importance in the context of growth transitions is yet unknown. The second starting point is somewhat related, but with a different emphasis. Ultimately, to understand economic growth it is essential to understand how economies manage to transform a medium-term growth acceleration into sustained growth. According to the previous analysis, achieving sustained growth likely requires replacing growth on the intensive margin (i.e. improving the efficiency of production) by growth on the extensive margin (i.e. capital accumulation, innovation). Therefore, a comparison of countries that manage this transformation against countries that do not can potentially illustrate a subset of required changes for achieving sustained growth. It can also clarify whether these changes are transferable recipes across countries or whether they are country-specific (Rodrik, 2005; Williamson, 1990b). Nonparametric growth accounting is a valuable tool to identify the onset of these transformations and to evaluate whether the transformation towards growth on the extensive margin has succeeded. Most likely, an analysis along these lines will require more detailed data on economic reforms and institutional changes than is currently available. Therefore, comparative country studies which take account of the lesser known cases of growth transitions appear to be of particular value as a first step.

Appendix 2.A: Multiple Structural Breaks Estimation in Stata Using the Bai and Perron Methodology

Abstract: One important topic in the context of macroeconomic time series is the possible prevalence of one or multiple structural breaks. Bai and Perron (1998, 2003a, 2003b, 2006) have developed a methodology for finding multiple structural breaks and testing their significance in a linear regression model. This paper shortly reviews their methodology and introduces a Stata command that implements it.

2.A.1 Introduction

One important topic in the economics and statistics literature concerns structural change. A typical analysis looks at macroeconomic time series and asks whether structural changes have occurred at exogenously determined break dates or whether a single change has happened at an unknown break date. In these cases, the Chow test and the Andrews-Ploberger test apply, respectively (Greene, 2003, chap. 7). For a long time little has been known about how to appropriately handle multiple structural breaks with unknown break points. However, in a series of influential papers, Bai and Perron (1998, 2003a, 2003b, 2006) have developed a methodology that allows consistent estimation of break dates in the presence of multiple unknown structural breaks along with testing procedures and algorithms to select the appropriate number of breaks. This paper reviews their methodology with a special emphasis on practical implementation issues and presents a newly implemented Stata command that allows estimation and sequential testing of multiple breaks in a pure linear structural change model.

2.A.2 Estimation and Testing

2.A.2.1 Estimating Break Points

In this note, the following linear regression model with m breaks and $m+1$ regimes is considered:

$$y_t = \delta_j + u_t, \quad t = T_{j-1}+1, ..., T_j \tag{S1}$$

for $j = 1, ..., m+1$. y_t is the observed stationary dependent variable of a time series at time t that is regressed on a regime-specific constant δ_j $(j = 1, ..., m+1)$ yielding a model with regime-specific means in each resulting data segment. The disturbance term u_t has an expected value of zero, but may exhibit different variances across segments. Autocorrelation in the residuals is allowed. The total number of available observations is T. The purpose is to estimate the unknown break points $T_1, ..., T_m$ together with the unknown regression coefficients $\delta_1, ..., \delta_{m+1}$. $T_0 = 0$ and $T_{m+1} = T$ is assumed. The convention throughout this note is that T_j denotes the last observation belonging to regime j.

The method of estimation is based on the least-squares principle. For each m-partition $(T_1, ..., T_m)$ the coefficients δ_j $(j = 1, ..., m+1)$ minimize the sum of squared residuals. Formally,

$$S_T(T_1, ..., T_m) = \underset{\delta_1, ..., \delta_{m+1}}{\operatorname{argmin}} \sum_{j=1}^{m+1} \sum_{t=T_{j-1}+1}^{T_j} (y_t - \delta_j)^2 . \tag{S2}$$

The estimated break points minimize the sum of squared residuals over all conceivable m-partitions subject to the constraint that a minimum length of $h > 1$ between breaks is respected. Hence,

$$\begin{aligned} (\hat{T}_1, ..., \hat{T}_m) &= \underset{T_1, ..., T_m}{\operatorname{argmin}} S_T(T_1, ..., T_m) \\ \text{s. t. } & T_j - T_{j-1} \geq h \text{ for } j = 1, ..., m+1. \end{aligned} \tag{S3}$$

Thus, the final solution globally minimizes the sum of squared residuals both with respect to the break dates and with respect to the regression coefficients.

In practice, the global minimizers of the objective function are derived by summarizing the sum of squared residuals in a suitable way and by applying a dynamic programming algorithm afterwards. Both steps serve to avoid a curse of dimensionality problem. First, the upper-triangular $(T \times T)$ matrix M is defined. The entry $M[t_1, t_2]$ stores the sum of squared residuals (SSR) that result if y_t is regressed on a constant using observations $t_1, ..., t_2$. The SSR for every conceivable m-partition $S_T(T_1, ..., T_m)$ can be derived by summing up the SSR for each associated segment so that the essence of equation (S2) is implemented. In order to avoid too many matrix inversions, the SSR are obtained using the updating formula for recursive residuals suggested by Brown et al. (1975).[44]

The optimal m-partition is found by solving the following recursive problem:

$$SSR(T_{m,T}) = \min_{mh \leq t \leq T-h} [SSR(T_{m-1,t}) + SSR(t+1,T)]. \tag{S4}$$

$SSR(T_{r,n})$ denotes the SSR associated with the *optimal* partition of the time series containing r breaks and using the first n observations, $SSR(t+1,T)$ denotes the SSR for the data segment starting in $(t+1)$ and lasting until T. It is easiest to understand the logic of the procedure by following its empirical implementation. To that end, two further $(m+1) \times T$ matrices L and B are defined. Matrix L records the minimal estimated SSR for a partition running from period 1 to the column number for a given number of breaks, which equals the row number minus one. Matrix B stores the associated break dates following the same conventions. It follows that the first line of matrix L contains the estimated SSR for a sample running from period 1 to T, 1 to $(T-1)$ etc. with no break and is therefore equal to the first line of matrix M. The first line in matrix B is empty because no breaks are involved.

The second line of matrix L contains the minimal estimated SSR for a sample running from 1 to T with one structural break, the minimal estimated SSR for a sample running from 1 to $(T-1)$ with one structural break and so on. The structural break is chosen such that the estimated SSR is minimized and that the minimum duration requirement h for each regime is respected. Hence, for the entry $L[2,T]$ the resulting SSR is compared for all conceivable break dates ranging from h to $(T-h)$ and the break date leading to the smallest SSR is selected. This break date $\hat{T}_1$ is recorded in $B[2,T]$ while the associated SSR is recorded in $L[2,T]$. The other entries are derived accordingly. For instance, for $L[2,(T-1)]$ and $B[2,(T-1)]$ the resulting SSR is evaluated for possible break dates ranging from h to $(T-h-1)$.

The derivation of the third lines in L and B illustrates the working of the recursive procedure (S4). Suppose the aim is to derive $L[3,T]$ and $B[3,T]$. Since $\hat{T}_1 < \hat{T}_2$ and since the minimum duration requirement for each regime has to be respected, the second break can happen between period $2h$ and $(T-h)$. The resulting SSR for each conceivable second break date T_2 in the sample running from 1 to T is given by

[44] It is not even necessary to calculate all entries of M because certain entries are not permissible due to the minimal length requirement for each regime. However, this refinement is not implemented.

$L[2, T_2] + M[T_2 + 1, T]$. It automatically incorporates the optimal one-break partition for the sample spanning the observations from 1 to T_2. After the SSR has been derived for every conceivable second break date, the partition yielding the smallest SSR is chosen and the associated second break date $\hat{T}_2$ and the SSR are recorded in $B[3, T]$ and $L[3, T]$, respectively. All other entries in the second line are derived accordingly. The same routine is repeated until m breakpoints are imposed upon the time series. Once matrices L and B are derived, it is easy to read off the optimal break points. If m break points are estimated, $\hat{T}_m$ is recorded in $B[m + 1, T]$. The next break point $\hat{T}_{m-1}$ is found in $B[m, \hat{T}_m]$, $\hat{T}_{m-2}$ is available in $B[m - 1, \hat{T}_{m-1}]$. Going back step by step the first break is obtained from $B[2, \hat{T}_2]$.

2.A.2.2 Test Statistics

The test statistics in the presence of multiple structural breaks are derived under the shrinking shift asymptotic framework so that the consistency results do not directly refer to the break dates, but to the break fractions $\lambda_j = (T_j/T)$ for $j = 1, ..., m$.[45] Therefore, the test statistics are not expressed in terms of the m-partition $(T_1, ..., T_m)$, but in terms of the m-partition $(\lambda_1, ..., \lambda_m)$. Furthermore, the asymptotic distributions depend on the trimming parameter $\varepsilon = h/T$, which is the asymptotic equivalent of the minimum duration requirement and is necessary for the break fractions to be asymptotically distinct and bounded from the boundaries of the sample.

The first test statistic is called the supF_T test statistic and forms the basis for all following tests. The sup$F$ test tests the null hypothesis of no structural break $(m = 0)$ against the alternative hypothesis that $m = k$ structural breaks are present. This test is particularly useful if one has a fairly good idea a priori as to how many breaks to expect. The sup$F_T(k)$ test statistic is the supremum of all the standard F-statistics testing the equality of means across regimes over all admissible k-partitions. Asymptotically, the sup$F_T(k)$ test statistic is equivalent to the standard F-statistic that results if the consistently estimated break fractions $(\hat{\lambda}_1, ..., \hat{\lambda}_k)$ are used for its

[45]However, Bai and Perron (1998) show that with high probability the deviation between the estimated and true break dates is bounded by some constant. Therefore, in empirical applications the estimated break dates may be used with some confidence.

construction. Hence, only the following formula needs to be evaluated in practice:

$$\sup F_T(k) = F_T(\hat{\lambda}_1, ..., \hat{\lambda}_k) = \frac{1}{T}\left(\frac{T-(k+1)}{k}\right)\hat{\delta}'R'(R\hat{V}(\hat{\delta})R')^{-1}R\hat{\delta}. \tag{S5}$$

Thereby R is the conventional restrictions matrix such that $(R\delta)' = (\delta_1 - \delta_2, ..., \delta_k - \delta_{k+1})$ and such that the estimated break fractions are respected. $\hat{V}(\hat{\delta})$ is the covariance matrix of $\hat{\delta}$ that - if desired - can be made robust to serial correlation and heteroscedasticity. $\hat{V}(\hat{\delta})$ is estimated by the standard OLS covariance matrix using all observations if the errors are assumed to be identically distributed across segments. It is estimated as the standard OLS covariance matrix using the data for each segment separately if the errors are assumed to have different variances across regimes but are serially uncorrelated. If both serial correlation and different variances across regimes prevail, the covariance matrix is estimated using the quadratic spectral kernel based method introduced by Andrews (1991). In this case prewhitening as in Andrews and Monahan (1992) is recommended. The value of the $\sup F_T(k)$ test statistics is compared to simulated critical values, which depend both on k and ε. A large test statistic indicates that the break points significantly improve the fit of the model. Hence, in these cases the null hypothesis tends to be rejected.

In many interesting applications the number of breaks is not known beforehand. In this case the double maximum tests allows to test the null hypothesis of no break ($m = 0$) against the alternative of an unknown number of breaks up to K. The test statistic is defined as largest $\sup F_T(k)$ statistics for $k = 1, ..., K$ or formally as

$$\text{UDmax}F_T(K) = \max_{1 \le k \le K} F_T(\hat{\lambda}_1, ..., \hat{\lambda}_k). \tag{S6}$$

The critical values depend on K and ε. As before, a large test statistic indicates that the null hypothesis should be rejected. The power of the double maximum test exceeds that of the $\sup F$ test if k used in the latter does not correspond to the true number of breaks.

Ultimately, if the number of breaks is not known beforehand, the aim is to find the appropriate number of breaks by testing. One easy way to derive the appropriate number of breaks is to calculate the Bayesian information criterion (BIC) and choose the number of break points which minimizes the associated BIC. Formally, for a series with k break points the BIC is defined as

$$BIC(k) = \ln\left(\frac{\hat{u}'\hat{u}}{T}\right) + \frac{(2k+1)\ln(T)}{T}, \tag{S7}$$

with $\hat{u}$ denoting the estimated residuals accounting for the k breaks. It should be noted that this version of the BIC penalizes each estimated coefficient and each estimated break point, hence the factor $(2k+1)$ in the second term. The BIC performs reasonably well in the absence of serial correlation, but tends to opt for too many breaks in the presence of it.

A more refined method for determining the appropriate number of structural breaks is the $\sup \mathrm{F}_T(\ell+1|\ell)$ sequential testing procedure, which is called supFL in the following. Here the null hypothesis of $k=\ell$ breaks is tested against the alternative that $k=\ell+1$ breaks are present. Starting with $\ell=0$ and increasing the number of break points one by one until the null is accepted, the number of required breaks is derived systematically. The test is implemented as follows. If the number of breaks under the null equals ℓ, an additional break point is introduced into each of the $\ell+1$ data segments and the corresponding $\sup \mathrm{F}_T(1)$ test statistics are derived.[46] The largest $\sup \mathrm{F}_T(1)$ test statistic across all segments is selected and compared against the critical values that depend on k and ε.[47] The null is rejected in favor of a model with $(\ell+1)$ breaks if the overall minimal value of the SSR is sufficiently smaller the the SSR from the model with ℓ breaks.

In some instances it may be difficult to reject the null of zero against one break, but easy to reject the null of zero against a higher number of breaks. In these cases the supFL testing procedure breaks down. Since the power of the double maximum test is almost as high as the power of a test of no breaks against the alternative specifying the true number of breaks, Bai and Perron (2006) recommend to adjust the supFL procedure and use the double maximum test in the first step when the null hypothesis of $m=0$ breaks is tested. After this altered first step the test proceeds exactly like the supFL test. This test is called the udmaxL test. All tests presented in this section are implemented in the Stata command *sbbpm*. In order to achieve as much power as possible, the covariance matrix should be corrected for

[46] If the minimum duration requirement precludes the introduction of an additional break point, $\sup \mathrm{F}_T(1)$ equals zero by definition.

[47] Notice that this is equivalent to calculating the $\sup \mathrm{F}_T(\ell+1)$ test statistic using the whole time series.

heteroscedasticity and serial correlation whenever necessary.

2.A.3 Stata Implementation

2.A.3.1 Syntax

`sbbpm` *depvar timevar*, [minspan(#) maxbreaks(#) alpha(#) trimming(#) het(*string*) prewhit(#) method(*string*)]

2.A.3.1.1 Description

The stata command `sbbpm` fits a pure multiple structural change model for means using the methods suggested by Bai and Perron (1998, 2003a, 2003b, 2006). As a minimum it requires the name of the dependent and the time variable. The dependent variable must not contain any missing values. The data may be tsset beforehand.

2.A.3.2 Options

`minspan`(#) specifies the minimal length h that needs to be respected between breaks. The default value is 5.

`maxbreaks`(#) specifies the maximum number of breaks M that the time series may contain. The default value is 5.

`alpha`(#) specifies the significance level for the tests. The values $0.1, 0.05, 0.025$ and 0.01 are allowed. The default value is 0.1.

`trimming`(#) specifies the trimming parameter ε that is needed for the critical values. The values $0.05, 0.10, 0.15, 0.20$ and 0.25 are allowed. The default value is 0.1. However, it is strongly recommended to adjust this default value to match $\varepsilon = h/T$ because otherwise wrong critical values are applied in the tests.

`het`(*string*) specifies the assumptions made with respect to the distribution of the data and the errors across segments. If the distributions for the data are different across segments, but there is no serial correlation and distributions for the errors across segments are identical, *iid* should be selected. With no serial correlation in the errors, but different data and error distributions across segments, the heteroscedasticity consistent covariance matrix *hc* should be selected. If in addition autocorrelation is assumed, the relevant option is the heteroscedasticity and autocorrelation consistent matrix *hac*. The default value is *iid*.

`prewhit`(#) specifies whether the heteroscedasticity and autocorrelation consistent matrix should be derived using prewhitening. If prewhitening should be used, the value 1 has to be entered. 0 denotes no prewhitening. The default value is 1.

`method`(*string*) specifies the methods to be applied. Possible entries are: *bonly, sup, udmax, bic, supseq, udseq*. In this order they indicate to calculate the breaks only, to apply the supF_L or the UD$maxF_T$ test, to report the BIC, to apply the original sequential sup$\mathrm{F}_T(\ell+1|\ell)$ testing procedure or the udmaxL sequential testing procedure. The default value is *bonly*.

2.A.3.3 Saved Results

`sbbpm` saves in e(). The following is a complete list of saved results. The returned results vary depending on the chosen method.

Scalars:

`e(baserss)`	SSR for model with no breaks
`e(bicbreak)`	Final number of breaks chosen according to BIC
`e(ellfinal)`	Final number of breaks chosen with sequential methods

Matrices:

`e(delta)`	Reports the regime-specific means for all breaks up to *maxbreak* breaks
`e(var)`	Reports the regime-specific variance for all breaks up to *maxbreak* breaks
`e(intervalrss)`	Matrix M
`e(bestrss)`	Matrix L
`e(lastbreak)`	Matrix B
`e(breaks)`	Reports the break periods counted from 1 onwards for up to *maxbreak* breaks according to the number of the observations

`e(dates)`	Reports the break dates for up to *maxbreak* breaks according to the time variable
`e(supF_res)`	Reports the supF test statistics
`e(udmax)`	Reports the largest supF-statistic for each number of breaks up to *maxbreak* breaks
`e(udres)`	Reports the results of the double maximum test
`e(bic)`	Reports the *BIC* for all breaks up to *maxbreak* breaks
`e(supFL)`	Reports the results of the sequential supF_L test

Appendix 2.B: Structural Breaks

Table 2.B.1: Structural Breaks: Break Dates and Average Growth During Regimes

Country	Break 1	Break 2	Break 3	Regime 1	Regime 2	Regime 3	Regime 4
Algeria	1971			−0.25	1.66		
Argentina	1990			0.56	2.98		
Australia	1961			1.36	2.50		
Austria	1973			5.02	2.21		
Bangladesh	1996			0.18	3.48		
Belgium	1974			3.71	1.98		
Benin	1982			1.95	0.45		
Bolivia	1958			−2.31	0.70		
Botswana	1991			7.07	2.42		
Brazil	1980			4.79	0.53		
Burkina Faso	1971			−1.03	1.99		
Burundi	1992			1.84	−2.71		
Cameroon	1986	1994		2.54	−5.43	1.17	
Canada	1961			1.35	2.46		
Chile	1971	1983		2.09	−0.85	4.47	
China	1977			2.66	8.74		
Colombia	1967	1980		1.36	3.40	1.36	
Congo	1974			1.78	−4.13		
Congo, Republic of	1984			6.25	−0.79		
Costa Rica	1979	1991		3.18	−1.20	3.14	
Cote d'Ivoire	1978			3.39	−0.90		
Denmark	1973			3.29	1.98		
Dominican Republic	1991			2.60	4.59		
Ecuador	1970	1978	1999	1.86	7.14	−0.55	2.92
Egypt	1975			0.83	4.31		
El Salvador	1978	1986		2.25	−3.44	1.61	
Finland	1974			4.45	2.24		
France	1974			4.22	1.62		
Gabon	1976			8.07	−0.91		
Ghana	1972			8.17	0.14		
Greece	1973	1995		6.32	0.56	3.96	
Guatemala	1962	1980	1988	0.61	3.71	−2.72	1.39
Guinea	1991			−0.56	1.83		
Guinea-Bissau	1997			2.92	−3.15		
Haiti	1972	1980		−0.99	4.68	−1.42	
Honduras	1963			−0.69	1.31		
Hong Kong	1988			6.95	3.06		
Hungary	1978	1996		5.00	0.19	4.48	
India	1994			2.24	4.89		
Indonesia	1968			0.74	4.15		
Iran	1973			8.61	0.29		
Ireland	1993			2.76	6.45		
Israel	1973			4.86	1.54		
Italy	1974			5.05	1.89		

Table 2.B.1 *(continued)*

Country	Break 1	Break 2	Break 3	Regime 1	Regime 2	Regime 3	Regime 4
Jamaica	1972	1980		4.32	−3.79	1.10	
Japan	1970	1991		8.52	3.27	0.72	
Jordan	1965			5.26	0.00		
Korea	1962			1.31	6.07		
Lesotho	1978	1992		4.82	−0.84	4.24	
Malaysia	1970			2.79	4.99		
Mauritius	1960			−3.95	3.67		
Mexico	1981			3.72	0.57		
Morocco	1960			−0.50	2.88		
Mozambique	1995			−0.06	6.67		
Netherlands	1970			3.50	1.86		
New Zealand	1992			1.28	2.70		
Nicaragua	1977			3.56	−1.81		
Nigeria	1999			0.49	9.63		
Norway	1986			3.36	2.37		
Pakistan	1960			−0.30	2.99		
Panama	1959			0.18	3.52		
Papua New Guinea	1976			6.84	0.13		
Paraguay	1973	1981		0.88	6.12	−0.19	
Peru	1974			3.13	0.47		
Philippines	1959			4.53	1.72		
Poland	1979	1991		4.96	−1.68	4.65	
Portugal	1973			6.09	2.15		
Puerto Rico	1972			5.93	2.38		
Romania	1979	1999		9.11	−1.25	6.07	
Senegal	1997			−0.91	1.35		
Sierra Leone	1990	1999		1.75	−9.35	6.65	
Singapore	1997			5.87	3.15		
South Africa	1980	1994		2.05	−0.53	2.54	
Spain	1974	1984		6.21	0.14	3.35	
Sweden	1975	1993		2.93	0.77	3.03	
Switzerland	1973			3.37	1.00		
Taiwan	1962	1994		4.52	7.28	4.08	
Tanzania	1999			0.92	4.28		
Thailand	1958			−2.38	4.74		
Togo	1979			3.67	−2.11		
Trinidad & Tobago	1980	1993		4.57	−3.26	8.17	
Tunisia	1972			5.24	2.87		
Uganda	1988			−0.53	2.99		
United Kingdom	1982			2.02	2.66		
Uruguay	1985			0.74	2.79		
Venezuela	1974			3.03	−0.24		
West Germany	1960			6.70	2.58		
Zambia	1968	1999		3.83	−3.41	9.78	
Zimbabwe	1998			2.18	−5.76		

Notes: The structural breaks are derived using the udmaxL testing procedure as described in the main text. The minimum duration requirement of is set to 8 years and a significance level of 0.1 is used. The recorded break years are the final years of the previous growth regimes. Regimes report the average yearly growth rate of income per capita during growth regimes.

Appendix 2.C: Details of Nonparametric Growth Accounting

The two counterfactual distance functions that need to be solved additionally are:

$$D_t^j(K_{t+1}^j, L_{t+1}^j; Y_{t+1}^j) = \min\ \phi^j \text{ subject to } \frac{Y_{t+1}^j}{\phi^j} \leq \sum_{\tau \leq t} \sum_j \mu_\tau^j Y_\tau^j,$$
$$K_{t+1}^j \geq \sum_{\tau \leq t} \sum_j \mu_\tau^j K_\tau^j, L_{t+1}^j \geq \sum_{\tau \leq t} \sum_j \mu_\tau^j L_\tau^j, \tag{S8}$$
$$\mu_\tau^j \geq 0\ \forall j, \tau,$$

and

$$D_{t+1}^j(K_t^j, L_t^j; Y_t^j) = \min\ \phi^j \text{ subject to } \frac{Y_t^j}{\phi^j} \leq \sum_{\tau \leq t+1} \sum_j \mu_\tau^j Y_\tau^j,$$
$$K_t^j \geq \sum_{\tau \leq t+1} \sum_j \mu_\tau^j K_\tau^j, L_t^j \geq \sum_{\tau \leq t+1} \sum_j \mu_\tau^j L_\tau^j, \tag{S9}$$
$$\mu_\tau^j \geq 0\ \forall j, \tau.$$

The individual elements of the tripartite decomposition in equation (2.6) are calculated using the following formulas:

$$\frac{\phi_{t+1}}{\phi_t} = \frac{D_{t+1}(\tilde{k}_{t+1}, \tilde{y}_{t+1})}{D_t(\tilde{k}_t, \tilde{y}_t)}, \tag{S10}$$

$$\left(\frac{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^t(\tilde{k}_{t+1})} \frac{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_t)}{\tilde{\mathbf{y}}^t(\tilde{k}_t)}\right)^{1/2} = \left(\frac{D_t(\tilde{k}_{t+1}, \tilde{y}_{t+1})}{D_{t+1}(\tilde{k}_{t+1}, \tilde{y}_{t+1})} \frac{D_t(\tilde{k}_t, \tilde{y}_t)}{D_{t+1}(\tilde{k}_t, \tilde{y}_t)}\right)^{\frac{1}{2}}, \text{ and} \tag{S11}$$

$$\left(\frac{\tilde{\mathbf{y}}^t(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^t(\tilde{k}_t)} \frac{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_t)}\right)^{1/2} = \left(\frac{D_t(\tilde{k}_t, \tilde{y}_t)}{D^t(\tilde{k}_{t+1}, \tilde{y}_{t+1})} \frac{D_{t+1}(\tilde{k}_t, \tilde{y}_t)}{D_{t+1}(\tilde{k}_{t+1}, \tilde{y}_{t+1})}\right)^{\frac{1}{2}} \left(\frac{\tilde{y}_{t+1}}{\tilde{y}_t}\right). \tag{S12}$$

Appendix 2.D: Bootstrapping

Simar and Wilson (1999) present their method for bootstrapping Malmquist indices in the context of a balanced panel and without restrictions on technological progress. However, the analysis in this paper by construction happens in an unbalanced panel setting with technological regress ruled out. The following paragraphs indicate the adjustments made to the bootstrapping procedure to account for this situation.[48] As indicated in the main text, the calculation of Malmquist indices requires the knowledge of the associated distance functions. The following paragraphs focus on the derivation of bootstrapped distance functions. Compared to the main text, some additional notation is introduced. In particular, $D^j_{t|t_x}$ is used to denote the efficiency score obtained for entity j in period t in relation to the observed technology frontier of period t_x. If $t = t_x$, $D^j_{t|t} = \phi^j_t$ is used for convenience. The number of currently observed input-output bundles in t is denoted n_t, the number of entities for which input-output bundles are observed in both t_1 and t_2 is denoted n. The number of input-output bundles in $\mathcal{T}_t$ exceed n_t if $t > 1$ and technological regress is ruled out. The pseudo sample associated with bootstrap repetition b is denoted $\mathscr{S}^b$ and comprises the pseudo production sets $\mathcal{T}^b_{t_1}$ and $\mathcal{T}^b_{t_2}$.

The original bootstrapping procedure in Simar and Wilson assumes a balanced panel with no further assumptions on technological progress. The main steps of the procedure can be summarized as follows:

- Estimate the joint density over all factual distance function estimates $\hat{\Phi}^j = (\hat{\phi}^j_{t_1}, \hat{\phi}^j_{t_2})$. This yields $\hat{\mathcal{F}}$.
- In a balanced panel $n_1 = n_2 = n$. The panel therefore consists of n pairs of observations, one pair for each entity. For each pair draw with replacement from $\hat{\mathcal{F}}$ to obtain the bootstrapped efficiency scores $\Phi^{j*} = (\phi^{j*}_{t_1}, \phi^{j*}_{t_2})$. In detail follow the steps outlined in Simar and Wilson (1999) for smoothing.
- Use the bootstrapped efficiency scores to calculate the corresponding pseudo input-output bundles. For each entity j, one pair of pseudo input-output

[48] Notice that the adjustment for dealing with unbalanced panels has already been implemented in the R-Package "FEAR" (Wilson, 2008) and is not a contribution of this paper.

bundles is created according to $(Y_t^j/\phi_t^{j*}; K_t^j, L_t^j)$ for $t = t_1, t_2$. $\mathscr{S}^b$ consists of the pseudo production sets $\mathcal{T}_{t_1}^b$ and $\mathcal{T}_{t_2}^b$.

- Use $\mathcal{T}_{t_1}^b$ and $\mathcal{T}_{t_2}^b$ to estimate the pseudo technology frontiers for the respective periods and obtain the efficiency scores for each *actual* input-output bundle with regard to the corresponding pseudo technology frontier. If the calculation of Malmquist indices requires the knowledge of counterfactual distance functions, the actual input-output bundles need to be related to the respective counterfactual pseudo frontiers in the bootstrapping procedure.
- Repeat this procedure B times and proceed as described in Section 2.3.2.3.

In an unbalanced panel $n_1 \neq n_2$ holds and Malmquist indices can only be calculated for the n entities with input-output bundles in both t_1 and t_2. However, all available observations n_1 (n_2) are used to estimate the technology frontier in t_1 (t_2). The construction of pseudo-production sets is modified along the following lines:

- When drawing the bootstrap efficiency scores, treat observations with input-output bundles in one period only as if a pair of observations existed with the input-output bundle in the other period being a missing entry. Draw Φ^{j*} for these "fake" observation pairs, too. If the actual input-output bundle of the "fake" observation pair is observed in t_1, use $\phi_{t_1}^{j*}$ of the draw to derive the associated pseudo input-output bundle, otherwise use $\phi_{t_2}^{j*}$.
- $\mathscr{S}^b$ consists of $\mathcal{T}_{t_1}^b$ and $\mathcal{T}_{t_2}^b$. In each pseudo production set one pseudo input-output bundle is recorded for each factually observed input-output bundle. Relate actual input-output bundles to pseudo technology frontiers as above.

Technological regress in the factual estimation is ruled out by including all presently and previously observed input-output bundles in $\mathcal{T}_t$ in the factual estimation. By analogy, in the bootstrapping procedure the pseudo production possibility set in t_2 should include the newly and the previously generated pseudo input-output bundles. Formally, if $\mathcal{T}_{t_1}^b$ consists of the n_1 generated pseudo input-output bundles in t_1, $\mathcal{T}_{t_2}^b$ consists of the n_2 generated pseudo input-output bundles for each actual observation in t_2 *and* the n_1 pseudo input-output bundles from $\mathcal{T}_{t_1}^b$. Entities with input-output bundles in one period only are treated as indicated above. The additional n_1 pseudo observations in $\mathcal{T}_{t_2}^b$ ensure that the pseudo technology frontier never implodes. Since the number of observations in $\mathcal{T}_{t_2}^b$ by construction equals $n_1 + n_2 > n$, Malmquist indices can only be calculated for the subset of n entities that have observations both in t_1 and t_2. In practice, the main challenge in the bootstrapping procedure is to correctly identify the observations such that

- the appropriate observations are treated as pairs of observations and if necessary "fake" observations are generated,
- the pseudo input-output bundles are derived using the sampled efficiency scores of the appropriate period,
- the correct pseudo observations are added in particular to $\mathcal{T}_{t_2}^b$, and
- the Malmquist index is calculated for the appropriate n pairs of observations.

Appendix 2.E: Breaks And Incomes

Table 2.E.2: Classification of Breaks According to Income Levels

	High Income Countries		Middle Income Countries		Low Income Countries	
Upbreaks	Australia	1961	Argentina	1990	Burkina Faso	1971
	Canada	1961	Chile	1983	Bangladesh	1996
	Spain	1984	Costa Rica	1991	Bolivia	1958
	United Kingdom	1982	Hungary	1996	China	1977
	Greece	1995	Jamaica	1980	Cameroon	1994
	Ireland	1993	Mauritius	1960	Colombia	1967
	New Zealand	1992	Poland	1991	Dominican Republic	1991
	Sweden	1993	Trinidad & Tobago	1993	Algeria	1971
			Uruguay	1985	Ecuador	1970
					Ecuador	1999
					Egypt	1975
					Guinea	1991
	Low income countries (continued):				Guatemala	1962
	Mozambique	1995	Sierra Leone	1999	Guatemala	1988
	Malaysia	1970	El Salvador	1986	Honduras	1963
	Nigeria	1999	Thailand	1958	Haiti	1972
	Pakistan	1960	Taiwan	1962	Indonesia	1968
	Panama	1959	Tanzania	1999	India	1994
	Paraguay	1973	Uganda	1988	Korea	1962
	Romania	1999	South Africa	1994	Lesotho	1992
	Senegal	1997	Zambia	1999	Morocco	1960

	High Income Countries		Middle Income Countries		Low Income Countries	
Downbreaks	Austria	1973	Brazil	1980	Burundi	1992
	Belgium	1974	Chile	1971	Benin	1982
	Switzerland	1973	Costa Rica	1979	Botswana	1991
	Denmark	1973	Hungary	1978	Cote d'Ivoire	1978
	Spain	1974	Jamaica	1972	Cameroon	1986
	Finland	1974	Jordan	1965	Congo, Republic of	1984
	France	1974	Mexico	1981	Colombia	1980
	Gabon	1976	Peru	1974	Ecuador	1978
	Germany	1960	Poland	1979	Ghana	1972
	Greece	1973	Portugal	1973	Guinea-Bissau	1997
	Hong Kong	1988	Romania	1979	Guatemala	1980
	Iran	1973	Taiwan	1994	Haiti	1980
	Israel	1973	South Africa	1980	Lesotho	1978
	Italy	1974			Nicaragua	1977
	Japan	1970			Philippines	1959
	Japan	1991			Papua New Guinea	1976
	Netherlands	1970			Paraguay	1981
	Norway	1986			Sierra Leone	1990
	Puerto Rico	1972			El Salvador	1978
	Singapore	1997			Togo	1979
	Sweden	1975			Tunisia	1972
	Trinidad & Tobago	1980			Congo, Dem. Rep.	1974
	Venezuela	1974			Zambia	1968
					Zimbabwe	1998

Appendix 2.F: Quadripartite Decomposition

As noted in footnote 14, changes in the capital intensity per worker can occur due to changes in the aggregate capital stock and due to changes in the number of workers. The impact of a change in the aggregate capital stock holding the number of workers constant can be interpreted as the (counterfactual) effect of capital deepening whereas the impact of a changing number of workers assuming a constant capital stock can be interpreted as the (counterfactual) effect of capital widening. The main decomposition can be extended to incorporate these effects. Let $\hat{k}_{t+1} = \frac{K_t}{L_{t+1}}$ denote the counterfactual capital intensity if aggregate capital at time t were divided between the number of workers at time $t+1$.[49] Then, the equivalent of equation (2.6) incorporating the effects of capital deepening and capital widening becomes

$$\frac{\tilde{y}_{t+1}(\tilde{k}_{t+1})}{\tilde{y}_t(\tilde{k}_t)} = \frac{\phi_{t+1}}{\phi_t} \frac{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^t(\tilde{k}_{t+1})} \frac{\tilde{\mathbf{y}}^t(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^t(\hat{k}_{t+1})} \frac{\tilde{\mathbf{y}}^t(\hat{k}_{t+1})}{\tilde{\mathbf{y}}^t(\tilde{k}_t)} \tag{S13}$$

The interpretation of terms one and two are identical to equation (2.6). The third term measures the effect of capital deepening keeping the number of workers constant at the level prevailing in period $t+1$. The last term reflects the effect of capital widening keeping the aggregate capital stock constant at the level prevailing in period t and focusing on the changing number of workers, only. Similar to Section 2.3.2.2, there is no compelling reason to measure the changes in capital deepening and widening with respect to the base-period world technology frontier; the current-period frontier could be used as well. The Fisher ideal decomposition is once again applied to deal with this arbitrariness. Applying $y_t = \tilde{y}_t \cdot lfp_t$ and rearranging yields the final

[49] By analogy, $\hat{k}_t = \frac{K_{t+1}}{L_t}$

decomposition

$$\frac{y_{t+1}}{y_t} = \frac{\phi_{t+1}}{\phi_t} \left(\frac{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^{t}(\tilde{k}_{t+1})} \frac{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_{t})}{\tilde{\mathbf{y}}^{t}(\tilde{k}_{t})} \right)^{1/2} \left(\frac{\tilde{\mathbf{y}}^{t}(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^{t}(\hat{k}_{t+1})} \frac{\tilde{\mathbf{y}}^{t+1}(\hat{k}_{t})}{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_{t})} \right)^{1/2} \left(\frac{\tilde{\mathbf{y}}^{t}(\hat{k}_{t+1})}{\tilde{\mathbf{y}}^{t}(\tilde{k}_{t})} \frac{\tilde{\mathbf{y}}^{t+1}(\tilde{k}_{t+1})}{\tilde{\mathbf{y}}^{t+1}(\hat{k}_{t})} \right)^{1/2} \frac{lfp_{t+1}}{lfp_t}. \tag{S14}$$

As before, all components of (S14) can be expressed solely in terms of distance functions and observed inputs and outputs. However, compared to Section 2.3.2.2, two additional linear programs per country and period have to be solved in order to obtain the efficiency scores of the counterfactual input-output observations $(\hat{k}, \hat{y})$ relative to the two world technology frontiers.[50] Results for the differences in growth are summarized in Table 2.F.3 on the following page.

The impact of capital deepening always exceeds the impact of capital widening. Regarding upbreaks, capital deepening contributes significantly more to growth after an upbreak than before in the total sample and in all country subgroups. Capital widening is either insignificant or negative. This, for instance, implies that workers join the workforce at a faster rate after the break than before if the number of workers increases both before and after the break. In low income countries, workers seem to join the workforce quite independently from the prevailing growth regime as indicated by both the positive, but insignificant contribution of the component to growth over upbreaks and the negative, but insignificant contribution to growth over downbreaks. Apart from that, capital deepening and capital widening contribute negatively and significantly to growth decelerations. Whereas the negative contribution of capital deepening over downbreaks is in line with the notion that aggregate capital is no longer accumulated at the same rate as before, the negative contribution of capital widening is not easily explained. Summing up, the growth impact of capital accumulation seen in the main text is mainly the impact of capital deepening. Over and above that, the additional insights from the extended decomposition are limited.

[50] $\hat{y}_t$ and $\hat{y}_{t+1}$ are defined analogously to $\hat{k}_t$ and $\hat{k}_{t+1}$.

Table 2.F.3: Bias Corrected Contributions to Growth and Confidence Intervals: Differences

Upbreaks	Total Sample	High Income Countries	Middle Income Countries	Low Income Countries
Income per Capita	5.347	3.801	6.131	5.490
Efficiency Change	4.316	0.702	4.940	4.946
	[4.081, 4.589]	[0.174, 1.232]	[4.738, 5.167]	[4.613, 5.321]
Technological Change	–0.196	1.803	0.181	0.719
	[–0.445, 0.064]	[1.311, 2.368]	[–0.048, 0.378]	[–1.079,–0.356]
Capital Deepening	0.810	0.423	0.330	1.011
	[0.655, 0.951]	[0.126, 0.665]	[0.234, 0.442]	[0.785, 1.199]
Capital Widening	–0.064	–0.292	–0.175	0.013
	[–0.204, 0.052]	[–0.554,–0.031]	[–0.289,–0.073]	[–0.180, 0.186]
Labor Force Participation	0.401	1.115	0.788	0.153
Observations	54	8	9	

Downbreaks	Total Sample	High Income Countries	Middle Income Countries	Low Income Countries
Income per Capita	7.152	–5.208	–6.560	–9.337
Efficiency Change	–5.007	–3.239	–4.700	–6.867
	[–5.217,–4.800]	[–3.639,–2.808]	[–5.066,–4.367]	[–7.216,–6.542]
Technological Change	–0.465	–0.581	–0.686	–0.234
	[–0.656,–0.240]	[–0.997,–0.181]	[–0.969,–0.374]	[–0.497, 0.002]
Capital Deepening	–1.526	–0.811	–1.209	–2.383
	[–1.642,–1.407]	[–1.069,–0.559]	[–1.359,–1.053]	[–2.526,–2.244]
Capital Widening	–0.150	–0.258	–0.300	–0.035
	[–0.254,–0.045]	[–0.469,–0.060]	[–0.465,–0.118]	[–0.129, 0.205]
Labor Force Participation	0.074	–0.186	0.418	0.137
Observations	60	23	13	24

Notes: Upbreaks and downbreaks are derived using the udmaxL procedure as described in the text. Nonparametric growth accounting is carried out in the five-year period before and after the break. Bias corrections and confidence intervals are based on 250 bootstrap replications. The estimates are estimated average annual growth rates for the respective quantities.

Chapter 3

Growth Miracles and Failures in a Markov Switching Classification Model of Growth

Abstract: In this paper economic growth is interpreted as a sequence of transitions between distinct growth regimes that countries visit with different frequencies. Countries featuring similar growth dynamics are endogenously grouped into three different clusters. The first cluster comprises successful countries that are characterized by lengthy periods of high or very high growth. Moderately successful countries in the second cluster experience both periods of reasonable growth and periods of stagnation, whereas failing countries in the third cluster suffer from highly volatile growth rates with frequent episodes of crisis. Successful countries are characterized by better initial conditions, policies and institutions compared to the other countries. Neither initial conditions nor institutions distinguish moderately successful from failing countries; what makes them different is policy in the form of investments into infrastructure and human capital, trade liberalization and limited policy volatility.

Keywords: Economic Growth, Regime Switching, Latent Class Models

JEL Classification: O11, O40

3.1 Introduction

Most countries do not grow at a steady rate, but rather experience substantial variations in growth over time. In order to gain a more thorough understanding of economic growth, it is necessary to shift the focus away from explaining differences in the cross-country average growth rates to explaining the growth dynamics within countries, i.e. transitions from phases of low growth to phases of high growth and vice versa (Hausmann et al., 2005; Jones and Olken, 2008; Pritchett, 2000, 2003). This paper extends the regime switching growth framework proposed by Pritchett (2003) and Jerzmanowski (2006) with a clustering mechanism that enriches the analysis of the forces driving the growth dynamics within countries.

In the regime switching model of growth, a country's observed growth process is the result of transitions between different growth regimes, which are states of nature characterized by a specific growth behavior and which are common to all countries. Regime switching is country-specific and occurs for different reasons, like policies or external shocks. The long-run growth rate of a country and its pattern crucially depend on the time spent in each growth regime. This behavior can be captured by country-specific transition probabilities that determine how frequent and how lasting a switch to a certain regime is. Transition probabilities may depend on medium- or long-term conditions ("growth fundamentals") whereas short-term events may manifest themselves in switches of the growth regimes. Whether the relevant medium- or long-term conditions are, say, institutions, geography or human capital, is still an open question. Therefore, instead of conditioning the transition probabilities on a preselected growth fundamental, the regime switching framework proposed in this paper is supported by a clustering framework, whereby those countries whose growth patterns can be described by similar transition probabilities are grouped together. An analysis of the resulting country clusters offers insights into the determinants of the observed distinct growth dynamics.

I estimate a Markov switching classification model using the growth rate of GDP per capita for 84 countries over the period 1962 – 2003. Four distinct growth regimes are identified: a steady growth regime, which is characterized by stable growth around two percent, a miracle growth regime, which is characterized by sustained high growth rates, a stagnation regime, which is volatile and on average features zero to slightly negative growth rates and a crisis regime that captures highly volatile growth behavior ranging from double-digit negative to double-digit positive growth rates. The countries are endogenously divided into three clusters: the first cluster comprises successful countries that are characterized by long periods of stable or miracle growth. The second cluster consists of moderately successful countries that alternate between periods of stagnation and steady growth. Countries in the third cluster spend most of the time either in stagnation or in crisis and are referred to as growth failures. The country clusters differ in several respects. In addition to being open and well-educated, a distinctive feature of successful countries is the prevalence of trust-inspiring institutions. Neither moderately successful nor failing countries are characterized by a similar quality of institutions. However, compared to countries in the third cluster, moderately successful countries benefit not only from more favorable geographic conditions, but also from better policies that have resulted in a more educated workforce, more infrastructure investments, more trade liberalization and more macroeconomic stability. This is true even though institutions are of comparable quality in both country groups. Hence, even though good institutions are important, a lack of them does not necessarily translate into dismal growth behavior.

This paper is related to previous applications of clustering techniques and Markov switching models in the economic growth literature. The idea of modeling the growth process as a Markov-switching model has been proposed by Pritchett (2003). Jerzmanowski (2006) implements the idea empirically by estimating a Markov switching model with four growth regimes and country-specific transition probabilities that depend on an indicator of the quality of institutions. The clustering of countries in the empirical growth literature has been suggested as a means to tackle the issue of parameter heterogeneity. In a seminal contribution, Durlauf and Johnson (1995) point out that the marginal impacts of growth correlates need not be homogeneous across countries and show that the hypothesis of homogeneity is rejected when taken to the data. In order to identify homogeneous country clusters, they employ a regression-tree analysis, which groups countries according to endogenously determined thresholds with regard to predetermined variables. More recently, threshold regressions have been applied. The intuition of the clustering is the same, but contrary to the regression tree analysis the asymptotic distribution of the estimates is known (Hansen, 2000; Papageorgiou, 2002). The major drawback of both methods is the need to explicitly name and determine the threshold variables beforehand, a decision that to some extent predetermines the clusters. A more data-based approach is the application of mixture analysis. In this modeling framework, cluster membership is interpreted as a latent variable that is estimated at the same time as the rest of the parameters. The models may or may not condition the latent membership variable on a set of exogenous variables. Examples of the latter approach are Alfo et al. (2008), Baştürk et al. (2012), Bloom et al. (2003), Owen et al. (2009) and Paap et al. (2005) who use the "classical" estimation approach, or Ardiç (2006) who applies Bayesian estimation. A related latent class model has been estimated by Bos et al. (2010). Other clustering methods such as projection pursuit (Desdoigts, 1999; Kourtellos, 2002), correlation clustering (Lavezzi and Matteo, 2010) or the predictive density approach (Canova, 2004) have been proposed, but they have not yet been widely used.

The contribution of this paper to the literature is threefold. First, it applies the Markov switching classification method, which has predominantly been used for automatic speech recognition before, to an economic problem. Unlike other clustering approaches the suggested method is aimed at deriving similarities in the patterns of growth rates instead of similarities related to marginal effects. Second, compared to the empirical study by Jerzmanowski (2006), the approach in this paper avoids the a priori determination of a conditioning variable for the transition probabilities. Therefore, the estimated Markov model avoids any issues that might arise in Jerzmanowski's (2006) work as a consequence of the transition probabilities depending on a potentially endogenous measure for the quality of institutions (Glaeser et al., 2004). Third, previous approaches emphasizing the instability of growth rates have concentrated on determining the factors that start or sustain episodes of high or low growth (Aizenman and Spiegel, 2010; Berg et al., 2012; Hausmann et al., 2005, 2006; Jones and Olken, 2008; Jong-A-Pin and de Haan, 2011). Yet, for instance Hausmann et al. (2005) and Rodrik (2005) remark that initiating a growth episode might well require different measures than sustaining it. The present study separates shocks that initiate growth episodes from structural variables that determine the general conduciveness to growth. It therefore by construction handles both problems simultaneously. The results offer important hints at control variables that should be included when studying growth accelerations.

The remainder of the paper is organized as follows. Section 2 presents the Markov switching classification approach. Section 3 describes the data. Section 4 discusses the resulting regimes and clusters before section 5 presents differences of growth fundamentals across clusters. Section 6 concludes.

3.2 Methodology

3.2.1 The Model

Following Jerzmanowski (2006), economic growth is interpreted as a result of countries switching between distinct growth regimes. Within each regime economic growth evolves according to an AR(1) process that exhibits regime-specific coefficients and error terms. Using y_{tk} to denote the growth rate of country k in period t, s_t to denote the regime or state that is in effect in period t, and $\varepsilon_{kt}^{s_t}$ to denote the country- and state-specific error term in period t, the growth process within each regime is given by

$$y_{tk} = \alpha_{s_t} + \beta_{s_t} y_{t-1k} + \varepsilon_{tk}^{s_t}, \tag{3.1}$$

$$\varepsilon_{tk}^{s_t} \sim \text{i.i.d. } N(0, \sigma_{s_t}^2). \tag{3.2}$$

A country does not remain in a single state indefinitely, but switches from one regime to another from time to time. These transitions between growth regimes are governed by transition probabilities that follow a first-order Markov chain. The probability of switching from regime i to regime j is given by

$$p_{ij} = P(s_t = j | s_{t-1} = i, s_{t-2} = i_2, ...) = P(s_t = j | s_{t-1} = i). \tag{3.3}$$

Jerzmanowski (2006) assumes that each country is characterized by a unique set of transition probabilities that depends on the country's quality of institutions. Under this conjecture economic growth is the result of countries' switching between the four growth regimes steady growth, stagnation, crisis and miracle growth. This approach has two drawbacks. First, conditioning the transition probabilities on some exogenous variable results in a highly non-linear problem that essentially prevents the use of more than one conditioning variable due to the associated computational burden. Yet, it seems quite likely that the transition probabilities are the result of complex interactions. Second, the measure for the quality of institutions is only available for the *end* of the sample period, which potentially raises an endogeneity problem because institutions may change as a consequence of economic growth (Glaeser et al., 2004). The high non-linearity of the problem makes it infeasible to implement procedures in order to test the endogeneity of the variable. Yet, if the quality of institutions were endogenous, the estimates of the Markov switching model would be inconsistent (Kim, 2004a,b; Kim et al., 2008).

The following classification or clustering approach offers a way around the non-linearity problem while at the same time avoiding the endogeneity problem. Instead of assuming country-specific transition probabilities, countries are grouped into m clusters C_m, which differ from each other in their transition probabilities. Formally, the transition probabilities conditional on belonging to cluster C_m are defined as

$$p_{ij}(C_m) \equiv P_{C_m}(s_t = j | s_{t-1} = i). \tag{3.4}$$

Cluster membership is endogenously determined in the estimation process. The resulting clusters are used in the second stage to identify differences in the underlying growth fundamentals.

3.2.2 Parameter Estimation

The model is estimated using the EM algorithm (Dempster et al., 1977) augmented by a classification step. In order to derive the steps of the estimation algorithm, it is useful to consider the complete-data log-likelihood function first. The complete-data log-likelihood function assumes that all variables including the latent state and cluster variables are known. In the following the complete time series of country k consisting of the dependent variable $(y_{1k}, ..., y_{Tk})$, the predetermined variable $(y_{0k}, ..., y_{Tk-1})$ and the history of regimes $(s_{1k}, ..., s_{Tk})$ are summarized in $\mathcal{O}^k$, and the estimated parameters for the Markov switching model of cluster C_m are collected in θ_m. The well-known complete-data log-likelihood referring to country k in cluster C_m is denoted by $\ell_k(\mathcal{O}^k|\theta_m)$ (Diebold et al., 1994). In order to extend the complete-data log-likelihood function to the clustering context, an indicator variable $\mathcal{C}_m(\mathcal{O}^k)$ is introduced that takes the value one if $\mathcal{O}^k$ belongs to cluster C_m and zero otherwise. Then the complete-data log-likelihood function is given by

$$\mathcal{L} = \sum_{k=1}^{K} \sum_{m=1}^{M} \mathcal{C}_m(\mathcal{O}^k) \ell_k(\mathcal{O}^k|\theta_m). \tag{3.5}$$

The parameters in θ_m are restricted such that the coefficients α_{s_t} and β_{s_t}, and the variances $\sigma^2_{s_t}$ are the same across clusters, whereas the transition probabilities $p_{ij}(C_m)$ differ.

Standard Markov switching models are usually estimated using the EM algorithm that maximizes the expected instead of the complete-data log-likelihood function to reduce the nonlinearity in the estimation. The basic idea of this algorithm is to first replace the unknown states s_t with the corresponding smoothed probabilities as the best possible guess given the available information (expectation step), and to estimate the model parameters conditional on this best guess (maximization step). The smoothed probabilities depend on the estimated parameters and vice versa. Therefore, given an initial guess for the parameters, the estimation and maximization steps are iterated until the estimated parameters converge. The limit of the iterations corresponds to the maximum likelihood estimator (Diebold et al., 1994; Hamilton, 1994, chap. 22).

In order to estimate the suggested clustering model, the standard EM algorithm is augmented by a classification step (Alon et al., 2003; Knab, 2000). First, the smoothed state probabilities for each observation in each cluster are calculated using the current estimate of the model parameters and current classification of time series, and the corresponding log-likelihood values for each time series in each cluster are derived (expectation step). Next, each time series is allocated towards the cluster which exhibits the highest log-likelihood value (classification step). Finally, the model parameters are reestimated conditional on the smoothed state probabilities and the cluster classification (maximization step). These steps are iterated until convergence is achieved, which means that countries no longer switch clusters and that a convergence criterion for the estimated parameters is met. Standard errors are derived from the inverse of the associated information matrix.

Three important issues arise from this procedure: how to start and end the algorithm, how to decide on the number of regimes and clusters, and whether the assignment to clusters is reliable. All variants of the EM algorithm are known to be sensitive with regard to the starting values, because these determine both its speed of convergence and its ability to locate the global maximum of the problem (Biernacki et al., 2003; Karlis and Xekalaki, 2003; McLachlan and Krishnan, 1997, chap. 4). Therefore, the algorithm is started from 1000 random parameter values and cluster allocations, and the expected log-likelihood values after 25 iterations are calculated (Biernacki et al., 2003; Karlis and Xekalaki, 2003). Then, those 10% of the starting values that have yielded the highest expected log-likelihood are chosen and iterated until convergence. Convergence is achieved if the relative change in the expected log-likelihood function does not exceed 10^{-5}.

Both Pritchett (2003) and Jerzmanowski (2006) suggest that the appropriate number of regimes equals four if states are characterized by growth rates only. This paper, too, assumes four regimes. There is no theoretical guidance regarding the appropriate number of clusters so that this decision is based on three different information criteria.[1] Li and Biswas (2000) suggest a Bayesian information criterion (LB-BIC) that penalizes the number of estimated parameters with the logarithm of the included cross-sections. Alon et al. (2003) argue that the above penalty term should apply to both the number of estimated parameters and the number of clusters (A-BIC). Finally, in the context of latent class models the consistent Akaike information criterion (CAIC) is known to perform well (Baştürk et al., 2012; Jedidi et al., 1997).

Table 3.1: Share of Time-Series Correctly Classified in Simulations

	M = 2	M = 3	M = 4
T = 41	0.9528	0.8647	0.8122
T = 50	0.9694	0.8933	0.8540
T = 100	0.9968	0.9798	0.9583

Notes: This table reports the share of 30 simulated time-series that are correctly classified if parameters very similar to the estimation results are used for simulation. The algorithm was computed from ten different starting values for each group of simulated time-series and the best estimation results have been selected in order to generate the table.

A final question concerns the reliability of the assignment to clusters. The present paper uses a hard clustering approach, i. e. each time-series is deterministically assigned to one cluster only. Hence, by construction statistical inference on the assignment to clusters is not possible.[2] However, due to the availability of panel data the assignment is consistent for long enough time series, and thus so are the parameter estimates. The question remains whether the number of observations for each country is sufficient to achieve reasonable accuracy. Table 3.1 reports the average accuracy of assignment when the suggested method is applied to 30 simulated time-

[1] Formal tests are difficult to implement because model selection involves inference for an overfitted model. Cf. Hansen (1992) or Garcia (1998).

[2] Soft clustering as in finite mixture models is conceivable for Markov switching models, too, but computationally very demanding (Alon et al., 2003; Butler, 2003; Cadez et al., 2003; Wichern, 2001). A further difficulty arises in the present context because clusters differ only with respect to the transition probabilities. Therefore, the differences in the expected log-likelihood functions are small by construction and lead to too similar smoothed probabilities across clusters for a soft clustering mechanism to be well defined.

series of different length. Parameters resemble those obtained in the actual solution.[3] The classification becomes more accurate the larger the number of observations per time series and less accurate the larger the number of clusters. The first observation follows from the consistency of the assignment for large T, the second from the fact that the transition matrices tend to be more dissimilar the smaller the number of clusters. The number of observations per country in this paper equals 41 and is therefore sufficient to obtain informative results. Unlike the number of clusters, the number of growth regimes is not a serious restriction for the accuracy of the method: since all countries visit the same four growth regimes, there are enough observations to identify them.

3.3 Data

GDP per capita is taken from the Penn World Table (PWT), Version 6.2 (Heston et al., 2006b). The data set consists of 84 countries (27 African, 19 Asian, 15 European, 11 North-American, 10 South-American, Australia and New Zealand) that have uninterrupted GDP per capita entries for the years 1961 – 2003. In order to be included in the estimation, countries were required to have a population exceeding one million for at least half of the sample period. Moreover, newly added countries to PWT 6.2 were disregarded because they suffer from implausibly high income estimates in the past. The growth rate of GDP per capita is constructed by taking the first difference of the log levels. Accounting for the AR(1) component leaves time-series of length $T = 41$.[4]

Cluster membership is explained by several variables. Investment and population growth rates are taken from PWT 6.2. Education is measured as the average years of schooling in the non-studying population aged 15 – 64 (Cohen and Soto, 2001) and as the percentage of the population that has at least completed primary school (Barro and Lee, 1993, 2001). The coverage of both data sets is extended by applying regression techniques and the additional dataset provided by Lutz et al. (2007). Geographic variables are taken from Gallup et al. (1998), an indicator of

[3]Only ten different starting values were used for the simulation, so that the reported percentages should be interpreted as lower bounds for the success of the suggested method.

[4]Johnson et al. (2012) remark that growth studies using annual PWT data tend to be unreliable across PWT revisions. Given that the results of this paper closely resemble those by Jerzmanowski (2006), who uses a different version of PWT, this does not appear to be a major problem. A more thorough evaluation is left for future research.

Table 3.2: Information Criteria for Different Numbers of Clusters

	M = 1	M = 2	M = 3	M = 4
LB-BIC	5.6370	5.5777	5.5690	5.5710
A-BIC	5.6382	5.5803	5.5729	5.5761
CAIC	5.6383	5.5804	5.5730	5.5763

Notes: The table presents values of different information criteria for Markov switching models with 4 states and M clusters. For simplification, the information criteria are divided by the number of observations. Each information criterion prefers the model with the smallest value.

openness from Sachs et al. (1995) and Wacziarg and Welch (2008). The quality of institutions is measured by the government antidiversion index (Hall and Jones, 1999), the voice and accountability indicator (Kaufmann et al., 2008), an indicator for judicial independence (La Porta et al., 2004) and the business environmental risk indicator (Knack and Keefer, 1995). Infrastructure investments are taken from Canning (1998), and an indicator of the stability of macroeconomic policy from Sirimaneetham and Temple (2009). Data on saving rates, dependency ratios, credit to GDP ratios and inflation is taken from the World Development Indicators (WDI) 2007 and data on health expenditure is taken from WDI 2011.

3.4 Results

3.4.1 Parameter Estimates

The model is estimated using a multitude of starting values and varying the number of clusters between one and four. The corresponding information criteria are calculated. For each solution an informal Jarque-Bera test statistic based on the regime-conditional error distribution is obtained for every cluster and for the model as a whole (Campbell, 2002). Table 3.2 reports the information criteria for the results that simultaneously maximize the expected log-likelihood function and satisfy the normality assumption on the five percent significance level within each cluster and for the model as a whole. The information criteria are formulated such that the model showing the smallest value should be chosen. All information criteria consistently reject a model without clustering in favor of a model containing three clusters.

Table 3.3 presents the regime-specific parameter estimates of the autoregressive processes for each state. The first column contains the constants, the second the

Table 3.3: Parameter Estimates (Four Growth Regimes, Three Clusters)

	Constant	AR Coefficient	Standard Deviation	Steady State Growth Rate
Crisis	−0.43	−0.5683*	13.89	−0.27
Stagnation	−0.04	0.0722*	4.70	−0.04
Steady Growth	1.17*	0.3787*	1.94	1.89
Miracle Growth	4.92*	0.2494*	2.52	6.56

Notes: Except for the AR coefficients all numbers are percentages. Stars denote significance at the 5 % level.

autoregressive coefficients and the third the associated standard deviations of the error terms. Column four lists the implied steady state growth rates of each regime. The results resemble those obtained by Jerzmanowski (2006). The first state displays a negative constant, a negative autoregressive coefficient and a negative steady state growth rate. The most striking feature is the implied instability of growth as indicated by the combination of a huge standard deviation and the negative autocorrelation. Therefore, despite the negative steady state growth rate, this regime not only captures extremely negative growth episodes such as the halving of GDP in Rwanda from 1993 to 1994, but also extremely positive ones such as the 20 % growth rate in Zimbabwe in 1968. The state essentially accounts for one-time extreme events and, following Jerzmanowski (2006), is labeled the ”crisis regime”. The second state features a constant close to zero, slightly positive autocorrelation and a considerable standard deviation. It implies a steady state growth rate close to zero and is called the stagnation state. This regime dominates the growth experience of countries which do not grow on average. It is well suited to account for alternating booms and busts that are not persistent. For instance, Argentina spent most of the time in this regime. The third regime is characterized by persistent (0.38) and modestly positive growth rates. It has the smallest standard deviation across all regimes (1.94%) and implies a steady state growth rate of 1.89%. Industrialized countries have spent most of the time in this steady growth regime. Finally, the miracle growth regime is characterized by a large positive constant, positive autocorrelation and a modest standard deviation, and therefore implies long-lasting fast growth spells. The implied steady state growth rate equals 6.56%. This state is most often visited by the well-known growth miracle countries such as Korea, Taiwan, Singapore or China. However, other countries, too, have spent non-negligible amounts of time in this regime when they caught up with leading economies. Examples are Japan, Greece, Portugal, Ireland or Spain.

Table 3.4: Transition Probability Estimates and Country Classification

Successful Growth Cluster

	Crisis	Stag-nation	Steady	Miracle
Crisis	0.0000	0.0000	0.0023	0.0000
Stagnation	0.0010	0.4416	0.0094	0.1491
Steady	0.0000	0.1800	0.9862	0.0000
Miracle	0.9990	0.3784	0.0020	0.8509
Ergodic Distribution	0.0018	0.0587	0.7682	0.1713

Moderately Successful Growth Cluster

	Crisis	Stag-nation	Steady	Miracle
Crisis	0.0000	0.0208	0.0206	0.0000
Stagnation	0.6146	0.6822	0.0713	0.4506
Steady	0.0000	0.0009	0.8101	0.5226
Miracle	0.3854	0.2961	0.0980	0.0268
Ergodic Distribution	0.0169	0.3667	0.4525	0.1638

Growth Failures

	Crisis	Stag-nation	Steady	Miracle
Crisis	0.3331	0.1923	0.0000	0.1298
Stagnation	0.5199	0.7382	0.1900	0.3329
Steady	0.0000	0.0521	0.8099	0.1178
Miracle	0.1470	0.0174	0.0001	0.4194
Ergodic Distribution	0.1759	0.5685	0.1939	0.0616

Successful Growth Cluster

Africa: South Africa

Asia: China, Hong Kong, Japan, South Korea, Malaysia, Singapore, Taiwan, Thailand

Europe: Austria, Belgium, France, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom

North America: Canada, Guatemala, El Salvador, United States

South America: Brazil, Colombia, Paraguay

Oceania: Australia, New Zealand

Moderately Successful Growth Cluster

Africa: Burkina Faso, Egypt, Guinea, Kenya, Morocco, Tunisia

Asia: India, Indonesia, Israel, Nepal, Pakistan, Philippines, Sri Lanka, Turkey

Europe: Denmark, Finland

North America: Costa Rica, Dominican Rep., Honduras, Jamaica, Mexico, Panama

South America: Bolivia, Chile, Uruguay

Growth Failures

Africa: Algeria, Benin, Burundi, Cameroon, Chad, Cote d'Ivoire, Ethiopia, Ghana, Madagascar, Malawi, Mali, Mozambique, Niger, Nigeria, Rwanda, Senegal, Tanzania, Togo, Uganda, Zambia, Zimbabwe

Asia: Iran, Syria

North America: Nicaragua

South America: Argentina, Ecuador, Peru, Venezuela

In each transition matrix the entry in row j, column i should be interpreted as $p_{ij} = P(s_t = j|s_{t-1} = i)$.

Table 3.4 presents the cluster-specific transition probability matrices with the associated countries. The transition matrices show the probability of moving from the column regime to the row regime. The implied ergodic distribution is given in the last row of the respective matrices.

Countries in the leftmost cluster spend 77 % of the time in the steady and 17 % in the miracle growth state in the long run. Both states are very persistent. The countries in this cluster seldom find themselves stagnating and if they do, they return to steady or miracle growth in the next year with a probability exceeding 0.5. A large shock that catapults a country into crisis is almost certainly followed by miracle growth so that countries make up the associated income loss very quickly.[5] Not surprisingly, almost all of today's industrialized countries are assigned to this cluster. Somewhat more unexpectedly, the newly developed countries belong to this cluster, too, despite the considerably higher average growth rates they have experienced in the period under consideration. In fact, the persistence of the miracle growth state can be traced back to their presence in the cluster.[6] The cluster also contains developing countries that have either experienced prolonged episodes of miracle growth such as Brazil or that have grown steadily like Columbia or Paraguay. This feature is a consequence of defining the growth regimes without consideration of countries' income levels.

In the long run, countries in the second cluster spend considerable time both in the steady growth regime (45 %) and in stagnation (37 %). Although the long-run frequency of miracle growth is similar to that of the previous cluster (16 %), the implied dynamics are very different. In this cluster, miracle growth is a one-off event that is quickly followed either by steady growth or by stagnation. Thus, while countries in cluster one manage to generate extended periods of catch-up growth with the associated extension of production capacities, the experience of countries in cluster two resembles more that of an unsustained growth acceleration (Hausmann et al., 2005). Miracle growth usually happens after a crisis or after stagnation and hence reflects the renewed utilization of existing production capacities rather than an extension thereof. In contrast to cluster one, stagnation is quite persistent with

[5]Strictly speaking, this is only true if countries are in the steady growth state beforehand.

[6]Indeed, if the model is estimated assuming four clusters, the separation of industrialized and newly developed countries is the main difference to the present assignment. With regard to the transition probabilities, industrialized countries do not experience persistent miracle growth whereas newly developed countries do.

a probability of remaining in this state close to 0.7. Moreover, the growth process is characterized by more frequent regime changes and higher volatility. The majority of countries assigned to this cluster are middle income developing countries that have neither experienced prolonged episodes of miracle growth nor dismal stagnation. A short remark on Denmark and Finland is in order: Common sense suggests that these countries should belong to the successful growth cluster. However, given that income levels play no role in the classification process it is easy to see why the classification mechanism says otherwise. Denmark's growth rates lack positive autocorrelation and Finland has suffered a prolonged deep recession at the beginning of the nineties. Neither feature is likely to be generated by the first transition matrix.

The transition probability matrix of the final cluster implies prolonged periods of stagnation combined with a very uneven growth process. In the long run, countries in this cluster spend approximately 75 % of the time either in stagnation or in crisis while steady growth occurs only in 19 % of the time and rapid growth is an occasional event (6 %). Compared to the other two clusters, the persistency of the crisis regime is remarkable (0.33). Furthermore, the probability to enter stagnation is very high regardless of the current growth regime. In fact, stagnation is the regime that follows with the highest probability if a regime change occurs regardless of the previous state. The income gap relative to developed countries widens in the long run, so that the countries associated with this cluster are in a sense "growth failures". The majority (75 %) of the African countries in the sample and countries known for their erratic growth patterns and economic policies such as Argentina or Venezuela belong to this cluster.

3.4.2 Illustrating Regimes and Clusters

Similar average growth rates can be achieved via very different growth processes and the processes themselves are of interest due to their welfare consequences (Loayza et al., 2007; Pritchett, 2000). Table 3.5 reports the average smoothed regime probabilities for selected countries. Strictly speaking, they indicate the probability that a country has been in a certain regime in an average year. These probabilities can more concretely be interpreted as the amount of time a country has spent in each regime during the estimation period.[7] While extremely poor performers (e.g. Chad, Senegal and Togo) spend a lot of time in crisis and miracle performers (e.g. China and South

[7] Jerzmanowski (2006) uses the same interpretation in his section 5.1.

Table 3.5: Average Regime Probabilities

Country	Cluster	Crisis	Stagnation	Steady Growth	Miracle Growth	Average Growth Rate
Chad	Failing	0.25	0.70	0.02	0.03	-0.68
Senegal	Failing	0.15	0.72	0.09	0.05	-0.48
Togo	Failing	0.15	0.70	0.07	0.08	-0.40
Burkina Faso	Mod. Successful	0.01	0.65	0.15	0.19	1.24
El Salvador	Successful	0.00	0.07	0.92	0.00	1.18
Malawi	Failing	0.15	0.48	0.31	0.06	1.29
Finland	Mod. Successful	0.01	0.28	0.54	0.17	2.66
France	Successful	0.00	0.00	0.99	0.00	2.69
Ghana	Failing	0.36	0.53	0.09	0.03	2.74
Israel	Mod. Successful	0.03	0.39	0.41	0.17	2.62
Italy	Successful	0.00	0.08	0.78	0.13	2.75
Greece	Successful	0.00	0.08	0.61	0.30	3.11
Norway	Successful	0.00	0.00	1.00	0.00	3.11
Japan	Successful	0.00	0.05	0.70	0.26	3.97
Portugal	Successful	0.00	0.12	0.57	0.31	3.79
Sri Lanka	Mod. Successful	0.01	0.26	0.52	0.21	3.83
Malaysia	Successful	0.02	0.16	0.23	0.58	4.77
Singapore	Successful	0.00	0.23	0.02	0.75	4.72
China	Successful	0.00	0.16	0.00	0.84	6.69
South Korea	Successful	0.00	0.13	0.03	0.84	6.35

Notes: This table reports the average smoothed state probabilities. Formally, each column equals $(1/T)\sum_{t=1}^{T} P(s_t = j|\psi_T)$, where $P(\cdot)$ is the estimated probability of country k being in state j given the information of the entire sample and conditional on its cluster assignment (ψ_T).

Table 3.6: Counterfactual Average Regime Probabilities

Country	Cluster	Crisis	Stagnation	Steady Growth	Miracle Growth
China	**Successful**	0.00	0.16	0.00	0.84
	Moderately Successful	0.02	0.43	0.24	0.30
	Failing	0.12	0.30	0.03	0.55
France	**Successful**	0.00	0.00	0.99	0.00
	Moderately Successful	0.00	0.04	0.89	0.07
	Failing	0.00	0.05	0.94	0.01
Ghana	Successful	0.08	0.66	0.15	0.12
	Moderately Successful	0.19	0.59	0.11	0.11
	Failing	0.36	0.53	0.09	0.03
Malawi	Successful	0.01	0.37	0.47	0.16
	Moderately Successful	0.05	0.48	0.34	0.13
	Failing	0.15	0.48	0.31	0.06
Malaysia	**Successful**	0.02	0.16	0.23	0.58
	Moderately Successful	0.03	0.23	0.56	0.19
	Failing	0.07	0.33	0.42	0.18
Norway	**Successful**	0.00	0.00	1.00	0.00
	Moderately Successful	0.00	0.04	0.89	0.08
	Failing	0.00	0.04	0.95	0.01
Sri Lanka	Successful	0.00	0.24	0.26	0.50
	Moderately Successful	0.01	0.26	0.52	0.21
	Failing	0.07	0.42	0.42	0.09

Notes: This table reports both the actual and the counterfactual average smoothed regime probabilities for selected countries. The actual cluster classification is indicated in bold.

Korea) in the miracle growth regime, the process to achieve growth rates in between is much more varied. Consider the group of countries with yearly average growth around 2.65 %. France and to a lesser extent Italy have achieved this growth rate by growing smoothly as is reflected in the high average regime probability of remaining in the steady growth state. Contrary to that, Finland's and Israel's growth process has been much more volatile: they have been in stagnation for one third of the time, but they have compensated the associated lower growth rates by episodes of rapid growth. Ghana has achieved the same growth rate by jumping erratically between very high and very low growth rates. The last example emphasizes that the crisis regime not only captures meltdowns, but also unsustainable extreme expansions. Similar differences in the growth patterns can be observed for both lower and higher average growth rates as long as they are not too extreme. It is worth emphasizing that the dynamics of growth for a given growth rate may differ both within the same cluster (e.g. Greece versus Norway or Singapore versus Malaysia) and across clusters.

To assess the impact of cluster assignment, Table 3.6 documents the average smoothed regime probabilities both under the actual and the two counterfactual classifications. The impact of the assignment depends on the stability of the growth rate series. France and Norway are characterized by very stable growth processes and accordingly spend most of the time in the steady growth regime. This feature lasts even if the smoothed probabilities are calculated using the parameter estimates of the moderately successful and failing cluster, because the steady growth regime is persistent across all clusters. If countries experience more volatile or extreme growth, the classification becomes more important. Consider for instance China and Malaysia, two miracle growth countries. If these countries are assigned to the successful cluster, most growth episodes are explained as miracle growth. If, however, they are assigned to the other two clusters, the number of periods depicted as miracle growth is diminished considerably because the associated transition matrices display much less persistence of the miracle growth state. Failing countries with highly erratic growth behavior (e. g. Ghana or Malawi) usually spend a large fraction of their time in crisis. If these countries are counterfactually assigned to the other two clusters, a large fraction of the time in crisis is reinterpreted as a combination of stagnation and miracle growth for the simple reason that the respective transition matrices make no allowance for persistent crisis. Hence, the assignment to the clusters influences the interpretation of the growth process and becomes more relevant the more distinctive the growth process under consideration.

3.4.3 Regime Changes

Unlike the classification results, regime changes are often related to specific economic or political events such as external shocks or changes of leadership. Fig. 1 plots the smoothed regime probabilities for Japan as an example for successful countries. Before 1973, Japan developed rapidly, but following the oil crisis of 1973 changes in monetary and structural policies occurred that reduced growth (Komiya and Yasui, 1984). According to the model, Japan experienced a permanent regime change from the miracle growth regime before 1973 to the steady growth regime afterwards. Japan also illustrates one limitation of the present model. Since countries are not allowed to change clusters over time, the model is not sensitive enough to pick up the prolonged recession following the Japanese banking crisis in the 1990s.[8]

In Mexico, a moderately successful country, the most common regime was steady growth except for two periods starting in 1982 and 1994, where the probability of

[8]Therefore, the introduction of time-varying transition probabilities should be attempted in future research.

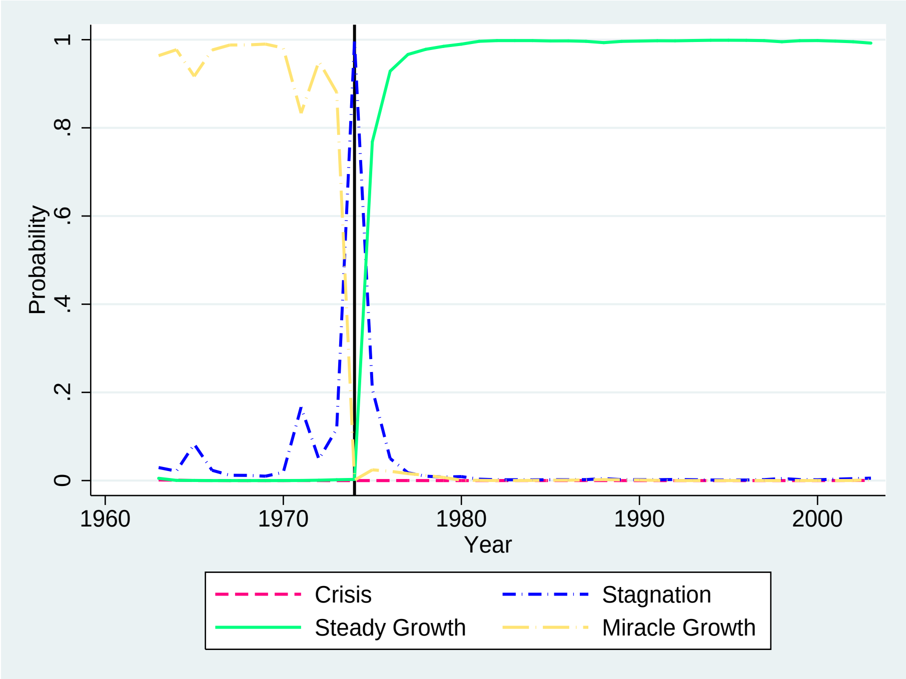


Figure 3.1: Average Regime Probabilities: Japan

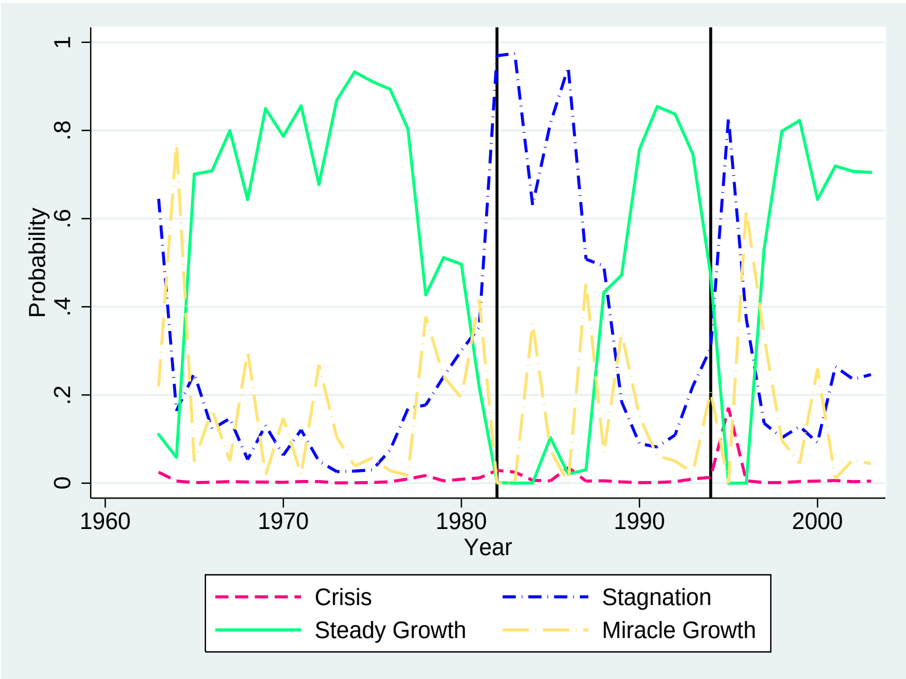


Figure 3.2: Average Regime Probabilities: Mexico

stagnation increased sharply (Fig. 3.2). The first spike picks up Mexico's debt-default in 1982 that initiated the Latin American debt crisis, while the second spike picks up the break-up of the fixed currency exchange rate system and the associated sharp devaluation of the peso in the Mexican currency crisis of 1994. Algeria as an

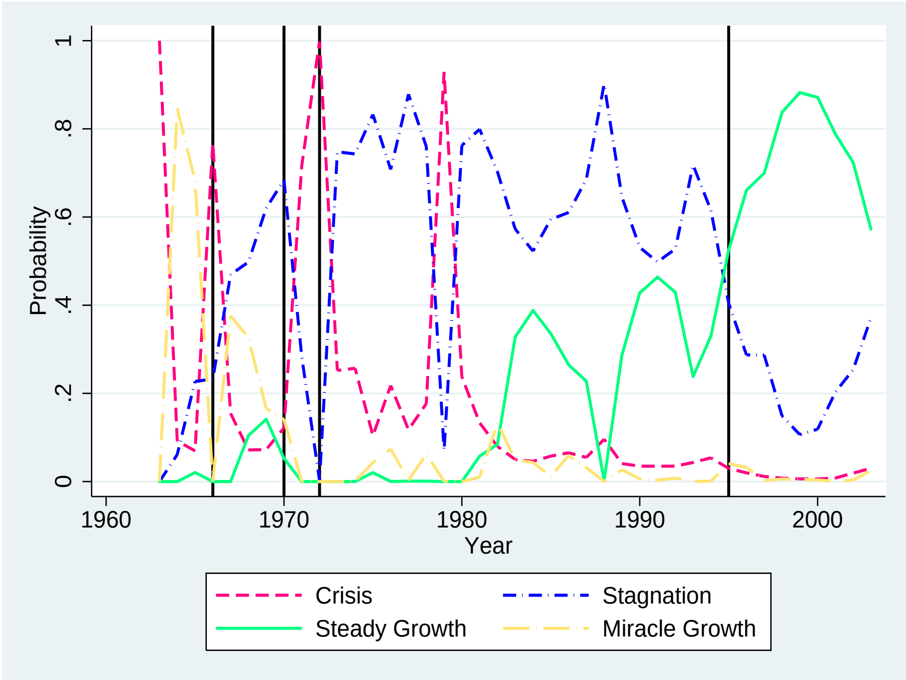


Figure 3.3: Average Regime Probabilities: Algeria

example of failing countries (Fig. 3.3) stagnated most of the time with periods of crisis after 1965, 1971 and 1978. In 1965 Boumedienne took over as president in a military coup d'état and remained in power until his death in 1978, which caused serious struggles for his succession. 1971 was characterized by the confiscation of French energy operations. Algeria entered steady growth in 1994, when it arranged a comprehensive debt rescheduling with the support of the IMF. Apparently, the associated structural reforms such as trade liberalization helped the country to initiate sustainable growth.

3.5 Determinants of Cluster Assignment

In order to address the determinants of cluster assignment, today's developed countries that were already highly developed in 1960 are separated into a cluster of their own.[9] There are two reasons for this approach: First, it is well known that both growth policies and growth fundamentals in developed countries were and still are

[9]The developed countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Italy, Norway, New Zealand, The Netherlands, Sweden, Switzerland, the United Kingdom and the United States of America. In order to be selected, income per capita in 1960 had to equal at least half the income per capita in the United States and the countries had to belong to today's OECD countries.

Table 3.7: Mechanisms Related to Factor Accumulation

	Investment Rate 1960	Saving Rate 1965	Population Growth Rate 1960	Dependency Ratio 1960	Average Years of Schooling 1960	Primary School Completed 1960
Successful (Cluster 1)	17.15^{4}	20.92	2.47^{4}	$0.8^{3,4}$	$3.77^{2,3,4}$	$39.36^{2,3,4}$
	(2.40)	(2.78)	(0.36)	(0.04)	(0.43)	(4.11)
	18	14	18	17	18	18
Moderately Successful (Cluster 2)	11.97^{4}	14.23^{4}	2.48^{4}	0.85^{4}	$2.5^{3,4}$	$25.88^{3,4}$
	(1.57)	(1.83)	(0.15)	(0.02)	(0.41)	(3.69)
	22	18	23	23	23	21
Failing (Cluster 3)	12.71^{4}	14.63^{4}	2.53^{4}	0.89^{4}	1.43^{4}	13.73^{4}
	(3.14)	(2.47)	(0.12)	(0.02)	(0.24)	(1.68)
	28	23	28	28	28	25
Industrialized (Cluster 4)	24.9	26.51	1.17	0.59	7.81	75.57
	(1.38)	(1.77)	(0.17)	(0.02)	(0.34)	(2.86)
	15	8	15	15	15	15

Notes: For each cluster the mean, standard error of the mean and the number of observations is reported. The superscript i attached at entry j indicates a significant difference between the means of cluster i and cluster j at the five percent level using Sattersthwaite's degree of freedom adjustment.

more favorable than in developing countries. By separating developed countries from the rest in the successful cluster, the more interesting question why some underdeveloped countries of 1960 managed to start successful catch-up growth processes whereas others did not becomes the focal point of interest. Second, growth in developed countries is spurred by other forces than growth in developing countries. For instance, innovation is much more important in rich countries whereas poorer countries rely more on imitation (Benhabib and Spiegel, 2005; Nelson and Phelps, 1966). Hence, the fundamentals required for these different engines of growth are possibly distinct, too. Moreover, the separation of developed countries crudely incorporates Pritchett's (2003) original idea that growth states are a function of both growth rates and income levels.[10]

3.5.1 Growth Fundamentals

The logic of the Markov switching model of growth implies that the classification of countries depends on slowly moving, relatively stable fundamental growth determinants, which allow some countries to grow quickly and keep others in poverty. One

[10]It is debateable whether the Markov switching model should have been estimated without the developed countries to start with. This approach has not been pursued in order to keep the Markov switching results comparable to Jerzmanowski (2006).

reason why countries have varying transition probabilities could be the existence of externalities with a threshold property, which hamper the accumulation of production factors.[11] Examples are insufficient saving and investment or insufficient human capital in the presence of increasing returns to scale (Azariadis and Drazen, 1990). Negative trends may be reinforced by high population growth either because capital is diluted or because capital is reduced to meet subsistence consumption (Ben-David, 1998; Nelson, 1956). Table 3.7 tests whether the arithmetic means of investment, saving and population growth rates, dependency ratios,[12] average years of schooling and the percentage of the population having completed at least primary school differ across clusters. All data is reported for 1960 or the earliest available date to separate initial conditions from later policy choices. The equality of means is tested pairwise using Satterthwaite's degree of freedom adjustment and unequal variances. A significant difference at the five percent level is indicated by a superscript at the cluster with the smaller reference number.[13] As expected, the initial conditions across all measures are significantly more favorable in developed countries. Among developing countries, however, the only noteworthy difference relates to education. Successful developing countries had significantly more human capital in 1960 than moderately successful ones, and these again were significantly better educated than failing countries.

Different structural features are another possible reason for varying transition probabilities. For instance, the absence of a well-developed financial system or the lack of a liberal trade regime can lead to inefficient investment (King and Levine, 1993a,b; Sachs et al., 1995). Moreover, geographic conditions are essential because they determine disease burdens, feasible production mixes and transport costs (Gallup et al., 1999). Table 3.8 reports initial financial development (domestic credit to private sector credit/GDP), the percentage of liberalized countries in 1970,[14] the number of years trade has been liberalized between 1960 and 2002, and several geographic variables. While initial financial conditions in developing countries were similar, differences in openness are significant. Longer periods of liberalized trade

[11] The structure of the analysis in this section imitates Berthelemy (2006).

[12] The dependency ratio is defined as the ratio of the number of people younger than 15 or elder than 64 to the number of people between 15 and 64 of age.

[13] No adjustments are made to account for the inherent uncertainty in the clustering results. Similar approaches have been used by Ardiç (2006) and Durlauf and Johnson (1995).

[14] The year 1970 is chosen in order to cover the large number of countries that liberalized shortly after 1960 in the Kennedy GATT round from 1964 – 1967 (WTO, 2011).

Table 3.8: Mechanisms Related to Structural Features

	Private Sector Credit to GDP 1965	Openness Dummy 1970	Years of Liberalized Trade 1960 – 2002	Landlocked Country (1 = yes, 0 = no)	Percentage of Land Within 100km to the Coast	Percentage of Land in Tropical Climate
Successful (Cluster 1)	29.33^{3}	$0.61^{2,3,4}$	$28.61^{2,3,4}$	0.06^{3}	0.59^{3}	$0.50^{3,4}$
	(5.78)	(0.12)	(3.40)	(0.06)	(0.09)	(0.11)
	15	18	18	18	18	19
Moderately Successful (Cluster 2)	16.68^{4}	0.13^{4}	$15.04^{3,4}$	0.13	0.51^{3}	$0.58^{3,4}$
	(2.07)	(0.07)	(1.90)	(0.07)	(0.08)	(0.10)
	20	23	23	23	23	23
Failing (Cluster 3)	11.93^{4}	0.04^{4}	7.61^{4}	0.36	0.14^{4}	0.85^{4}
	(1.34)	(0.04)	(1.46)	(0.09)	(0.03)	(0.06)
	23	28	28	28	28	28
Industrialized (Cluster 4)	44.30	0.93	40.00	0.13	0.45	0.03
	(6.54)	(0.07)	(1.73)	(0.09)	(0.09)	(0.03)
	15	15	15	15	15	15

Notes: For each cluster the mean, standard error of the mean and the number of observations is reported. The superscript i attached at entry j indicates a significant difference between the means of cluster i and cluster j at the five percent level using Sattersthwaite's degree of freedom adjustment.

are associated with more favorable cluster assignment. Moreover, difficult geographic conditions are associated with less favorable growth outcomes. Countries in the failure cluster tend to be landlocked or have limited access to the sea and they are predominantly located in the tropics. Developed countries display the best structural features.

The varying transition matrices could also result from differences in the quality of institutions, as Jerzmanowski (2006) suggests. Table 3.9 reports four indicators for this trait with larger values indicating better quality: the government antidiversion index, the voice and accountability indicator, an index of judicial independence and the business environmental risk intelligence indicator BERI. Except for BERI 1972, all indicators refer to the situation in the 1990s. As expected, developed countries have the best institutions. Among developing countries, successful countries display significantly better institutions than the other two clusters. However, institutions in moderately successful countries are not significantly better than those in failing countries.

Summing up, the following growth fundamentals differ between clusters and are therefore potentially responsible for the differences in transition probabilities: initial human capital stocks, the quality of institutions, geographic conditions and partici-

Table 3.9: Mechanisms Relating to the Quality of Institutions

	Government Antidiversion Index	Voice and Accountability (1996)	Judicial Independence	BERI index 1972	BERI index 1995
Successful (Cluster 1)	$0.69^{2,3,4}$ (0.04) 17	$0.28^{3,4}$ (0.17) 18	0.69 (0.08) 13	$10.51^{2,3,4}$ (0.54) 12	$10.07^{2,3}$ (0.60) 13
Moderately Successful (Cluster 2)	0.53^{4} (0.02) 22	$-0.09^{3,4}$ (0.14) 23	0.79 (0.08) 13	6.74^{4} (0.74) 11	7.71^{4} (0.43) 8
Failing (Cluster 3)	0.49^{4} (0.01) 28	-0.54^{4} (0.14) 28	0.73 (0.09) 15	7.22^{4} (0.55) 5	6.84^{4} (0.58) 5
Industrialized (Cluster 4)	0.96 (0.01) 15	1.32 (0.05) 15	0.84 (0.06) 15	12.56 (0.37) 10	11.13 (0.29) 12

Notes: For each cluster the mean, standard error of the mean and the number of observations is reported. The superscript i attached at entry j indicates a significant difference between the means of cluster i and cluster j at the five percent level using Sattersthwaite's degree of freedom adjustment.

pation in free trade. The quality of institutions is special in that it does not differ significantly between moderately successful and failing countries, whereas the other growth fundamentals differ between all developing countries. The developed countries of 1960 had better growth fundamentals across the board.

3.5.2 A Closer Look at Institutions and Policies

Ultimately, the differences in initial human capital stocks and in openness between moderately successful and failing countries can be traced back to different policies. Coupled with the limited relevance of institutions between the two clusters, this implies that the implementation of good policies may be sufficient to improve the growth path of a country considerably without addressing the daunting task of improving institutions. In order to assess this line of reasoning, this section analyzes whether the two country groups implemented diverging policies in other areas as well and whether different policies are related to institutional differences that are obscured in the averaging process. The following additional policy variables are considered: health expenditures as an indicator of investments in disease prevention (only available for the end of the sample period), investments in roads and telephone lines to facilitate transport in the presence of adverse geographic conditions, expansion of education as a prerequisite to attract and adapt foreign capital, inflation, and

Table 3.10: Policies and Institutions

	All countries				Bad Institutions Subgroup			
	Moderately successful		Failing		Moderately successful		Failing	
Average Years of Schooling 1960	1.701	(23)	1.005	(28)	2.096	(10)	0.846	(15)
Primary School Completed 1960	20.1	(21)	12.3	(25)	20.1	(9)	11.3	(14)
Years of Liberalized Trade	14	(23)	7	(28)	13.5	(10)	6	(15)
Relative Health Exp. 2003 (% GDP)	5.223	(23)	5.597	(27)	5.320	(10)	5.400	(15)
Health Exp. in US$ 2003	79.54	(23)	24.01	(27)	35.46	(10)	23.40	(15)
Expansion of roads 60 - 00 (in km)	8985	(22)	4297	(28)	3989	(10)	3458	(15)
New telephone lines (in 1000)	1070	(22)	169	(28)	659	(10)	73.3	(15)
Improvements in Schooling 60-00	3.254	(23)	2.096	(28)	3.453	(10)	1.767	(15)
Average inflation 61-03	10.378	(23)	11.023	(28)	9.819	(10)	10.493	(15)
Index of Macroeconomic Stability 70-99	0.201	(22)	-0.280	(24)	0.379	(9)	-0.237	(15)

Notes: The median for each variable is reported and the number of observations is given in parenthesis.

an index of macroeconomic stability to account for the growth enhancing effect of limited volatility. For each policy variable the median for each cluster as a whole and for the subgroup of countries for which the quality of institutions is below the median of the two clusters is reported.[15]

Table 3.10 shows that the differences between clusters in initial human capital and openness continue to exist in the bad institutions subgroup. With the exception of relative health expenditures and average inflation, moderately successful countries have implemented better policies than failing countries and these differences continue to be observed in the bad institutions subgroup. The observed differences regarding education and the stability of macroeconomic policies become even more pronounced if only the bad institutions subgroup is considered. These results suggest that policy choices have a strong influence on the growth process and this is true even if good institutions are lacking.

The importance of policies also becomes apparent when looking at particular growth dynamics. The moderately successful countries quite frequently experience transitions from stagnation to miracle and then steady growth, a growth pattern that is not observed in failing countries. One example for such a shift is Bolivia. From the end of the seventies until 1986 the country went through chaos with political

[15]The median is reported because some variables are reported as absolute numbers and would otherwise be unduly influenced by very big or very small countries. The qualitative results do not change if the mean adjusted for very influential observations is considered. Due to the small number of observations standard errors are not reported.

instability, debt defaults and hyperinflation. The prevalent regime in these years was stagnation, which was followed by miracle growth in 1987 and steady growth afterwards. At the end of 1985 a wide ranging stabilization program was initiated by president Paz Estenssoro that included fundamental fiscal and monetary changes, debt renegotiations, a unified market exchange rate, trade liberalization, deregulation, privatization and administrative reforms. The new economic policy showed quick results and the country embarked on a successful growth process (Morales and Sachs, 1988). Another prominent example of this transition is India at the beginning of the eighties. Unlike Bolivia, India did not undergo extensive economic reform at that time, but rather encouraged the incumbent private sector to become more productive. Extensive economic reforms occurred only in the nineties and had a stabilizing effect on the experienced transition (Rodrik et al., 2004). Many more examples of medium- or long-term transitions can be found, e.g. Turkey in 1981 or Egypt in 1982. What all these transitions have in common is that at some point at least a limited amount of growth-conducive policies was implemented. In contrast, short-run miracle growth episodes without at least temporary transitions to a different regime are generally not related to meaningful policy changes (e.g. Costa Rica 1977, Dominican Republic 1980, Jamaica 1972 or Morocco 1987). A unique pattern of growth that failing countries experience is a period of miracle growth that is followed either by stagnation or even by crisis. For instance, Mozambique stagnated after miracle growth in 1990 as did Nigeria after 1970, Togo after 1968 or Venezuela after 1975. In 1962 Algeria experienced miracle growth only to fall into a crisis in 1963. These episodes of miracle growth are recoveries after a war (Mozambique, Nigeria) or military coup (Togo), a short-run positive event such as independence (Algeria) or a short-run impact of a positive external shock (high oil prices in Venezuela). None of the episodes was followed by supporting economic reforms or stabilization policies. Hence, these cases confirm that policies matter both for the evolution of growth at a certain point in time and for the classification results. While the ultimate question concerns the fundamentals that keep failing countries from implementing equally successful policies as moderately successful countries, the lack of good institutions is only a partial answer according to the present analysis.

3.6 Conclusion

This paper has estimated a regime-switching model of growth along the lines proposed by Pritchett (2003) and Jerzmanowski (2006), which has been enriched by an endogenous classification mechanism. In this framework, each country's growth pattern is the result of transitions between distinct growth regimes. The transitions are governed by cluster-specific transition probabilities in order to strike a balance between capturing the most important differences in the dynamics of growth across countries and keeping the estimation problem manageable. Four distinct growth regimes and three clusters of countries are identified. Countries switch between a steady growth state, a stagnation growth state, a crisis growth state and a miracle growth state. The clusters capture the different growth patterns of countries. There are successful countries that have maintained steady or miracle growth rates over long periods of time. A second cluster comprises moderately successful countries that mainly switch between moderately positive growth rates and stagnation. Countries in the third cluster are failing countries in the sense that they are characterized by a very volatile growth process with frequent incidents of crisis occurring during prolonged periods of stagnation. The resulting country groups do not correspond to conventional geographic variables, which is in accordance with other clustering results. However, since contributions differ widely in the number of clusters and exact specifications, the identified clusters between studies show no close correspondence to each other (Alfo et al., 2008; Baştürk et al., 2012; Owen et al., 2009; Paap et al., 2005; Papageorgiou, 2002).

Good institutions, high initial human capital, favorable geographic conditions and trade openness distinguish successful developing countries from less successful ones. Moderately successful as opposed to dismal growth patterns are to a large extent the result of policy interventions: even though neither country group has good institutions, moderately successful countries have invested more in infrastructure and education than failing countries, they have opened up their economies earlier and they have conducted less volatile macroeconomic policy. The clustering literature has not yet arrived at a generally accepted conclusion of the relevant cluster determinants: institutions, human capital and literacy, financial development, openness, structure of production, initial income, trade and macroeconomic policies have all been suggested (Bos et al., 2010; Durlauf and Johnson, 1995; Hansen, 2000; Lavezzi and Matteo, 2010; Owen et al., 2009; Papageorgiou, 2002). Contrary to the approach in this paper, the previous studies determine a priori potential sorting variables for cluster membership, then define a statistical model and check the significance of the variables. If countries are grouped without a sorting equation, it is not uncommon to see no clear relationship between conditioning variables and cluster assignment (Baştürk et al., 2012). In this light, the present model is successful in pointing out distinguishing features between clusters.

According to this paper, bad institutions are not a binding constraint for achieving reasonable growth patterns. Even if the institutional framework is bad and difficult to improve, policies and geography do have an effect on growth that is independent of the current quality of institutions. These results are opposed to the institutional view of economic growth (Acemoglu et al., 2003, 2001; Rodrik et al., 2004), but in line with cross-country studies by Durlauf et al. (2008), Glaeser et al. (2004), Jerzmanowski (2011) and Sachs (2003). Moreover, Henry and Miller (2009) demonstrate the relevance of policies as opposed to institutions in a case study for Barbados and Jamaica.

In future work, the Markov-switching model of growth should be extended to allow for country- or cluster-specific time-varying transition probabilities because policy changes or economic reforms in developing countries are carried out for the very reason to obtain more favorable dynamics. Since this will require considerably longer time-series than are available today, learning about the determinants of the transition probabilities in the past is a valuable, albeit first step.

Acknowledgements

I would like to thank Giacomo Corneo and Wolfram Schrettl for advice and insightful suggestions. I am also indebted to two anonymous referees whose comments have helped to substantially improve the paper and to Knack and Keefer, who kindly provided their data collection. All remaining errors are mine.

Chapter 4

Growth Accelerations and Real Exchange Rates - A Reassessment

Abstract: This paper provides new evidence on the popular, yet not convincingly verified claim that real exchange rate depreciations help triggering growth accelerations. It relates episodes of fast growth and events of modest, but sustained real depreciations over the years 1950 – 2007 in 107 countries to each other using a binary choice model. The link between real depreciations and growth accelerations turns out to be less robust than often assumed. Whether real depreciation events are growth-conducive depends in particular on the associated level of the real exchange rate and on the time period under consideration. For instance, a growth effect of further depreciations of undervalued currencies is only observable in more recent times. It is not only the link between real depreciation events and growth accelerations that is less robust than assumed. The same is true for "traditional" determinants of growth accelerations, making more recent growth accelerations even less predictable than earlier ones.

Keywords: Economic Growth, Growth Accelerations, Real Exchange Rates

JEL Classification: F31, O11

4.1 Introduction

Reviewing the literature on the nexus between real exchange rates and economic growth, researchers sooner or later invariably encounter the statement that real exchange rate depreciations play an important role in growth accelerations.[1] In contrast to the ubiquity of this statement, the empirical evidence is far from convincing: it is based on Hausmann et al. (2005) [HPR] who analyze growth accelerations and report that in their sample growth accelerations coincide with real exchange rate depreciations of 21.7 %.[2] Other than that, the real exchange rate does not enter their analysis. In particular, HPR do not show that real depreciations are significant predictors of growth accelerations. Therefore, the first aim of this paper is to search for the maintained link between real depreciations and growth accelerations and to underpin it empirically.

The more recent literature tends to focus on the level as opposed to changes of the real exchange rate. Interest is focused in particular on the growth impact of real undervaluation, and this paper aims to provide some additional evidence on this issue, too. According to the "Rodrik view" of real exchange rate misalignment, competitive (meaning undervalued) real exchange rates stimulate economic growth. Contrary to that, the "Washington Consensus view" claims that any kind of real exchange rate misalignment is detrimental to growth. As a result of the Chinese growth miracle in particular, the "Rodrik view" of real exchange rate misalignment has gained acceptance in recent years and is deemed particularly relevant in the context of low-income countries (Berg and Miao, 2010; Rodrik, 2008; Subramanian, 2010; Williamson, 1990b). And even though real depreciations do not automatically imply undervalued real exchange rates, the positive association between real depreciations and growth accelerations is frequently used as an additional piece of evidence in favor of competitive real exchange rates.[3] Empirically, the evidence for the growth-promoting effect of undervalued currencies is heavily based on panel growth regressions with the samples being restricted to developing countries. Yet, growth

[1] A non-exhaustive list of recent examples is: Couharde and Sallenave (2013); Frenkel and Rapetti (2008); Glüzmann et al. (2012); Nouira and Sekkat (2012); Rapetti et al. (2012); Razmi et al. (2012).

[2] The average level of the real exchange rate in the seven years leading up to a growth acceleration is compared to the average level in a three year window around the start of the growth acceleration. The change in the real exchange rate prior to the accelerations is reported to be significantly different from zero. Unfortunately, HPR do not indicate how they calculate the real exchange rate.

[3] For references see Section 4.2.

in developing countries is known to be highly unstable. In such a context growth regressions are notoriously unreliable and difficult to interpret (Pritchett, 2000).[4] Hence, the link between real undervaluation and economic growth should ideally be corroborated by further empirical approaches. This paper complements the evidence by linking turning points in economic growth not only to changes of the real exchange rates, but also to the associated levels thereof.

The central question analyzed in the following is whether countries have experienced growth accelerations conditional on sustained episodes of real exchange rate depreciations. The empirical approach is based on the seminal contributions by HPR and Rodrik (2008). Specifically, the data covering the years 1950–2007 and 107 countries is reorganized around turning points of growth rates and PPP-based real exchange rates.[5] Growth accelerations are constructed following HPR. Real depreciation events are defined as modest to large real exchange rate depreciations that are sustained for several years. In order to account for the level of real exchange rate misalignment, the depreciation events are further subdivided into events that correct sizable currency overvaluation, events that increase preexisting currency undervaluation and events that turn a modestly overvalued currency into a modestly undervalued one. A pooled binary choice framework is then used to test for a statistically significant relationship between the fast growth episodes and real depreciation events.

Contrary to the popular hypothesis the results in this paper do not support a general and robust link between the initiation of growth accelerations and real depreciations. Growth accelerations on average are not accompanied by real depreciations. And despite focusing on the subset of real depreciation events that are the most likely candidates to trigger growth accelerations, there is no obvious association between the two events. For instance, a statistically significant association between

[4] Pritchett (2000) warns that growth regressions lead to unstable results if growth is not reasonably constant over time. He criticizes panel growth regressions in particular for their lack of power, their sensitivity to measurement errors, the inherent dynamic misspecification problems and the exacerbation of endogeneity problems.

[5] In his seminal contribution, Rodrik (2008) has also focused on the evolution of PPP-based real exchange rate levels in the context of growth accelerations. However, by focusing exclusively on real exchange rate movements that have occurred around growth accelerations Rodrik effectively discards all information on real exchange rate movements that have not been growth-conducive. As a result of this selectivity, the analysis cannot convincingly attribute any causal interpretation to the depicted real exchange rate movements (Henry, 2008).

real depreciation events and growth accelerations is observed in the overall sample, but not in the subsample of developing countries.

Digging deeper, the overall fragile results can be explained by distinct and partly offsetting effects of real depreciation events depending on the concomitant level of the real exchange rate and on the time period under consideration. In particular, before 1980 sustained real depreciations of overvalued currencies were related to growth accelerations. In more recent times, this applies to the further depreciation of already undervalued currencies. The analysis reveals that changing impacts over time are not only observed for real depreciation events, but also for other determinants of growth accelerations. This notably includes "traditional" and well-accepted determinants such as political regime changes. In general, recent growth accelerations are even less predictable than earlier ones.

The remainder of this paper is organized as follows. Section 4.2 gives a short review of the related literature. Section 4.3 defines growth accelerations and real depreciation events and provides the descriptive statistics. Section 4.4 presents the empirical analysis before Section 4.5 concludes.

4.2 A Short Review of the Related Literature

This paper is linked to the literature on real exchange rates and economic growth, growth accelerations and currency crises. The early literature on the link between real exchange rates and economic growth has focused on the detrimental effects of overvalued real exchange rates.[6] Recently and in light of the East Asian and Chinese growth miracles, interest has shifted to potentially beneficial effects of undervalued real exchange rates. From a theoretical point of view, the beneficial effects of real undervaluation have been linked to positive externalities in the tradeable sector, to the ability of the real exchange rate to mitigate negative effects of market failures as a second-best solution and to the increase in the domestic capital stock, whereby the latter is the result of redistributive effects or the result of relaxing foreign exchange rate constraints for imported capital goods (Dooley et al., 2003; Levy-Yeyati et al., 2013; Montiel and Serven, 2008; Rapetti et al., 2012; Razmi et al., 2012; Rodrik,

[6] Early samples e.g. in Cottani et al. (1990), Dollar (1992), and Ghura and Grennes (1993) generally have a large bias towards overvalued real exchange rates. Cf. Nouira and Sekkat (2012) and Schröder (2013) for a similar argument.

2008).

The empirical evidence on real exchange rates and growth is inconclusive. Empirical studies usually establish a link between economic growth and either a PPP-based or a model-based measure of real exchange rate misalignment in a panel of countries.[7] If real under- and overvaluation are depicted as deviations from the equilibrium exchange rate of different signs and only one common coefficient is estimated, authors generally conclude that real exchange rate overvaluation harms growth whereas real exchange rate undervaluation boosts it (Berg and Miao, 2010; Cottani et al., 1990; Dollar, 1992; Ghura and Grennes, 1993; MacDonald and Vieira, 2010; Rodrik, 2008). Results are contradictory once differentiated growth impacts for real over- and undervaluation are accounted for in the estimation. Razin and Collins (1997) and Aguirre and Calderon (2005) find a negative growth effect of real overvaluation that becomes more detrimental the larger its size while small to moderate degrees of real undervaluation seem to be conducive to growth. In contrast, Nouira and Sekkat (2012) find no evidence neither for a positive growth effect of real undervaluation nor for a detrimental growth effect of real overvaluation. Schröder (2013), on the other hand, reports negative effects for both real over- and real undervaluation. Results remain contradictory with more refined models, too. Using a panel-smooth transition model Béreau et al. (2012) confirm an asymmetric growth effect of real under- and overvaluation. Using the same methodology, Couharde and Sallenave (2013) report differentiated growth effects for real undervaluation below and above a threshold of approximately 20 %. Levy-Yeyati and Sturzenegger (2007), Levy-Yeyati et al. (2013) and Polterovic and Popov (2003) focus exclusively on real exchange rate undervaluation as measured by central banks' accumulation of foreign reserves and find that undervaluation fosters growth.

In the context of event-study approaches real exchange rates have featured only incidentally with conflicting results. HPR include real exchange rate changes in their descriptive analysis exclusively. In a sample of Sub-Saharan African countries, Pattillo et al. (2005) find that real exchange rate depreciations are significantly correlated to the likelihood of being in (as opposed to initiating) an acceleration period.

[7] A limited number of studies focuses on the actual transmission mechanisms. Mbaye (2013) examines the total factor productivity channel, Montiel and Serven (2008) and Levy-Yeyati et al. (2013) the capital accumulation channel, whereas Qu and Sylwester (2010) focus on the weak institutions hypothesis as suggested by Rodrik (2008). Glüzmann et al. (2012) estimate the effect of real exchange rates on the different components of GDP in order to identify the most relevant channel.

Bluedorn et al. (2014) report a negative effect of overvalued real exchange rates and real appreciations on the probability of a growth-takeoff in low-income countries. In a more encompassing sample, de Mello et al. (2011) find that changes in real exchange rate levels are not robustly related to neither upbreaks nor downbreaks of GDP growth. This is similar to Jones and Olken (2008), who see no systematic change in exchange rate levels at the onset of growth upbreaks or downbreaks, either. In a different context, Freund and Pierola (2012) report that export surges are preceded by large real exchange rate depreciations in developing countries, but they do not address the predictive power of depreciations for such events. Berg et al. (2012) report that episodes of rapid growth are more likely to break down if the real exchange rate appreciates, whereas Eichengreen et al. (2012) show that real exchange rate undervaluation increases the likelihood of a sharp slowdown in growth once rapidly growing economies reach a per capita income level of approximately 17000 US $ per year.

This paper contributes to the existing literature by focusing on the contribution of real exchange rate depreciations in initiating growth accelerations. It does so by defining appropriate real depreciation events. Despite some similarities to analyses of the growth effect of currency crises, there are notable differences (Bussière et al., 2012; Gupta et al., 2007; Hong and Tornell, 2005). First, the currency crisis literature considers *large nominal* depreciations. While these are likely to translate into *real* depreciations in the short run (Edwards, 2011; Taylor and Taylor, 2004), they may or may not be sustained. Contrary to that, this paper requires real depreciations to be sustained in the medium term. Second, the focus in this paper is on *moderate* changes. The depreciation events considered may even occur without concomitant changes in the nominal exchange rate, e.g. as a result of restrictive monetary and fiscal policies (Henry, 2008; Rapetti, 2012). Third, the currency crisis literature typically focuses on the immediate aftermath of crises whereas in this paper the interest lies on medium-term growth effects.

4.3 Identifying Growth Accelerations and Real Depreciation Events

4.3.1 Growth Accelerations and the Real Exchange Rate: Definitions

Growth accelerations are medium-term episodes of rapid growth. Formally, they meet the following criteria as established by HPR:

1. Growth is rapid, i.e. $\bar{g}_{t,t+n} \geq 3.5\%$,
2. Growth accelerates, i.e. $\bar{g}_{t,t+n} - \bar{g}_{t-n,t} \geq 2.0\%$,
3. Post-episode output exceeds peak pre-episode output, i.e. $y_{t+n} \geq \max\{y_i\}, i \leq t$.

Growth and output refer to per-capita values, $\bar{g}_{t,t+n}$ denotes the average growth rate from period t to $t+n$. Following HPR, n equals 7. If several observations in a row satisfy the criteria, the beginning of the growth acceleration is determined via spline regressions.[8] Each country can experience an unlimited number of accelerations provided that the starting dates are n years apart.[9] For consistency reasons with the previous chapters, first differences are used to estimate average growth rates.[10]

The PPP-based measure of the real exchange rate suggested by Rodrik (2008) is used. The real exchange rate r_{it} of country i at time t is defined as the ratio of the nominal exchange rate e_{it} to the purchasing power conversion factor ppp_{it}, both expressed in terms of national currency to US \$. Since nontradeable, locally

[8] In this case, growth rates from $t-n$ to $t+n$ are regressed on a constant with a break at time t for all possible starting years t. The beginning of the growth acceleration is determined by selecting the year t that yields the highest F-statistic.

[9] This is different from HPR, who only require a pause of five years between growth accelerations. This specification, however, is inconsistent with their probit analysis where they drop all data pertaining to the years $t+2, ..., t+7$ of an episode for the reason that no acceleration can start within those years (HPR, p. 306 and 321).

[10] HPR use a log-linear trend in their seminal contribution. Given that there is still no consensus on the question whether output is I(1) or I(0), there are no compelling reasons for either solution. For seminal contributions on the unit-root question cf. Nelson and Plosser (1982), Perron (1989), and Zivot and Andrews (1992). More recent contributions like Cuestas and Garratt (2011), Darné (2009) or Murray and Nelson (2000) show that the controversy is not yet settled.

produced goods are typically cheaper in poorer countries, the equilibrium value of r_{it} does not equal one, but should be adjusted for the Balassa-Samuelson effect. It is estimated as the predicted value of the following regression (4.1). All calculations are carried out in logs.

$$\ln r_{it} = \alpha + \beta \ln y_{it} + f_t + u_{it}. \tag{4.1}$$

f_t and u_{it} denote period dummies and error terms, respectively. The index of real exchange rate misalignment m_{it} is defined as

$$m_{it} = \frac{r_{it}}{\widehat{r}_{it}}, \tag{4.2}$$

whereby $\widehat{r}_{it}$ denotes the predicted value according to equation (4.1). $\ln m_{it}$ approximately equals the percentage amount of real exchange rate misalignment. Positive values of $\ln m_{it}$ indicate real exchange rate undervaluation, negative values real exchange rate overvaluation. If the level of misalignment increases from period $t-1$ to t, a real depreciation has occurred. A decreasing level of real exchange rate misalignment indicates an appreciation.

4.3.2 Growth Accelerations and the Real Exchange Rate: Patterns

Growth accelerations and real exchange rate misalignments are derived using the Penn World Tables (PWT) version 6.3 (Heston et al., 2009).[11] Following HPR, countries with less than 20 observations or with a population smaller than 1 million in the most recent available year are excluded from the analysis. Moreover, due to unreliable data country-year observations before 2000 are only considered if they have already been available in PWT 6.1.[12] These rules leave 107 countries for the analysis.

[11] Even though a newer version of PWT, PWT 7 (Heston et al., 2011, 2012), has been available at the time of writing, data from PWT 6.3 has been used. There are substantial differences in the estimated price levels between the versions. Breton (2012) argues that the data in PWT 7 is less reliable and accurate for low-income countries than the data in PWT 6.3. Since my interest lies particularly in low-income countries, I decided to use PWT 6.3. Moreover, by using PWT 6.3 the results are more readily comparable to the majority of other studies using the PPP-based real exchange rate. The question to what extent results on the undervaluation-growth nexus are comparable across different versions of PWT (for a critical review cf. Johnson et al. (2012)) is a distinct research question that should be addressed separately.

[12] From PWT 6.2 onwards, the Penn World Tables have been extended to include historical data even if the national accounts data has been known to be unreliable (Heston et al.,

Table 4.1: Growth Accelerations - Summary Statistics by Regions and Decades

	Region									
Decade	Africa	Asia	Europe	Latin America	Other	No. of Growth Accelerations	Prior Growth	Post Growth	Average Accel-eration	Uncond. Prob-ability (%)
1950	3	3	7	2	2	17	1.48	5.73	4.25	11.64
1960	11	10	5	7	3	36	1.29	6.63	5.34	7.03
1970	10	7	1	8	0	26	0.39	6.44	6.05	3.26
1980	7	8	4	3	0	22	0.12	5.77	5.65	2.44
1990	8	5	8	4	2	27	−0.49	5.03	5.52	3.10
2000	5	4	0	1	0	10	0.02	6.93	6.90	11.36
No. of Growth Accel.	44	37	25	25	7	138	0.52	6.06	5.54	4.16
Prior Growth	−1.38	2.01	1.62	0.37	1.11	0.52				
Post Growth	6.81	6.35	5.39	5.37	4.64	6.06				
Average Accel.	8.18	4.33	3.76	5.00	3.53	5.54				
Uncond. Prob.(%)	3.55	6.36	4.28	3.34	4.35	4.16				

Notes: This table reports the number of growth accelerations by region and decade based on the respective starting years. Prior and post growth refer to the average growth rate per capita observed in the 8-year period prior and post the start of the acceleration. The unconditional probability of an acceleration is calculated as the number of actual accelerations divided by the number of observations in which in principle an acceleration could have occurred.

Applying the filter for growth accelerations yields 138 growth episodes. The unconditional probability for the beginning of a growth acceleration equals 4.2 %.[13] Table 4.1 tabulates the frequency and unconditional probability for growth episodes by decades and regions as well as the average growth rates before, during and after an acceleration. The results reflect the success stories in East Asia: 37 growth accelerations are recorded for Asia alone. However, with 44 events even more are recorded for Africa. The insight that Africa is not a continent in permanent agony, but rather a continent that manages to ignite, but not to sustain growth episodes is one of the most important insights gained by the literature on structural breaks in growth (Hausmann et al., 2005; Jones and Olken, 2008; Kerekes, 2011, 2012; Paap

2006a). This problem mainly concerns oil-rich countries and the former communist countries. However, it also applies to Germany. It is excluded from the analysis because PWT data refers to the counterfactual United Germany between 1970 and 1990. Apart from these cases, the observation for Zimbabwe in 2007 is excluded because it is a clear outlier in the real exchange rate estimation specification.

[13] Number of growth accelerations divided by the number of observations in which an acceleration could have occurred. In particular, this excludes the observations after a growth acceleration during which by definition no second acceleration can start and the observations in the beginning and the end of the sample period of each country.

et al., 2005). Consistent with the experience of fast growth in many emerging and developing countries in the nineties and after the millennium, a large number of growth accelerations is recorded in these decades: 37 growth accelerations started in 1990 or later. This is true even though the number of growth accelerations in the 1950s and 2000s is truncated: the first possible date for an acceleration is 1957, the last one 2000.[14]

Not only the number of accelerations, but also their magnitude is impressive. On average, per capita income growth accelerates from 0.5 % per year to 6.1 %, which implies a difference of more than 5.5 percentage points [pp.]. Growth spurts are particularly pronounced in Africa with an average difference of more than 8 pp. This performance, however, results from the growth rate before the acceleration being particularly low (-1.4 %) and not from the growth rate within the acceleration being extraordinarily high. The average acceleration of growth rates in other regions varies between 3.5 and 5 pp. Growth accelerations have been the least impressive in Europe and in the countries summarized in the category "other regions", which comprises North America and Oceania.[15]

Turning to the real exchange rate, results closely resemble Rodrik (2008). The Balassa-Samuelson effect is estimated as -0.261 with a standard error of 0.005, i.e. on average an increase in income per capita by 10 % leads to an appreciation of the equilibrium real exchange rate by 2.6 %. Average real exchange rate misalignment equals zero with variance 0.18. Differentiating between developing and developed countries,[16] developing countries on average feature slightly undervalued real exchange rates (5 %) whereas currencies in developed countries are overvalued by 18 % on average. The variance of the real exchange rate in developing countries (0.19) exceeds that of developed countries (0.08) by a factor of more than two.

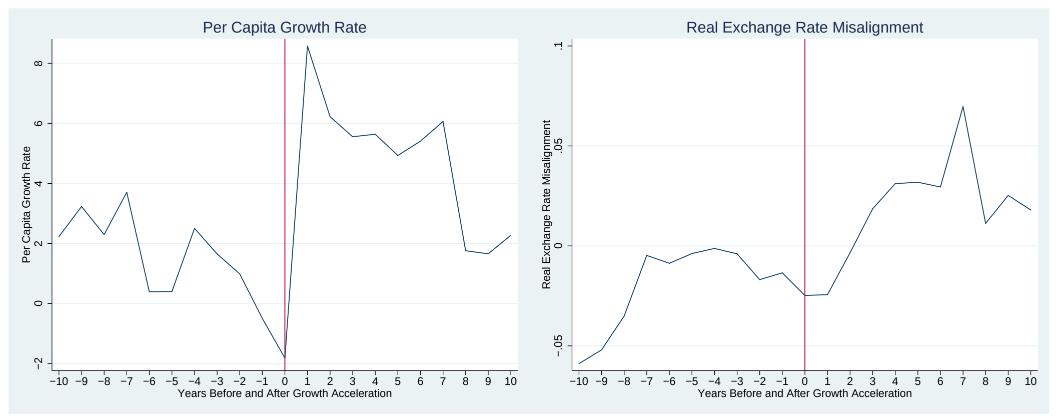
In the following, the patterns of real exchange rate movements around growth accelerations are examined as a first indicator for the strength of the association between growth events and real depreciations. Figure 4.1 depicts the behavior of

[14]Ten growth accelerations are recorded in the year 2000. Even though it is conceivable that some of these accelerations would be recorded in a later year in an extended dataset (this would require several observations in a row satisfying the acceleration criteria), this is not very likely because of the financial crisis beginning in 2007/2008. However, the results of this paper are robust to dropping accelerations starting in 2000.

[15]A complete list of the identified growth accelerations is given in Appendix 4.B.

[16]The relative definition introduced in Section 4.4.3 is used.

Figure 4.1: Growth Accelerations: Per Capita Growth and Real Exchange Rate Misalignment



per capita growth rates and real exchange rate misalignment centered on growth accelerations.[17] The typical growth acceleration happens after an economic downturn and features a massive jump of per capita growth. Per capita growth decreases somewhat after the first year, but remains much higher than prior to the acceleration for approximately seven years. Afterwards, growth returns to normal. In contrast to the popular claim, there is no obvious evidence that real depreciations are important for triggering growth accelerations on average. The indicator for real exchange rate misalignment remains more or less stable in the run-up to the typical acceleration. Surprisingly, a real depreciation is only observed once the acceleration has started.[18]

However, aggregate descriptions always run the risk of averaging out important details. Therefore, Figure 2 depicts the evolution of the real exchange rate depending on whether it depreciates or appreciates in the run-up to the growth acceleration.[19] Indeed, a significant number (56 and thus 40 %) of the identified growth accelerations coincides with real depreciations. In this subset of events the average real exchange rate depreciates steadily and moves from being overvalued prior to the acceleration to becoming correctly aligned at its start. The depreciated real exchange rate level is sustained after the onset of the acceleration. Looking beyond averages, about half of the events (30 out of 56) show a real undervaluation at the beginning of the

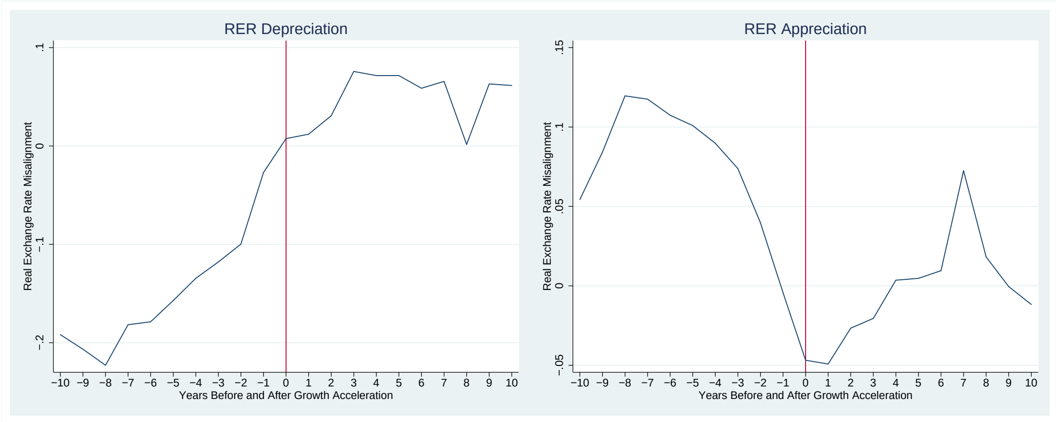
---

[17] OLS regressions of the dependent variable are run dummies such that moving window estimates are obtained. The moving window dummies are kept as long as no new event starts.

[18] This implies a potential endogeneity problem between growth accelerations and real depreciation events, which is considered in Section 4.4.1.

[19] Following the descriptive evidence in HPR, events are classified based on calculating the change in average real misalignment from $t-7$ to $t-1$ and t to $t+2$, whereby t is the year of the acceleration.

Figure 4.2: Real Exchange Rate Misalignment Around Growth Accelerations



Summary Statistics - Real Depreciation Around Accelerations (pp.)	
Mean	0.145
1. quartile	0.046
2. quartile	0.115
3. quartile	0.195

Summary Statistics - Real Appreciation Around Accelerations (pp.)	
Mean	-0.117
1. quartile	-0.148
2. quartile	-0.086
3. quartile	-0.051

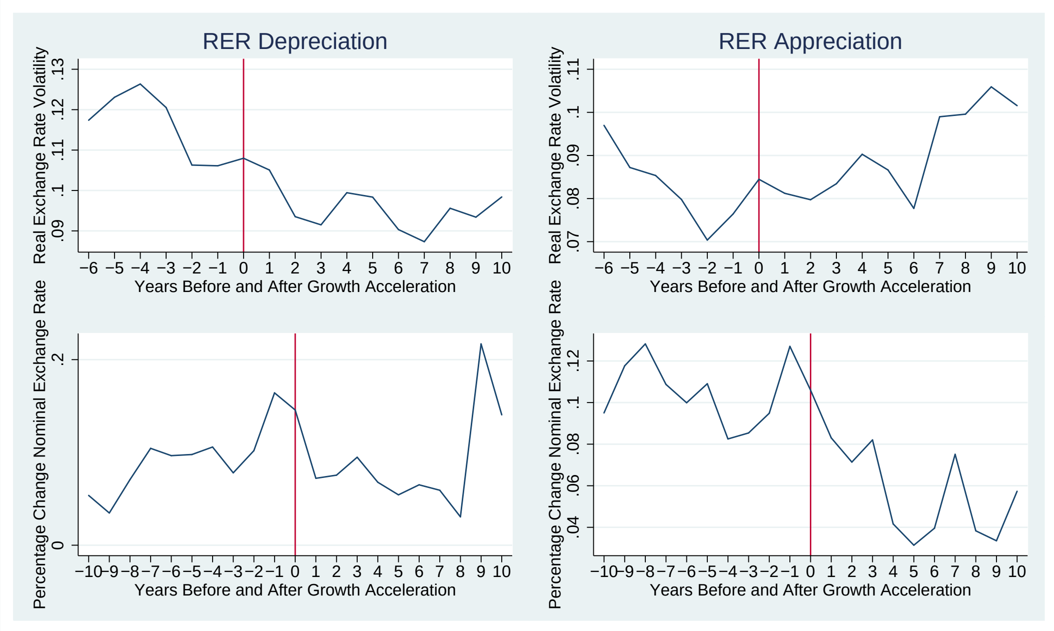
acceleration. The other half of the events continues to feature an overvalued real exchange rate despite the preceding real depreciation.

The majority of growth accelerations (82 and thus 60 %), however, happens in the presence of real appreciations. The appreciation of the real exchange rate occurs steadily and turns an average real undervaluation of 12 % into a slight real overvaluation of 5 %. However, the appreciated level of the real exchange rate is not sustained over time. This feature can potentially explain the observed real depreciation after the onset of growth accelerations in Figure 4.1.

Below each graph summary statistics for the magnitude of the real exchange rate changes are reported. The majority of real depreciations that are followed by growth accelerations feature changes of modest magnitude only: 75 % of the recorded real depreciations are smaller than 20 pp. The same applies to real appreciations: three quarters of the observed appreciations are smaller than 15 pp.

Figure 4.3 looks at two additional, potentially interesting features of exchange rate developments in the vicinity of growth accelerations. The upper part of the figure depicts the evolution of real exchange rate volatility around growth accelerations, separate for real depreciations and appreciations. A reduction of real exchange rate volatility is thought to encourage trade and investment and could therefore play a

Figure 4.3: Real Exchange Rate Volatility and Nominal Exchange Rates Around Growth Accelerations



role in growth accelerations, too (Eichengreen, 2008).[20] An interesting pattern arises. In the case of real depreciations, volatility falls steadily prior to the acceleration and continues to fall afterwards. Contrary to that, real appreciations are characterized by increasing volatility immediately prior to the acceleration. The lower part of the figure depicts the evolution of nominal exchange rates. On average, both real depreciations and real appreciations happen in the presence of modest nominal depreciations. Hence, the depreciations preceding growth accelerations are different from those preceding currency crises because the latter are characterized by large nominal depreciations that usually exceed 25 or 30 %.[21]

4.3.3 Real Depreciation Events: Definition and Description

Even though growth accelerations are not preceded by real depreciations as a general rule, the previous section has shown that a sizable minority is. Hence, despite not being obvious a significant statistical association between growth accelerations

[20] Real exchange rate volatility in t is measured as the standard deviation of real exchange rate misalignment from $t-4$ to t.

[21] Cf. references in Section 4.2.

and appropriately defined real depreciations might exist as claimed in the literature. Both the depicted patterns and theoretical considerations suggest that relevant, i.e. growth-conducive depreciation events are at the very least characterized by the following two features. First, real depreciations of interest are limited in magnitude. Large nominal depreciations as featured in currency crises or sudden stops are usually linked to contractionary output effects (Edwards, 2004; Frankel, 2005; Guidotti et al., 2004; Hutchison and Noy, 2006).[22] Since real and nominal exchange rates are highly correlated in the short run (Rapetti, 2012; Taylor and Taylor, 2004), the same should apply to large real depreciations. Second, the depreciated real exchange rate has to be sustained for several years in order to allow the expansion of the tradeable sector and the associated positive externalities to materialize (Rapetti, 2012). A concomitant reduction of real exchange rate volatility may improve the identification of real depreciations that are conducive to growth accelerations. Aghion et al. (2009) argue that a high level of real exchange rate volatility is detrimental to productivity growth in financially underdeveloped countries.

Based on these considerations, this paper requires a real depreciation event to meet the following criteria in its main definition (definition 1):

1. The real exchange rate depreciates modestly: $\tilde{m} \geq \bar{m}_{post} - \bar{m}_{prior} > 0$.
2. The depreciated real exchange rate is sustained: $m_{t+i} > \bar{m}_{prior}, \forall i = 0, ..., 4$.

$\bar{m}$ denotes the average level of real exchange rate misalignment. The relevant time horizon is set to five years. Hence, the period prior to the depreciation event in t starts in $t-5$ and ends in $t-1$, the period post the event runs from t to $t+4$. In reference to the currency crisis literature, a real depreciation below 30 pp. is considered to be modest; hence $\tilde{m} = 0.3$ (Laeven and Valencia, 2008). The magnitude of the real depreciation is determined as the difference in average misalignment levels prior to and post the onset of the event. In order to ensure that the observed real depreciation is sustained and not merely the result of a single spike, real exchange rate misalignment after the event has to exceed average pre-event misalignment in every single year.[23] Even though the previous section did not point at a pivotal

[22] However, the contractionary output effect of currency crises has been challenged recently by Bussière et al. (2012) and Gupta et al. (2007).

[23] As usual, the definition of events involves some degree of arbitrariness. For instance, Bussière et al. (2012) note that the definition of currency collapses is controversial. Similarly, the conditions for growth accelerations have been altered frequently to account for specific features of the research question (e.g. Dovern and Nunnenkamp (2007); Imam and Salinas (2008)). One advantage of the event approaches, however, is that subjective decisions are

role of real exchange rate levels, the identified depreciation events will be further disentangled in order to ensure that effects are comparable both in the presence of over- and undervalued real exchange rates.

Using the suggested definition 923 real depreciation events are identified. This corresponds to roughly one sixth of the available observations. The frequency of depreciation events thus considerably exceeds the frequency of growth accelerations.[24] On average, the real exchange rate depreciates by 14.3 pp. and moves from an overvaluation of 6.7 % to an undervaluation of 7.6 %. However, more than 40 % (404) of the events start from an undervalued real exchange rate to begin with. A large number of depreciation events is recorded in consecutive years. The number of separate sequences amounts to 316, only. About half (one third) of the sequences consist of one or two observations (one observation only). The longest sequence consists of 19 consecutive years that qualify as depreciation events (Panama).

Figure 4.4: Real Depreciation Events - Basic Definition

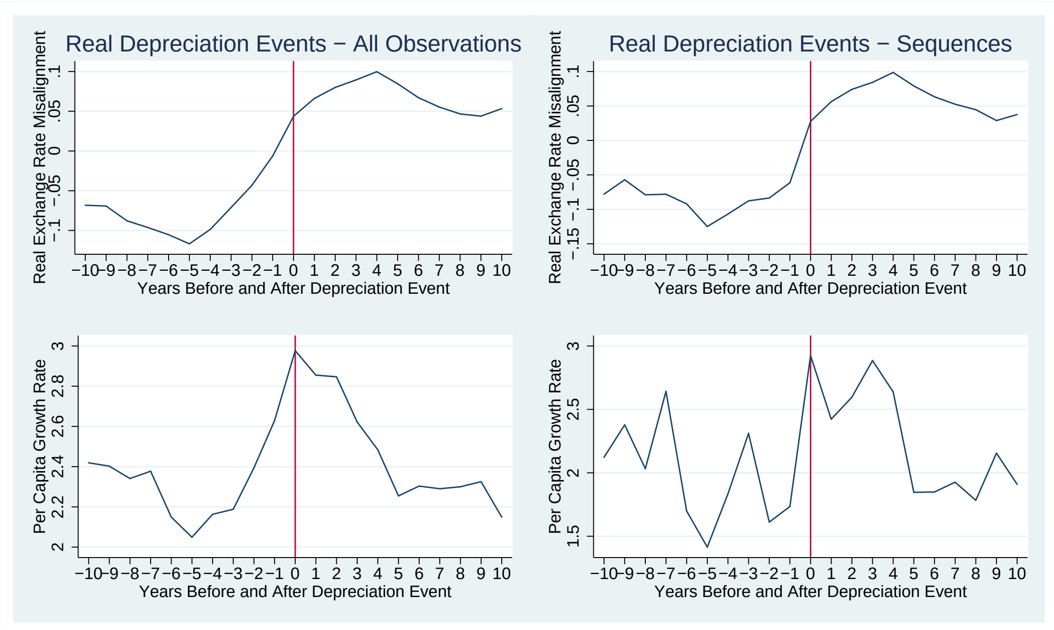


Figure 4.4 shows the evolution of real exchange rate misalignment and per capita growth centered on depreciation events. In the upper left panel a moving window

very transparent and that sensitivity tests can reveal the adequacy of the chosen thresholds.

[24] The difference in frequencies can be interpreted as a first indication that the association between growth accelerations and depreciation events is less clear-cut than generally suggested. It also highlights the importance of the selectivity problem mentioned in footnote 5.

Table 4.2: Growth Before and After Depreciation Events

Before Event \ After Event	Negative growth	Slow growth	Fast growth	Very fast growth	Total
Negative growth	46	60	29	35	170
	(0.27)	(0.35)	(0.17)	(0.21)	(0.18)
Slow growth	38	89	76	68	271
	(0.14)	(0.33)	(0.28)	(0.25)	(0.29)
Fast growth	13	57	65	58	193
	(0.07)	(0.30)	(0.34)	(0.30)	(0.21)
Very fast growth	31	46	61	151	289
	(0.11)	(0.16)	(0.21)	(0.52)	(0.31)
Total	128	252	231	312	923
	(0.14)	(0.27)	(0.25)	(0.34)	(1.00)

Notes: This table reports the transition probabilities of moving from the horizontal state of growth to the vertical one in the five years before and after a real depreciation event. Thereby, negative growth refers to average growth of income per capita below 0 %, slow growth to growth between 0 and 2 %, fast growth to growth between 2 % and 3.5 % and very fast growth to growth of more than 3.5 %. Numbers in parenthesis are percentages relative to the total number of events.

is placed around each observation that qualifies as a depreciation event whereas the upper right panel restricts attention to sequences.[25] As expected, real depreciation events start with a noticeable real depreciation. This is very obvious in the upper right panel. As a result of averaging over overlapping moving windows the real depreciation in the upper left panel starts well before the year in which the typical event is recorded. The lower part of Figure 4.4 analyzes the evolution of per capita growth centered on depreciation events. On average, economic growth increases by about one pp. While this is less than the two percentage point increase required for growth accelerations, it is a first indication of the existence of a growth-conducive effect. As a result of smoothing the growth effect is more visible in the lower left panel.

Going beyond averages the growth experiences around real depreciation events are reorganized in a transition matrix in Table 4.2. Growth is categorized as negative growth, slow growth ($0\% \leq \bar{g} < 2\%$), fast growth ($2\% \leq \bar{g} < 3.5\%$) or very fast growth ($\bar{g} > 3.5\%$). Rows refer to the state of growth in the five years preceding the event, columns to the five years following it.

[25]Unlike in Section 4.3.2 where the subsequent dependent variable has been considered, here the independent variables are of interest so that this time overlapping event windows are allowed.

Table 4.3: Basic Depreciation Events - Growth Effects By Regions and Decades

Region	Growth Prior to Event	Growth Post Event	Number of Obser-vations	Decade	Growth Prior to Event	Growth Post Event	Number of Obser-vations
Africa	2.220	1.558	322	1950	2.570	2.865	27
Asia	3.417	3.753	253	1960	3.623	3.437	218
Europe	3.235	3.370	90	1970	3.569	2.707	213
Latin America	1.520	2.685	216	1980	1.275	1.954	166
Other	1.930	2.212	42	1990	1.495	1.919	224
				2000	1.518	3.597	75
Total	2.470	2.630	923	Total	2.330	2.663	923

Notes: This table reports the average growth of income per capita in the five years before and after a real depreciation event by region and decade.

Real depreciation events do not follow obvious rules. Sustained real depreciations happen in all kinds of growth states and lead to all kinds of growth responses. While growth increases in 36 % of all cases after a real depreciation and moves up by at least one category, it slows down in 26 % of the cases and remains in the same category as initially in 38 % of the cases. Overall, this distribution is in accordance with the slight overall growth effect observed before. In terms of growth accelerations it is interesting to note that the growth rate jumps upwards by two or three categories in no fewer than 14 % of the identified events. In one third of the cases very fast growth is observed afterwards. Hence, while rapid growth may not be the rule after a depreciation event, neither does it seem to be an exception.

Finally, Table 4.3 reports the average level of growth five years before and after a depreciation event, divided by regions and decades. In line with the previous results average growth increases only modestly after an event. However, there are clear differences across regions and decades. For instance, in Latin America depreciation events increase the average growth rate by 1 pp. whereas in Asia an increase of only 0.3 pp. is recorded. However, growth before the event equals only 1.5 % in Latin America compared to 3.4 % in Asia. Interestingly, average growth decreases after a real depreciation event in Africa, a feature which cannot easily be reconciled with the notion that real depreciations and real undervaluation are particularly beneficial in very poor countries.[26] Turning to the impact over time, there is some evidence that real depreciations have become more growth-promoting in recent decades. The largest growth rate increases are recorded in the first decade of this century. In con-

[26] One reason for the negative growth effect observed in African countries might be strongly resource-dependent growth models.

trast, average growth decreased after real depreciation events in the sixties and the seventies of the last century.

According to Section 4.3.2 a concomitant reduction of real exchange rate volatility might improve the identification of growth-conducive real depreciation events. Therefore, an additional and refined definition is suggested (definition 2), whereby events have to fulfill one further condition:

3. Real exchange rate volatility decreases: $v_{post} - v_{prior} < 0$.

Surprisingly, the descriptive results remain essentially unchanged if the refined definition of depreciation events is used. Obviously, a smaller number of observations (537) qualifies as real depreciation events due to the additionally imposed condition. Besides that, the patterns of real depreciation events remain more or less unaffected. Average real misalignment moves from a 5 % overvaluation to an undervaluation of almost 10 %. Approximately 45 % (243) of the events begin with an undervalued real exchange rate to start with. Sequences of depreciation events happen, even though they are somewhat less common and the longest sequence consists of only seven consecutive years. In terms of Figure 4.4 one difference is that the actual depreciation *always* precedes the recorded starting date of the event. The array of growth experiences is very similar in relative terms to that of definition one as are the average growth rates across regions. Averages across decades differ slightly in that the largest increase in growth rates is recorded in the eighties.

4.4 Predicting Growth Accelerations

4.4.1 Estimation Strategy

This section analyzes whether there exists a *statistically* significant link between real depreciation events and growth accelerations. Having identified the set of depreciation events that is the most likely one to be linked to the beginning of growth accelerations, a pooled binary choice model in the vain of HPR is estimated:[27]

$$Pr(s_{it} = 1|x_{it}, d_t) = F(\beta_0 + \beta_1 x_{it} + d_t). \tag{4.3}$$

The dependent variable s is a dummy variable that takes the value 1 in a three year window centered on the identified growth accelerations and zero otherwise. The empirical strategy is to compare countries that have experienced a growth acceleration in a given year to countries that could have experienced one, but have not. Therefore, all observations are dropped if a growth acceleration cannot occur by definition. This concerns all observations before 1957 and after 2000 and all observations in the first n years after an acceleration.

As in HPR the explanatory variables (x) consist exclusively of indicator variables that capture potentially relevant changes in growth fundamentals. Apart from real depreciation events, the "traditional" determinants positive and negative political regime changes and major economic reforms are included. Major changes in the volumes traded are used instead of terms-of trade shocks for lack of a long time series of the latter.[28] A full set of time dummies (d) is used in all specifications to control for external circumstances that influence all countries in a similar way. The time dummies are jointly significant at the 1%-level. The cumulative logistic distribution is chosen as the main specification for F.

Subsequent studies on growth accelerations often include a wide variety of additional explanatory variables. As in growth regressions, it is easy to justify their inclusion given the open-endedness of growth theories.[29] Both changes of growth determinants and time-invariant country characteristics are used, the latter being

[27]Due to the panel nature of the data, other authors argue that a correctly specified model has to include country-specific effects. Therefore, they estimate either a random-effects probit model (Hausmann et al., 2006; Imam and Salinas, 2008) or a conditional fixed-effects logit model [CFEL] (Jong-A-Pin and de Haan, 2011). However, these specifications have their own difficulties. Random-effects models are inconsistent if explanatory variables are correlated with the country-specific effects. Fixed-effects models restrict the sample to countries that have experienced at least one growth acceleration, because the country dummy perfectly predicts the outcome in countries with no acceleration. I have attempted to estimate a random-effects probit model, too, but obtained numerically unstable results. I have tested the pooled specification versus the alternative CFEL model using a Hausman test statistics. The null hypothesis of no country-specific effects is usually not rejected at the five percent level if explanatory variables refer to shocks only. Cf. Greene (2010, chap. 23) and Dovern and Nunnenkamp (2007).

[28]The construction of the variables follows HPR; details are delegated to Appendix 4.A.

[29]Cf. e.g. Durlauf et al. (2005) or Durlauf et al. (2008) on this question.

justified as determining the capacity of a country to transform economic shocks into economic growth (Eichengreen, 2008; Imam and Salinas, 2008). The decision to stick to the parsimonious HPR-specification is rationalized as follows: First, the results on depreciation events are rather insensitive to this decision (cf. Section 4.4.6). Second, the deviation residuals, which in large samples should follow a standard normal distribution, feature less outliers in the parsimonious specification (Menard, 2001, Section 4.4). Third, a Hausman-test tends to reject the null hypothesis of no country-specific effects the more non-event variables are included.[30] Moreover, by sticking to the HPR-specification, this paper comes closest to corroborating *their* claim on the relation between real depreciations and growth accelerations.

Before proceeding and in light of Figure 4.1, it is crucial to consider whether the occurrence of real depreciation events is likely to be influenced by the occurrence of growth accelerations and, if so, in which way an endogeneity bias could cut. If growth accelerations made real depreciation events more likely, the growth effect of the latter would be overstated. Such a link is conceivable if governments following a competitive exchange rate strategy were encouraged to increase the dosage of undervaluation as a reaction to success (Eichengreen, 2008). However, from a theoretical point of view it is equally if not more likely that a sharp acceleration of the growth rate leads to rising price levels and capital inflows and thus to an appreciation of the real exchange rate (Rodrik, 2008). This could cause an endogeneity problem in the opposite direction: if growth accelerations reduce the likelihood of a real depreciation event, the growth effect of the latter would be understated in the analysis.

Compared to traditional panel growth regressions, the setup of the analysis makes an endogeneity problem less likely for the simple fact that the focus is on discrete events as opposed to continuous growth effects. Moreover, due to the sluggishness of price adjustment, increasing price levels will take a while before they materialize and prompt a change in the real exchange rate. This delay makes an endogeneity problem of the second sort less likely. Regarding the first channel, the fact that a further depreciation of the real exchange rate in the presence of fast growth is required as opposed to simply maintaining the level of real undervaluation makes the argument less convincing.

---

[30] For instance, de Mello et al. (2011) and Eichengreen et al. (2012) include per capita income in their specifications. If income per capita is included in my specification, the Hausman-test clearly rejects the hypothesis of no country-specific effects at the 1%-level.

Another way of gauging the extent of a potential endogeneity problem is to estimate a binary choice model that relates depreciation events to lagged growth accelerations (Furceri and Mourougane, 2012; Kappler et al., 2012). If lagged growth accelerations were predicting real depreciation events, this could be a sign for an endogeneity problem. However, in the implementation of this approach it is necessary to account for sequences of depreciation events. If several observations in a row qualify as depreciation events, depreciation events may coincide with lagged growth accelerations without necessarily pointing at an endogeneity problem because the latter may have been caused by preceding events of the former. Therefore, attention should be restricted to the onset of depreciation events. There is no evidence that lagged growth accelerations or lagged acceleration episodes are useful for predicting the onset of depreciation sequences.[31] In view of the following results,[32] it is of further interest to note that the coefficients on all measures of lagged growth accelerations, although insignificant, are always positive. Therefore, a negative effect of growth accelerations on the likelihood of depreciation events appears unlikely. Finally, various authors have accounted for the potential endogeneity of the real exchange rate in panel growth regressions by using a system GMM estimation approach. Usually, neither the sign nor the significance of the estimated effect is affected in comparison to the standard OLS approach (Nouira and Sekkat, 2012; Razmi et al., 2012; Rodrik, 2008; Schröder, 2013).

4.4.2 Baseline Results

The baseline parametric results are presented in Table 4.4. In order to facilitate the interpretation, average marginal effects (AME) and their significance levels are reported. Usually, if the AME is significant, the estimated coefficient is, too. If the AME is significant at least at the ten percent level, but the estimated coefficient is not (or vice versa), this is marked separately in the tables.[33]

For comparative purposes, col. 1 mirrors HPR's main specification and includes only economic reforms, political regime changes, and positive external shocks as explanatory variables. Economic reforms and negative political regime changes significantly increase the likelihood of a growth acceleration by four and five percentage

[31] A table is delegated to Appendix 4.C.

[32] The results do not support a strong link between real depreciation events and growth accelerations.

[33] Greene (2010) points out that AMEs are implications of the estimated model and should not be used for hypothesis tests and inferences about its structural aspects.

Table 4.4: Predicting Growth Accelerations - Basic Results

	Dependent Variable is a Dummy for the Timing of Growth Accelerations											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Economic Reforms	0.040*	0.043*	0.041*	0.044*	0.041*	0.040*	0.043*	0.041*	0.043*	0.041*	0.046*	0.042*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Pos. Regime Changes	−0.017	−0.019	−0.021	−0.018	−0.015	−0.019	−0.018	−0.017	−0.018	−0.017	−0.019	−0.020
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Neg. Regime Changes	0.051*	0.049*	0.050*	0.049*	0.053*	0.050*	0.052*	0.051*	0.050*	0.050*	0.048+	0.048+
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
Pos. External Shocks	0.022	0.018	0.015	0.018	0.027	0.021	0.019	0.020	0.020	0.020	0.016	0.015
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Depreciation Events 1		0.038*										
		(0.01)										
1. Over- to Overvalued											0.067**	
											(0.02)	
2. Under- to Undervalued											0.029	
											(0.02)	
3. Over- to Undervalued											−0.015	
											(0.03)	
Depreciation Events 2			0.049**									
			(0.02)									
1. Over- to Overvalued												0.058+
												(0.03)
2. Under- to Undervalued												0.068*
												(0.03)
3. Over- to Undervalued												−0.037
												(0.03)
Sensitivity - Event Definition 3				0.046*								
(Depreciation ≤ 15 %)				(0.02)								
Sensitivity - Event Definition 4					−0.036+							
(Depreciation > 30 %)					(0.02)							
Sensitivity - Event Definition 5						0.021						
(Lasting 7 years)						(0.02)						
Sensitivity - Event Definition 6							0.029**					
(Lasting 3 years)							(0.01)					
Sensitivity - Event Definition 7								0.017				
(Yearly Depreciation ≤ 30 %)								(0.01)				
Real Appreciation									−0.013			
(Sustained, up to 30 %)									(0.01)			
Real Appreciation										−0.016		
(Yearly, up to 30 %)										(0.01)		
Pseudo R^2	0.054	0.057	0.058	0.057	0.055	0.056	0.057	0.055	0.055	0.055	0.059	0.060
No. of Growth Accel.	128	128	128	128	128	127	128	128	128	128	128	128
Observations	3288	3288	3288	3288	3288	3285	3288	3288	3288	3288	3288	3288

Notes: Estimated by pooled logit. The coefficients are average marginal effects. Standard errors are given in parenthesis.
+,*,** denote significance at the 10, 5 and 1 percent level. ! denotes opposing conclusions regarding the significance of the AME and the estimated coefficient at the 10 percent level. For instance, ! means that the AME is not significant, but the estimated coefficient has a p-value lower than 0.1. *! indicates that the AME is significant at the 5 percent level, but the estimated coefficient is not significant at the 10 percent level. All estimations include a full set of time dummies.

points, respectively.[34] Unlike in HPR, there is no evidence that positive regime changes or positive external shocks impact significantly on the likelihood of growth accelerations. This finding is in line with Freund and Pierola (2012) who report that export surges do not generally coincide with growth accelerations. A standard finding in the growth acceleration literature is the limited explanatory power of the models. The current model is no different: Pseudo-R^2 is a meager 5 %.

Col. 2 and 3 introduce the variable of interest. Col. 2 uses the main definition of depreciation events, col. 3 employs the refined one. All depreciation events are included. Both types of depreciation events are significant predictors of growth accelerations and improve pseudo-R^2. The AME for the main definition equals 0.038, i.e. on average a depreciation event increases the likelihood of a growth acceleration by 3.8 pp. Using the refined definition the AME increases to almost 5 pp.

In the following, the sensitivity of results with regard to the key building blocks of the event definition is considered. Results are reported for the main definition, only, but results for the refined one are comparable. Col. 4 and 5 address the thresholds chosen for the magnitude of the real depreciations. For instance, if depreciated real exchange rates work chiefly via improved competitiveness of the export sector, larger real depreciations might do an even better job of predicting growth accelerations than the chosen ones. This conjecture, however, is not supported by the data. Col. 4 shows that sustained depreciation events remain significant predictors of growth accelerations if depreciations are restricted to be no more than 15 pp. Contrary to that, large real depreciations exceeding 30 pp. *reduce* the likelihood of growth accelerations significantly with the AME equaling – 3.6 pp. (col. 5). Hence, larger real depreciations do not trigger growth accelerations more successfully than smaller ones. One likely reason is the costs of sharp depreciations. While exports become more competitive, expenditure switching and balance sheet effects have to be considered, too (Bussière et al., 2012).

[34]The positive effect of autocratic regime changes has been noted frequently in the literature on growth turnarounds (Dovern and Nunnenkamp, 2007; Guillaumont and Wagner, 2012; HPR; Pattillo et al., 2005; Wong and Li, 2012) and is explained by the ability of benevolent autocrats to force savings, to resist particularistic pressures and to implement growth-enhancing measures without political constraints. Easterly (2011) cautions that empirically there is little evidence to support the benevolent dictator hypothesis. He argues that high growth episodes are more frequently found under autocracy than democracy simply because the variance of growth is higher under the former than under the latter.

Col. 6 – 8 deal with the second key assumption that requires the depreciated real exchange rate to be sustained for five years. Col. 6 and 7 consider depreciation events during which the real exchange rate is sustained for 7 or 3 years, respectively. Whereas real depreciations sustained for 3 years (col. 7) remain significant predictors of growth accelerations, those sustained for 7 years (col. 6) do not. Neither are depreciation events significant in the absence of a minimum duration requirement (col. 8).[35] The fact that depreciated real exchange rates have to be sustained for a minimum period of time in order to observe a positive effect on growth accelerations conforms to the notion that a reallocation of resources towards the tradeable sector is at the heart of the growth process. However, sustaining the depreciated real exchange rate for too long does not seem to be beneficial and might point at exchange rate induced misallocations.

Despite the majority of growth accelerations coinciding with real appreciations, col. 9 and 10 show that there is no significant positive association between these two events. In contrast, real appreciation events defined analogously to real depreciation events tend to make growth accelerations less likely as indicated by the negative sign of the AME. This is true whether sustained (col. 9) or yearly (col. 10) real appreciations of up to 30 % are considered. Changing the thresholds does not alter the thrust of the results. In sum, these results indicate that real depreciations have some leverage in explaining the beginning of growth accelerations. However, the association is only observed for a very specific subset where real depreciations are limited in magnitude and sustained over several years. It remains to be seen to what extent the uncovered link is robust to other variations.

In the final columns of Table 4.4 the level of the real exchange rate is used to split depreciation events into three categories: events that start and end at overvalued real exchange rate levels, events that start and end at undervalued levels and events that change the real exchange rate from being overvalued in real terms to becoming undervalued.[36] The average marginal effects both for definitions 1 and 2 are reported in col. 9 and 10.

[35] As a matter of fact, a minimum duration of two years does not lead to significant results, either.

[36] The means for the level of misalignment before and after the depreciation are -0.38/-0.25 for category one, 0.26/0.40 for category 2 and -0.08/0.09 for category three using event definition 1 and -0.36/-0.22, 0.26/0.41, -0.09/0.09 using event definition 2.

If the main definition is applied, only the subset of real depreciation events that reduces notable currency overvaluation increases the likelihood of growth accelerations significantly (col. 11). The AME of this category is almost twice as large as that for the overall depreciation event (6.7 pp.). Accordingly, the AME for the other two categories are insignificant and smaller than the overall effect. It is even negative if a real exchange rate close to its equilibrium value is depreciated. Using the refined definition, real depreciation events increase the likelihood of growth accelerations if they reduce serious overvaluation or if they further increase real undervaluation. As before, depreciating a more or less correctly aligned real exchange rate does not offer advantages (col. 12).

The more detailed analysis in col. 11 and 12 is a warning that real depreciations might have different and even offsetting effects depending on the level of the real exchange rate to begin with. This is similar to the problem arising in growth regressions: Estimating a common coefficient for real over- and undervaluation implicitly assumes equal and opposing effects of the two types of misalignment. However, this assumption is not warranted without further assumptions and needs to be explicitly tested for (Nouira and Sekkat, 2012; Schröder, 2013). Whether it is necessary to differentiate between the subcategories of depreciation events in this sample is not entirely obvious. The p-value of a likelihood-ratio test for the equality of coefficients equals 0.1034 for the main definition and 0.0876 for the refined one. Hence, while formally equal coefficients are accepted at the ten percent level in the first case but not in the second one, this result is teetering on the razor's edge. To be on the safe side, the following sections will account for possibly distinct impacts across subcategories of depreciation events, too.

4.4.3 Developing Countries

This section aims at validating the link between real depreciation events and growth accelerations in the subsample of developing countries, only. Developing countries are identified according to two schemes. The first definition focuses on relative income levels. A country is classified as a developing one if income per capita in 1960 does not exceed 60 % of US income per capita in that year (or, if 1960 is not available, in the year closest to 1960). The country switches its status from developing to developed if it successfully embarks on a development process such that its income exceeds 60 % of US income permanently in all remaining years in the sample.[37] The second classification is more restrictive and relies on absolute income levels. Inspired by Rodrik (2008) a country is classified as a developing one up until the year that income per capita exceeds 6000 US$ for the first time.[38] The two classifications differ in particular with regard to emerging markets, which are included as developing countries in the first definition, but not in the second one.

The initial columns of Table 4.5 refer to the relative country classification. The first two columns consider the aggregate effect of real depreciation events, the following two columns account for the level of real misalignment. Contrary to expectations, real depreciation events of type 1 are no longer significantly associated with growth accelerations. Events of type 2 remain significant predictors of growth accelerations, albeit the magnitude of the AME and its level of significance is reduced. When accounting for the level of real misalignment, depreciation events of type 1 that correct highly overvalued real exchange rates become significant predictors of growth accelerations in this sample, too. In contrast, depreciation events of type 2 are associated with growth accelerations only if they enhance an already existing real undervaluation. In both cases, however, a likelihood ratio test accepts the hypothesis of equal coefficients across misalignment categories by a wide margin and thus supports an overall insignificant effect at least for events of type 1.[39] Col. 5 to 8 refer to the alternative country classification relying on absolute income levels. In this sample neither depreciation events of type 1 (col. 7) nor depreciation events of type 2 (col. 8) nor subsets of depreciation events (col. 9 and 10) are useful predictors of growth accelerations.

The largely lacking association between real depreciations and the timing of growth accelerations in developing countries is puzzling. It is generally accepted that real exchange rate strategies work particularly well in low income countries (Rapetti, 2012; Razmi et al., 2012; Rodrik, 2008) even if the appropriate income thresholds remain disputed (Rapetti et al., 2012; Woodford, 2008).[40] The lack of

[37]Based on this rule, the following countries become developed with effect from the stated years: Spain (1995), Finland (1994), Greece (2004), Hong Kong (1980), Ireland (1995), Italy (1967), Japan (1969), Singapore (1988), Taiwan (2006), Trinidad & Tobago (2007).

[38]Rodrik (2008) defines countries with yearly per capita income below 6000 US$ as developing. Woodford (2008) and Razmi et al. (2012) criticize this cutoff point as arbitrary and show that the results are quite sensitive to the chosen threshold level of income. This is one reason why I use two different classification schemes for developing countries.

[39]The p-values are 0.2663 and 0.1745, respectively.

[40]Developing countries have idle resources in agriculture that can be reallocated towards

Table 4.5: Predicting Growth Accelerations – Developing Countries

	Dependent Variable is a Dummy for the Timing of Growth Accelerations							
	Relative Definition				Absolute Definition			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Economic Reforms	0.059*	0.059*	0.062*	0.059*	0.074*	0.074*	0.077*	0.075*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Pos. Regime Changes	–0.022	–0.024	–0.023	–0.024	–0.017	–0.018	–0.017	–0.018
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Neg. Regime Changes	0.044+	0.044+	0.043+	0.043+	0.058*	0.058*	0.057*	0.057*
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Pos. External Shocks	0.012	0.010	0.012	0.011	0.004	0.003	0.002	0.003
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Depreciation Events 1	0.019				0.006			
	(0.02)				(0.02)			
1. Over- to Overvaluation			0.046+				0.043	
			(0.03)				(0.03)	
2. Under- to Undervaluation			0.012				–0.008	
			(0.02)				(0.02)	
3. Over- to Undervaluation			–0.021				–0.041	
			(0.03)				(0.03)	
Depreciation Events 2		0.033+				0.015		
		(0.02)				(0.02)		
1. Over- to Overvaluation				0.034				0.031
				(0.03)				(0.04)
2. Under- to Undervaluation				0.054+				0.017
				(0.03)				(0.03)
3. Over- to Undervaluation				–0.042				–0.026
				(0.04)				(0.04)
p-value (categories)			0.266	0.175			0.133	0.613
Pseudo R^2	0.050	0.050	0.051	0.052	0.060	0.061	0.063	0.061
No. of Growth Accel.	114	114	114	114	80	80	80	80
Observations	2659	2659	2659	2659	1859	1859	1859	1859

Notes: Estimated by pooled logit. The coefficients are average marginal effects. Standard errors are given in parenthesis.
+,*,** denote significance at the 10, 5 and 1 percent level. ! denotes opposing conclusions regarding the significance of the AME and the estimated coefficient at the 10 percent level. For instance, ! means that the AME is not significant, but the estimated coefficient has a p-value lower than 0.1. *! indicates that the AME is significant at the 5 percent level, but the estimated coefficient is not significant at the 10 percent level. All estimations include a full set of time dummies.

association could in principle result from unfortunate averaging. For instance, HPR have noted that growth accelerations tend to be triggered by different conditions depending on whether the increase in average growth is sustained or not. If real depreciation events are relevant determinants of accelerations in one subset only, the relative frequency of sustained versus unsustained accelerations becomes an issue and could drive overall results. Alternatively, in view of Table 4.3 the lack of association might be attributable to distinct effects over time. Again, the composition of the sample would become relevant. However, it is also conceivable that poorer countries have difficulties in translating the advantages of a more depreciated real exchange rate into high growth. In addition to depending on exports of natural resources, the countries may lack human capital, production facilities, infrastructure or institutions that are necessary to turn a real depreciation event into a high growth event. This is not necessarily at odds with a significant marginal effect of real depreciations in growth regressions, since a marginal increase in the growth rate is arguably a different endeavor from a jump of the growth rate by several percentage points. The following two sections gauge to what extent distinguishing between sustained and unsustained growth accelerations and allowing for differential effects of real depreciations over time offer an explanation for the peculiar results of this section.

4.4.4 Sustained versus Unsustained Growth Accelerations

Following HPR, a growth acceleration is called sustained if average growth in the ten years following the acceleration remains above 2 %. The other episodes are labeled unsustained. Since this classification requires additional data points beyond the onset of a growth acceleration, only growth accelerations starting before 1991 can be considered. The sample size is diminished accordingly. Altogether, 104 growth episodes are identified of which 52 are sustained growth accelerations and 52 are unsustained ones.

Table 4.6 displays the results for real depreciation events of type 1. Results us-

the tradeable sector in the presence of real exchange rate undervaluation and thereby generate export-led growth. At the initial stages of development countries compete in low-tech products like light manufactures where low wages and prices are essential. As countries move closer to the technology frontier, their competitiveness tends to rely more and more on innovation and the quality of products, and the real exchange rate becomes only one of several levers for growth. For this reason a real exchange rate based growth strategy is expected to work best in poor countries. Cf. for instance Lin (2011, 2012), Rapetti (2012), Razmi et al. (2012), Rodrik (2008).

Table 4.6: Predicting Growth Accelerations - Sustained versus Unsustained

Dependent Variable is a Dummy for the Timing of Growth Accelerations

	All Countries			Developing Countries			
				Relative Definition		*Absolute Definition*	
	(1) all	(2) sus.	(3) unsus.	(4) sus.	(5) unsus.	(6) sus.	(7) unsus.
Depreciation Events 1	0.037*	0.035*	0.015	0.022	0.014	0.003	0.013
	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)
Economic Reforms	0.050+	0.040+	0.011	0.080*	0.003	0.206**	0.023
	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.06)	(0.03)
Pos. Regime Changes	−0.040*	−0.007	−0.031**	−0.005	−0.037**	0.020	−0.049**
	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.03)	(0.02)
Neg. Regime Changes	0.048+	0.031	0.024	0.041+	0.017	0.079**	0.013
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)
Pos. External Shocks	0.012	−0.007	0.013	−0.013	0.013	−0.015	0.003
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
Over- to Overvalued	0.080**	0.074**	0.001	0.062*	0.004	0.055+	0.003
	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
Under- to Undervalued	0.031	−0.002	0.039+	−0.010	0.031	−0.046**	0.028
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
Over- to Undervalued	−0.072**		−0.018		−0.020		−0.012
	(0.02)		(0.02)		(0.03)		(0.04)
p-value (categories)	0.004	0.007	0.143	0.013	0.311	0.001	0.618
Pseudo R^2	0.077	0.141	0.038	0.127	0.043	0.199	0.037
No. of Growth Accel.	96	48	48	42	44	27	35
Observations	2426	2186	2591	1782	2079	1082	1369

Notes: Estimated by pooled logit. The coefficients are average marginal effects. Standard errors are given in parenthesis.

+,*,** denote significance at the 10, 5 and 1 percent level. ! denotes opposing conclusions regarding the significance of the AME and the estimated coefficient at the 10 percent level. For instance, ! means that the AME is not significant, but the estimated coefficient has a p-value lower than 0.1. *! indicates that the AME is significant at the 5 percent level, but the estimated coefficient is not significant at the 10 percent level. All estimations include a full set of time dummies.

ing the refined definition of depreciation events are not presented separately because the main insights do not change. This applies to the present and all following sections. The first line reports the AME for the aggregate indicator of real depreciation events. The detailed results account for the level of real misalignment and are presented below. Col. 1 shows that results in the reduced sample are very similar to previous results. Real depreciation events remain significant predictors of growth accelerations. This feature is due to the growth-conducive effect of reducing large currency overvaluation that dominates a negative impact of depreciating relatively well aligned real exchange rates.

Col. 2 and 3 reveal striking differences in the respective determinants of sustained and unsustained growth accelerations.[41] The first point to note is the better predictability of sustained growth accelerations as reflected in the much higher Pseudo-R^2. The second point to note is that no determinant is a significant predictor of both sustained and unsustained accelerations. Sustained accelerations are ignited by economic reforms and by real depreciations that reduce real overvaluation and thereby move the real exchange rate towards its equilibrium value. Moving the real exchange rate further away from its equilibrium value by increasing real currency undervaluation triggers unsustained growth accelerations, but only barely. Improving political circumstances reduce the likelihood of unsustained accelerations. A likelihood ratio test rejects the hypothesis of equal coefficients across subtypes of depreciation events by a wide margin for sustained growth accelerations ($p = 0.008$), but not for unsustained one. Hence, this time there is strong evidence that different kinds of depreciations have distinct effects.

Col. 4 – 7 address developing countries specifically. As before, Pseudo-R^2 of sustained accelerations exceeds Pseudo-R^2 of unsustained ones by several orders of magnitude. Most intriguingly and in contrast to Section 4.4.3, sustained growth accelerations in the subset of poor developing countries are driven by the same determinants as in the total sample. This notably includes the reduction of currency overvaluation. However, even though real depreciations reducing real overvaluation increase the likelihood of sustained growth accelerations for poor countries by 6.2 pp. (col. 4) and 5.5 pp. (col. 6), respectively, depreciation events as a whole are never significant predictors thereof. Technically, this is due to the negative impact of real

[41] The varying number of observations is due to years in which no sustained or no unsustained acceleration is recorded and which therefore cannot be considered in the estimation.

depreciations that further increase prior undervaluation. The most effective measure in developing countries to achieve a sustained growth acceleration is economic reforms. In very-low income countries economic reforms have an overwhelming AME of more than 20 pp. (col. 6). Similar to the complete sample, unsustained growth accelerations remain essentially unpredictable in developing countries, too.

In reference to Easterly et al. (1993) the results suggest that sustained growth accelerations can be triggered by good policy whereas unsustained growth accelerations seem to be triggered by good luck. Since there are relatively more unsustained growth episodes in the sample of developing countries than in the total sample and since unsustained episodes are not linked to real depreciation events, this feature may partly explain the overall insignificance of real depreciation events observed in Section 4.4.3. More generally, this section implies that the impact of real depreciations on economic growth needs to be qualified. Realigning an overvalued currency closer to its equilibrium value seems to be a policy measure potentially triggering sustained growth accelerations regardless of the sample in question. Contrary to that, depreciating already undervalued currencies yet further does not have a similar positive effect and may even be detrimental. Hence, real exchange rate strategies have to account for the specific circumstances they are implemented in.

4.4.5 Stability over Time

This section explores the stability of the link between real depreciation events and growth accelerations over time. To that end, the sample is split into two subsamples using the year 1980 as the cut-off point.[42] Results are reported in Table 4.7, which presents the AME for the aggregate indicator of real depreciation events in the first line and the detailed results below.

Results are remarkably different across the two time periods. First, Pseudo-R^2 and thus predictability of growth accelerations is more than twice as large in the period up to 1980 (col. 1) than in the more recent one (col. 2). Second, the "traditional" determinants of growth accelerations, in particular economic reforms and political regime changes, are useful for predicting fast growth episodes in the first subperiod only. Third and related to the previous point, the likelihood of a growth acceleration in the second subperiod is increased significantly by real depreciation events, only.

[42] The following results also hold for different cut-off points in the vicinity of 1980.

Table 4.7: Predicting Growth Accelerations - Stability over Time

	Dependent Variable is a Dummy for the Timing of Growth Accelerations					
	All Countries		Developing Countries			
			Relative Definition		*Absolute Definition*	
	(1)	(2)	(3)	(4)	(5)	(6)
Before/After 1980	before	after	before	after	before	after
Depreciation Events 1	0.034	0.043*	0.015	0.025	−0.009	0.024
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
Economic Reforms	0.065!	0.017	0.132*	0.018	0.255**	−0.001
	(0.04)	(0.02)	(0.06)	(0.02)	(0.09)	(0.02)
Pos. Regime Changes	−0.043	−0.005	−0.033	−0.009	0.005	−0.010
	(0.03)	(0.02)	(0.03)	(0.02)	(0.04)	(0.02)
Neg. Regime Changes	0.068*	0.024	0.070+	0.015	0.075+	0.052
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
Pos. External Shocks	0.005	0.018	−0.002	0.011	−0.015	0.001
	(0.04)	(0.02)	(0.04)	(0.03)	(0.05)	(0.03)
Over- to Overvalued	0.134**	−0.005	0.133**	−0.067**	0.105*	−0.058**!
	(0.04)	(0.02)	(0.04)	(0.02)	(0.05)	(0.02)
Under- to Undervalued	−0.035	0.085**	−0.054+	0.071*	−0.082**	0.096*
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)
Over- to Undervalued	−0.079**!	0.036	−0.089*!	0.035	−0.091+!	0.005
	(0.04)	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)
p-value (categories)	0.000	0.071	0.000	0.002	0.000	0.003
p-value (subperiods)	0.002		0.000		0.000	
Pseudo R^2	0.087	0.032	0.072	0.044	0.069	0.061
No. of Growth Accel.	71	57	62	52	53	27
Observations	1434	1854	1142	1517	897	962

Notes: Estimated by pooled logit. The coefficients are average marginal effects. Standard errors are given in parenthesis.
+,*,** denote significance at the 10, 5 and 1 percent level. ! denotes opposing conclusions regarding the significance of the AME and the estimated coefficient at the 10 percent level. For instance, ! means that the AME is not significant, but the estimated coefficient has a p-value lower than 0.1. *! indicates that the AME is significant at the 5 percent level, but the estimated coefficient is not significant at the 10 percent level. All estimations include a full set of time dummies.

However, unlike in the previous sections, the effect is driven by real depreciations of *already undervalued currencies* post 1980. Prior to 1980, not only are real depreciation events on aggregate not significantly related to growth accelerations, but the overall insignificant effect is the result of a positive and significant influence if large currency overvaluations are reduced and a negative (and partly significant) effect of the other depreciation events. Likelihood ratio tests indicate that it is necessary to account for differential impacts over time and over depreciation events. The equality of coefficients over depreciation events is rejected at the 1 -% -level before 1980 and at the 10 -% -level afterwards. A pooled estimation over time is rejected in favor of the separate estimation at the 1 -% -level.

The main results continue to hold in developing countries (col. 3 – 6). Although real depreciation events in aggregate are not significant predictors of growth accelerations neither in developing countries following the relative nor in developing countries following the absolute definition, the same pattern as before holds if depreciation events are disaggregated. Prior to 1980, real depreciations of highly overvalued currencies have a positive and significant impact on the likelihood of growth accelerations; post 1980 this applies to real depreciation events that further increase real undervaluation. The positive effects of these depreciation events are offset by negative effects of other depreciation events and turn the overall impact of real depreciation events insignificant. As before, the equality of coefficients over depreciation events and time periods is soundly rejected. The same offsetting effects would be observed if real depreciation events following the refined definition were used.

Hence, important structural changes seem to have taken place. Regarding the main variable of interest, the growth effect of real depreciation events depends on the concomitant level of the real exchange rate with real undervaluation gaining importance in the course of time. One plausible reason for this development is the most recent wave of globalization, i.e. the increasing integration of the world economy since the beginning of the 1980s. Cheaper transportation and increased financial integration may have made it easier for developing countries to benefit from undervalued real exchange rates e.g. by facilitating technology transfers through foreign direct investment or by facilitating an expansion of the export industry. As a result, formerly important negative effects of undervalued real exchange rates such as more expensive intermediate and investment goods may have become less relevant. Negative externalities in the sense of "beggar-thy-neighbor" might be a related reason. The more countries rely on deliberate real undervaluation as an export-promotion tool and growth strategy, the less likely a country is to achieve growth without this artificial boost in price competitiveness. Moreover, undervalued currencies might have become an essential element in avoiding premature de-industrialization and growth-reducing structural change, both of which become more likely with a higher degree of globalization (Edwards, 1986; IMF, 2008; McMillan et al., 2014; Nouira et al., 2011).[43]

Getting back to the original question whether real depreciation events are likely candidates to trigger a growth acceleration, the answer unfortunately is: it depends. Real depreciation events have distinct effects depending on time and details with often offsetting effects. Therefore, it does not seem to be warranted to speak of a robust association between real depreciations and growth accelerations. However, in very specific circumstances real depreciations can help triggering growth. Prior to 1980 reducing considerable real overvaluation has been a successful strategy. In more recent times the winning strategy has become to widen real undervaluation. In any case, the level of the real exchange rate plays a pivotal role in determining the impact of a real depreciation - a fact that would be missed if equal effects were simply assumed as is often done in panel growth regressions in the literature.

Compared to overall accelerations, sustained growth accelerations have shown remarkable stability in the sense that real depreciations of overvalued currencies robustly predict sustained growth episodes in all subsamples. However, by definition sustained growth accelerations have to start before 1991 so that this result, too, may be driven by the observations prior to 1980. A detailed look at the data indeed reveals that any link between growth accelerations and depreciation events from 1979 to 1991 has to be the result of depreciations of already undervalued currencies. In these years, other depreciation events are perfect predictors of failure so that their influence on the probability of growth accelerations, let alone sustained versus unsustained ones, cannot be estimated. However, a comparison of the AME of these

[43]Growth reducing structural change occurs in economies with large productivity gaps between plants or across sectors if displaced workers from one industry/firm end up in even lower-productivity activities such as informality or unemployment. This danger is particularly pronounced if a country's comparative advantage is in natural resources and primary products, because openness may amplify tendencies for exchange rate appreciations and thereby reduce the incentives for diversification towards modern manufactures in particular. Cf. McMillan et al. (2014).

kind of depreciation events on the likelihood of sustained and unsustained growth growth accelerations post 1980 shows that the AME is almost twice as large and much more significant for unsustained episodes than for sustained ones. Hence, it still seems that movements away from equilibrium are more useful for unsustained growth episodes than for sustained ones. Yet, a more formal support for this claim has to await longer time series.[44]

Finally and over and above the original research question, this section inadvertently serves as a warning that well-accepted results, too, may be driven by early experiences only (e.g. the importance of economic reforms for triggering growth accelerations - and sustained ones in particular - or the positive impact of negative political regime changes on the likelihood of overall growth accelerations). The lack of significant predictors for growth accelerations after 1980 is remarkable and indicates that globalization has likely changed not only the role of the real exchange rate, but also the role of other levers that countries have at their disposal to support economic growth.

4.4.6 Robustness Tests

This section completes the analysis with a variety of robustness checks, whereby robustness is checked with regard to the offsetting effects uncovered in Section 4.4.5. Results are mostly reported for the overall sample, important deviations in the samples of developing countries are noted in the text. Robustness is assessed with regard to estimation methods, filtering techniques and the use of alternative indicator variables. Moreover and despite the specification concerns mentioned in Footnote 27, this section shows that results remain robust even if quantitatively measured variables are added, a common practice in recent contributions. The robustness checks are restricted to the main definition of depreciation events, only.

The pooled probit, the linear probability model, the rare events logit and the pooled logit with cluster-robust standard errors are used as alternative methods of estimation to the pooled logit model. Results are summarized in Table 4.8, which reports whether the different growth determinants are significant at the 10%-level in the respective estimations. The signs of the significant effects correspond to those in Section 4.4.5. Generally speaking, the results are robust to the estimation method. The biggest deviations are observed if cluster-robust standard errors are applied.

[44]The results are delegated to Appendix 4.D.

Table 4.8: Robustness Checks Part 1 - Alternative Estimation Methods

		Economic Reforms	Positive Political Regime Changes	Negative Political Regime Changes	Positive External Shocks	Depreciation Events – Over- to Overvaluation	Depreciation Events – Under- to Undervaluation	Depreciation Events – Over- to Undervaluation
Pre–1980	Pooled Logit	+	–	+	–	+	–	–
	Pooled Probit	+	–	+	–	+	–	–
	Linear Probablility Model (Robust Standard Errors)	+	–	+	–	+	–	+
	Rare Event Logit	+	–	+	–	+	–	–
	Pooled Logit (Cluster Robust Standard Errors)	–	–	–	–	+	–	–
Post–1980	Pooled Logit	–	–	–	–	–	+	–
	Pooled Probit	–	–	–	–	–	+	–
	Linear Probablility Model (Robust Standard Errors)	–	–	–	–	–	+	–
	Rare Event Logit	–	–	–	–	–	+	–
	Pooled Logit (Cluster Robust Standard Errors)	–	–	–	–	–	+	–

Notes: + indicates that the estimated coefficient is significant at the 10 %–level, otherwise – is recorded. The signs of the coefficients equal those in Table 4.7, col. 1 and 2.

However, it is the "traditional" growth determinants that lose significance whereas the impact of depreciation events remains unchanged.[45]

Next, the robustness to alternative filtering rules is assessed. The first alternative reduces the minimum duration period of a growth acceleration to five years only, the second one drops the required minimum growth rate of 3.5 %.[46] The third alternative implements the refinements suggested by Jong-A-Pin and de Haan (2011), who criticize that the HPR-filter often identifies counterintuitive starting years of growth accelerations.[47]

[45] HPR and many subsequent contributions report pooled probit or logit results with robust standard errors. However, using robust standard errors implies that there is some kind of specification error, e.g. heteroscedasticity. In this case, the parameter estimates of non-linear models are inconsistent themselves, so that there is no need to compute consistent standard errors of inconsistent estimates (Giles, 2013; Greene, 2010). For this reason, this paper does not use robust standard errors. However, using them would not have changed the results.

[46] A lot of studies have altered the criteria for growth accelerations along these lines. For instance, Arbache and Page (2010), Dovern and Nunnenkamp (2007), Guillaumont and Wagner (2012), Imam and Salinas (2008), Pattillo et al. (2005), and Timmer and de Vries (2009) reduce both the required duration and the required minimum growth rate in their definitions.

[47] More precisely, they note that some of the growth accelerations identified by HPR record a negative growth rate in the first year of the acceleration or a higher growth rate in the

Table 4.9: Robustness Checks Part 2 - Alternative Definitions

	Dependent Variable is a Dummy for the Timing of Growth Accelerations									
	Alternative Definitions of Growth Accelerations						Alternative Indicators For Economic Reforms			Pol. Changes
Before/After 1980	(1) before	(2) after	(3) before	(4) after	(5) before	(6) after	(7) after	(8) after	(9) after	(10) after
	Minimum Duration: 5 years		*No Minimum Growth Threshold*		*Jong-A-Pin and De Haan (2011)*		*Financial Reforms*	*Trade Restrictions*	*Globalization*	*Cheibub et al. (2010)*
Economic Reforms	0.075+	0.023	0.034	0.117**	0.044	–0.003	0.051*	0.030!	0.030+	0.014
	(0.04)	(0.02)	(0.04)	(0.04)	(0.04)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Pos. Regime Changes	–0.039	–0.003	–0.067+	0.073*	–0.033	–0.006	0.013	0.001	–0.000	–0.008
	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Neg. Regime Changes	0.063*	0.032	0.050	0.296**	0.094**	0.033	0.051	0.032	0.034	0.019
	(0.03)	(0.04)	(0.04)	(0.07)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)
Pos. External Shocks	0.017	0.015	0.067	0.106**	0.030	–0.004	0.016	0.020	0.020	0.017
	(0.04)	(0.02)	(0.05)	(0.04)	(0.04)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
Over- to Overvalued	0.112**	–0.007	0.085*	0.138**	0.119**	–0.033	0.031	0.001	–0.006	–0.001
	(0.04)	(0.02)	(0.04)	(0.05)	(0.04)	(0.02)	(0.04)	(0.03)	(0.02)	(0.03)
Under- to Undervalued	–0.039	0.088**	–0.038	0.022	–0.041	0.091**	0.098**	0.099**	0.085**	0.083**
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Over- to Undervalued	–0.080*!	0.027	–0.043	0.300**	–0.084*!	–0.003		0.044	0.030	0.038
	(0.03)	(0.04)	(0.06)	(0.08)	(0.04)	(0.04)		(0.05)	(0.04)	(0.05)
Pseudo R^2	0.083	0.032	0.070	0.082	0.101	0.020	0.067	0.036	0.035	0.032
No. of Growth Accel.	108	99	92	118	71	59	36	54	56	56
Observations	1557	1946	1308	1516	1431	1842	1290	1763	1821	1847

Notes: Estimated by pooled logit. The coefficients are average marginal effects. Standard errors are given in parenthesis. +,*,** denote significance at the 10, 5 and 1 percent level. ! denotes opposing conclusions regarding the significance of the AME and the estimated coefficient at the 10 percent level. For instance, ! means that the AME is not significant, but the estimated coefficient has a p-value lower than 0.1. *! indicates that the AME is significant at the 5 percent level, but the estimated coefficient is not significant at the 10 percent level. All estimations include a full set of time dummies.

Reducing the required length of an acceleration or refining the filter according to Jong-A-Pin and de Haan (2011) does not alter the core results (Table 4.9, col. 1 – 2 and 5 – 6). In contrast, results are turned upside down when the minimum growth threshold is dropped (col. 3 – 4). Prior to 1980, the only growth determinant maintaining a positive and significant influence on growth accelerations is a reduction of currency overvaluation. Post 1980, almost any change of a growth determinant with the notable exception of an increase in real undervaluation is suited to trigger a growth episode. This indicates that not only are initiating and sustaining growth two different endeavors (Rodrik, 2005), but that increasing growth is also different from growing rapidly. It is a warning that results on growth accelerations should not be generalized without taking appropriate account of what exactly is meant by growth accelerations. This paper is explicitly concerned with the impact of real depreciations on rapid growth.

The following columns of Table 4.9 address the peculiar result that economic reforms are no longer associated with growth accelerations post 1980. The most likely explanation is that the applied indicator for economic reforms does no longer capture the relevant elements of reform in recent years.[48] By focusing on the more recent time period, only, alternative indicators can be used that cover potentially more relevant aspects (Abiad et al., 2008; Dreher, 2006; Dreher et al., 2009). Table 4.9 confirms that alternative indicators for economic reforms retain predictive power for growth accelerations post 1980, too. Col. 7 shows that major financial reforms remain significant as does a broad index for participation in globalization (col. 9). Contrary to that, an indicator that mostly captures the further removal of trade barriers and thus captures a similar element of reforms as the original indicator is only borderline significant in the total sample and becomes insignificant for developing countries. Hence, successful economic reforms depend on specific building-blocks that differ across time-periods. Unlike economic reforms, an alternative indicator for political regime changes (Cheibub et al., 2010) does not restore significance in the second subperiod (col. 10). The conclusions regarding real depreciation events are not affected.

year preceding the acceleration than in the starting year itself.

[48]For instance, the indicator does never record economic reforms in China. Furthermore, it does not take account of one of the mega-trends of recent years, namely financial liberalization.

Table 4.10: Robustness Checks Part 3 - Additional Covariates

	Dependent Variable is a Dummy for the Timing of Growth Accelerations								
	Additional Covariates						Magnitude of Real Depreciations		
	(1) before 1980	(2) after 1980	(3) before 1980	(4) after 1980	(5) before 1980	(6) after 1980	(7) total sample	(8) total sample	(9) total sample
			Average Marginal Effects					*Estimated Coefficients*	
Economic Reforms	0.062!	0.013	0.083+	0.014	0.064!	0.031	0.383*	0.404*	0.415*
	(0.04)	(0.02)	(0.04)	(0.02)	(0.04)	(0.02)	(0.38)	(0.40)	(0.42)
Pos. Regime Changes	–0.049+!	0.002	–0.054+!	0.004	–0.043	–0.002	–0.202	–0.193	–0.219
	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(–0.20)	(–0.19)	(–0.22)
Neg. Regime Changes	0.036	0.051	0.014	0.054	0.064*	0.035	0.462*	0.472*	0.453*
	(0.03)	(0.05)	(0.03)	(0.05)	(0.03)	(0.04)	(0.46)	(0.47)	(0.45)
Pos. External Shocks	–0.000	0.018	–0.003	0.018	0.004	0.021	0.205	0.212	0.189
	(0.04)	(0.02)	(0.04)	(0.02)	(0.04)	(0.02)	(0.20)	(0.21)	(0.19)
Depreciation Events 1									0.504+
									(0.272)
Over- to Overvalued	0.146**	–0.003	0.131**	–0.003	0.121**	–0.006			
	(0.04)	(0.02)	(0.04)	(0.02)	(0.04)	(0.02)			
Under- to Undervalued	–0.029	0.070*	–0.040	0.072*	–0.044+!	0.076*			
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)			
Over- to Undervalued	–0.080*!	0.040	–0.087*!	0.042	–0.085*!	0.048			
	(0.04)	(0.05)	(0.04)	(0.05)	(0.03)	(0.05)			
Relative Income Position			–0.148**	0.009					
			(0.04)	(0.03)					
Change Investment Rate	0.018*	–0.010*	0.014+	–0.010*					
	(0.01)	(0.00)	(0.01)	(0.00)					
Change Population Growth	–0.001*	–0.001**	–0.002**	–0.001**					
	(0.00)	(0.00)	(0.00)	(0.00)					
Change Education	0.227	0.149	0.284+	0.152					
	(0.17)	(0.10)	(0.16)	(0.10)					
North America					–0.006				
					(0.05)				
Asia					0.073*	0.054*			
					(0.03)	(0.02)			
Europe					–0.009	0.045*			
					(0.03)	(0.02)			
South America					–0.006	–0.026+			
					(0.02)	(0.01)			
Oceania					0.008	0.056			
					(0.06)	(0.05)			
Change Real Misalignment							0.126		–0.082
							(0.13)		(–0.08)
Real Depreciation								–0.308	
								(–0.31)	
Real Appreciation								0.868	
								(0.87)	
Interaction: Depreciation * Change Real Misalignment									–0.816
									(–0.82)
Pseudo R^2	0.095	0.064	0.110	0.064	0.096	0.050	0.054	0.055	0.058
No. of Growth Accel.	68	51	68	51	71	57	128	128	128
Observations	1331	1703	1331	1703	1434	1812	3288	3288	3288

Notes: Estimated by pooled logit. The coefficients are average marginal effects. Standard errors are given in parenthesis. +,*,** denote significance at the 10, 5 and 1 percent level. ! denotes opposing conclusions regarding the significance of the AME and the estimated coefficient at the 10 percent level. For instance, ! means that the AME is not significant, but the estimated coefficient has a p-value lower than 0.1. *! indicates that the AME is significant at the 5 percent level, but the estimated coefficient is not significant at the 10 percent level. All estimations include a full set of time dummies.

As a concession to the recent literature, a final string of robustness checks is presented in Table 4.10, where quantitatively measured variables and time-invariant ones are introduced as explanatory variables. In reference to the augmented Solow-model (Mankiw et al., 1992), changes in the rate of investment, the rate of population growth and the availability of human capital are considered in col. 1 – 2.[49] In the spirit of the conditional convergence hypothesis income relative to the United States is added in col. 3 – 4. Col. 5 – 6 allow for distinct effects across continent. The main results are robust, in particular real depreciation events exhibit the familiar effects across subperiods. Control variables have the expected sign in the period before 1980. After 1980, the insignificance of the relative income position (col. 4) is particularly noteworthy. The use of continent dummies shows that Asia is special in that Asian countries are significantly more likely than other countries to experience a growth acceleration over the entire sample period.

The final columns analyze to what extent the magnitude of real depreciations matters. In accordance with Section 4.3.3, the magnitude of real depreciations is measured as $\bar{m}_{prior} - \bar{m}_{post}$. This time the estimated coefficients instead of AME are reported.[50] Regardless of whether a single coefficient or separate ones are estimated for the impact of real appreciations and depreciations (col. 7 – 8), there is no significant association between changes in real misalignment and growth accelerations. Col. 9 shows that even within the subset of identified depreciation events the magnitude of real depreciations is of no help in predicting growth accelerations. This feature also holds for subperiods. Hence, overall the results do not suggest that the focus on events as opposed to magnitudes leaves valuable information unconsidered in the estimation.

4.5 Conclusion

This paper has aimed at providing empirical evidence for the popular, but empirically not yet convincingly validated claim that real depreciations play an important role in triggering growth accelerations. At the same time it has aimed at clarifying the role of real undervaluation in this context. For this purpose growth accelerations

[49] Changes are measured as the average yearly changes occurring between $t-4$ and t to mitigate endogeneity issues.

[50] This decision is made because AME cannot convey the significance of the interaction term used in col. 9.

and PPP-based real depreciation events, i.e. sustained real depreciations of modest magnitude, have been constructed using data for 107 countries covering the years 1950 - 2007. Their association has been analyzed using a binary choice model.

Despite focusing on the subset of real depreciations that is most likely to initiate fast growth episodes, the overall association between growth accelerations and depreciation events is surprisingly fragile. For instance, it depends on the development status of the countries in question and on the specifics of the identified accelerations.

Many of the confusing results, however, can be reconciled if changing patterns over time and over attended real exchange rate levels are accounted for. More specifically, prior to 1980 sustained real depreciations of overvalued currencies increase the likelihood of experiencing a growth acceleration whereas depreciations of ex-ante or ex-post undervalued currencies reduce it. Post 1980, the effects of real depreciation events are reversed: The likelihood of growth accelerations increases by depreciations that further enhance preexisting real undervaluation whereas real depreciations of overvalued currencies reduce the likelihood of fast growth. Given that these different types of depreciation events occur in various frequencies in different samples and their effects partly offset each other, it comes as no surprise that the aggregate impact of real depreciation events depends on the particular composition of the respective samples. Nevertheless and contrary to the popular assertion, real depreciations are a promising strategy to jump-start growth in very specific circumstances, only.

Distinguishing between sustained and unsustained accelerations, real depreciation events that move an overvalued currency closer to its equilibrium value are conducive to sustained ones, whereas other types of real depreciation events are at best conducive to unsustained ones. While this result is theoretically appealing, this paper cannot verify whether the association is robust over time for the simple reason that sustained growth accelerations in the underlying sample had to start in the beginning of the nineties at the latest.

Regarding the broader debate on the growth effect of real exchange rate misalignment, this paper makes several contributions. As to the controversy between the "Washington Consensus view" and the "Rodrik view" of real exchange rate misalignment, the evidence in this paper is consistent with the "Washington Consensus view" in early periods and with the "Rodrik view" in recent ones. More generally, the results imply that structural breaks might explain some of the contradictory results reported in the literature. The paper reaffirms the necessity to allow for heterogeneous growth effects of real over- and real undervaluation.

Regarding the literature on growth accelerations, this paper not only confirms that igniting fast growth is different from sustaining it, but highlights that growing rapidly is quite different from growing faster, too. Moreover, the analysis illustrates that recent growth accelerations have become even less predictable than earlier ones for the reason that even the influence of ”traditional” explanatory variables has dwindled over time. To my knowledge, this analysis is the first one to point at a possible structural break in the determinants of growth accelerations.

Appendix 4.A: Construction of Variables

The definition of explanatory indicator variables in the main analysis follows HPR. The indicator for positive external shocks equals 1 if a country experiences an exceptional increase in its trade share over five years. Exceptional is defined as the change of the trade share being in the upper 10 percent of all recorded changes for the country in question. Trade shares are taken from the national accounts data underlying PWT 6.3 (Heston et al., 2009). Political regime changes are defined using the polity score given by the Polity IV dataset (Marshall et al., 2010). A positive regime change occurs if a country becomes substantially more democratic, which corresponds to a positive change in the polity score of at least three points. A negative regime change is an analogous movement towards autocracy. Each political regime change variable takes on the value 1 in the 5-year period beginning with the regime change in order to account for delayed effects. The indicator for broad economic reforms is based on Wacziarg and Welch (2008), who continue the work by Sachs et al. (1995) and report liberalization dates after which a country is classified as open. In principle, a country is liberalized if average tariff rates and the percentage of imports covered by nontariff barriers are below 40 % each, the economic system is not socialist, there is no state monopoly for major exports and if the difference between official and black-market exchange rates is below 20 %. However, Rodriguez and Rodrik (2000) have noted that the indicator tends to more broadly capture important changes in policy and institutional settings. Therefore, following HPR it is used as an indicator for economic reforms in this paper. The indicator equals 1 during the first five years of the liberalization.

The additional variables used in Section 4.4.6 are defined as follows. Financial liberalization is taken from Abiad et al. (2008) who define seven different dimensions of financial sector policy and determine a score between zero and three for each country in every dimension whereby a higher number indicates more liberalization. The overall index for financial liberalization equals the sum of the individual scores and lies between 0 and 21. A higher overall score indicates more financial liberalization. According to Abiad et al. (2008) years in which the overall index increases by three points or more indicate years of large financial reforms. To account for delayed effects, a 5-year period beginning with the date of large financial reforms is used in the estimation.

The further two indicators for economic reforms are taken from an updated version of the KOF globalization index introduced in Dreher (2006) and Dreher et al. (2009).[51] Globalization is measured along the three sub-dimensions economic, political and social globalization. Economic globalization is itself based on two subindices. The first subindex refers to actual flows in trade and investment, whereas the second subindex measures restrictions on trade and capital using hidden import barriers, mean tariff rates, taxes on international trade and an index of capital controls. In Table 4.9, col. 8 is based on the latter subindex while col. 9 is based on the overall globalization index. In both cases, an event is recorded if the indicator increases by more than one standard deviation as measured in the total sample. A 5-year period is marked to account for delayed effects.

The alternative indicator for political regime changes introduced in Table 4.9 distinguishes between democracy and dictatorship, only (Cheibub et al., 2010). A positive regime change is a movement from dictatorship to democracy, a negative regime change a movement into the opposite direction. Compared to the Polity IV dataset, this regime classification is based on events that are easy to ascertain and it does not involve disputable aggregation rules. As before, 5-year periods following a regime change are marked and used in the estimation.

Finally, the investment rate, population growth rate and relative income to the USA used in Table 4.10 are calculated from PWT 6.3 data. Education is measured as the average years of schooling in the population aged 15 and above taken from Barro and Lee (2013). Changes in the investment and population growth rates and years of schooling are averages of the recorded yearly changes over a five year period.

[51] The dataset can be downloaded at http://globalization.kof.ethz.ch/ (Oct. 2013).

Appendix 4.B: Details on Growth Accelerations

Table 4.B.1: Identified Growth Accelerations

Country	Acceleration Starts in	Growth Prior to Acceleration	Growth During Acceleration	Difference in Growth
Algeria	1967	−0.96	4.05	5.01
Angola	1981	−4.68	4.19	8.87
Angola	1993	−3.53	5.86	9.38
Argentina	1963	0.78	3.73	2.95
Argentina	1990	−2.25	4.45	6.70
Australia	1957	0.91	3.60	2.69
Australia	1992	1.08	3.55	2.48
Bangladesh	2000	1.36	3.89	2.53
Belgium	1958	1.87	4.55	2.68
Benin	1978	−0.81	4.90	5.71
Botswana	1967	3.98	11.61	7.63
Botswana	1982	4.96	8.70	3.75
Botswana	1999	−0.07	4.35	4.41
Brazil	1969	3.33	7.68	4.36
Burkina Faso	1966	−2.50	3.64	6.15
Canada	1962	1.39	3.70	2.32
Chad	1982	−5.89	4.68	10.57
Chad	2000	−1.45	8.73	10.17
Chile	1987	−0.76	6.15	6.91
China	1968	2.03	4.40	2.37
China	1977	3.20	9.14	5.94
China	1991	6.14	9.09	2.95
China	2000	7.12	11.12	4.00
Cameroon	1973	−0.33	5.72	6.05
Congo, Republic of	1967	3.11	12.82	9.71
Congo, Republic of	1977	3.56	8.55	4.99
Colombia	1967	1.54	3.75	2.21
Cuba	1998	−2.63	3.76	6.39
Denmark	1958	2.34	5.61	3.27
Dominican Republic	1969	0.42	6.42	6.01
Dominican Republic	1991	−0.06	5.63	5.69
Ecuador	1971	1.74	7.60	5.86
Egypt	1957	−0.19	3.75	3.95
Egypt	1975	−1.30	8.48	9.78
Finland	1958	2.39	5.58	3.19
Finland	1968	2.60	5.23	2.63
Finland	1996	−1.36	4.03	5.38
Gabon	1987	−4.17	3.88	8.05
Ghana	1965	−3.29	20.50	23.78
Ghana	1997	−1.34	4.14	5.48
Greece	1960	4.82	6.97	2.15
Greece	1996	0.61	3.99	3.38

Table 4.B.1 *(continued)*

Country	Acceleration Starts in	Growth Prior to Acceleration	Growth During Acceleration	Difference in Growth
Guatemala	1962	1.57	3.88	2.32
Guinea-Bissau	1971	−4.47	10.85	15.33
Guinea-Bissau	1988	−5.08	8.69	13.77
Haiti	1973	−0.53	5.06	5.59
Hong Kong	1975	5.66	7.80	2.14
Hong Kong	1999	1.02	4.19	3.17
Honduras	1970	1.55	3.60	2.05
Hungary	1996	−1.39	4.89	6.27
Indonesia	1967	−0.43	7.82	8.25
Indonesia	1987	2.79	5.87	3.07
India	1994	2.20	4.24	2.03
Ireland	1958	0.32	4.82	4.50
Ireland	1988	0.50	5.19	4.70
Iran	1966	6.06	10.06	4.00
Iran	1986	−4.12	3.89	8.01
Israel	1958	2.23	5.87	3.63
Israel	1967	3.03	8.05	5.02
Israel	1989	1.09	3.77	2.68
Jamaica	1985	−1.80	4.85	6.64
Jordan	1975	−4.68	6.72	11.40
Japan	1959	6.10	9.43	3.33
Korea, Republic of	1962	0.66	7.21	6.55
Korea, Republic of	1985	4.73	8.79	4.06
Korea, Republic of	1998	2.88	5.12	2.24
Lesotho	1971	−1.54	10.69	12.23
Lesotho	1992	0.73	4.67	3.94
Morocco	1957	−1.56	8.88	10.44
Madagascar	1979	−2.50	3.51	6.01
Mexico	1962	2.13	4.37	2.24
Mali	1974	−0.14	4.27	4.41
Mali	1995	1.35	3.59	2.24
Mozambique	1996	−1.74	6.98	8.73
Mauritius	1960	−4.51	4.00	8.51
Mauritius	1971	−3.31	7.05	10.36
Mauritius	1984	1.10	5.74	4.63
Malawi	1964	0.51	4.16	3.65
Malawi	1978	−0.54	5.92	6.45
Malawi	1992	−3.13	3.99	7.12
Malaysia	1964	3.00	5.72	2.72
Malaysia	1987	2.09	6.94	4.84
New Zealand	1958	1.35	4.37	3.02
Nicaragua	1960	0.32	5.90	5.57
Nicaragua	1979	−4.09	5.87	9.96
Nigeria	1957	1.21	3.77	2.57
Nigeria	1967	−4.24	9.30	13.54
Nigeria	2000	0.24	10.56	10.32
Netherlands	1963	2.24	4.63	2.39
Norway	1960	2.14	4.27	2.13
Norway	1993	1.17	3.86	2.68
Pakistan	1960	−1.03	4.05	5.09
Pakistan	1978	1.77	4.03	2.26
Pakistan	2000	0.92	4.19	3.27
Panama	1959	0.96	6.91	5.95
Panama	1974	2.50	6.55	4.04
Panama	2000	1.49	3.69	2.20

Table 4.B.1 *(continued)*

Country	Acceleration Starts in	Growth Prior to Acceleration	Growth During Acceleration	Difference in Growth
Papua New Guinea	1969	3.40	9.61	6.21
Papua New Guinea	1990	−1.37	3.93	5.30
Peru	1959	−0.07	5.70	5.78
Philippines	1970	1.30	3.74	2.44
Poland	1992	−0.72	5.53	6.25
Portugal	1958	3.57	6.16	2.59
Portugal	1966	5.97	8.57	2.60
Portugal	1984	0.99	5.60	4.61
Paraguay	1974	2.21	6.52	4.31
Romania	1970	6.73	10.18	3.45
Romania	1999	0.73	6.06	5.33
Rwanda	1994	−6.60	8.90	15.49
Singapore	1967	2.67	9.56	6.89
Singapore	1987	3.47	7.27	3.80
Sierra Leone	2000	−9.40	7.47	16.87
Slovak Republic	1994	−2.86	3.83	6.69
Spain	1959	3.55	8.76	5.20
Spain	1984	0.09	4.04	3.95
Spain	1996	1.65	4.08	2.44
Sri Lanka	1978	1.23	5.07	3.84
Switzerland	1958	1.85	4.53	2.68
Syria	1971	−0.04	6.08	6.12
Syria	1990	−3.08	4.69	7.78
Taiwan	1962	3.55	7.46	3.91
Taiwan	1985	5.22	7.60	2.38
Tanzania	2000	0.91	4.43	3.52
Thailand	1958	−1.58	5.20	6.78
Thailand	1987	4.40	8.36	3.96
Thailand	2000	1.11	4.19	3.09
Trinidad & Tobago	1971	2.46	4.86	2.40
Trinidad & Tobago	1993	−0.71	8.42	9.12
Tunisia	1968	3.04	5.27	2.22
Turkey	1965	0.34	4.15	3.82
Uganda	1987	−1.67	4.74	6.42
United Kingdom	1981	0.76	3.73	2.98
United States	1962	0.99	3.70	2.71
Uruguay	1973	0.53	4.75	4.22
Uruguay	1985	−1.32	4.26	5.58
Zambia	1963	−0.19	3.78	3.97
Zambia	2000	−2.07	11.00	13.07
Zimbabwe	1968	−1.98	8.70	10.68

Notes: Author's calculations according to the methodology presented in Section 4.3.1.

Appendix 4.C: Testing for Exogeneity

Table 4.C.2: Exogeneity Tests

Dependent Variable is a Dummy for the Onset of Depreciation Sequences

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged Growth	0.281	0.316			−0.190	0.054		
Accelerations (t-1)	(0.33)	(0.36)			(0.43)	(0.44)		
Lagged Growth		0.411				0.343		
Accelerations (t-2)		(0.34)				(0.37)		
Lagged Growth		0.335				0.297		
Accelerations (t-3)		(0.35)				(0.38)		
Lagged Growth			0.306	0.248			0.219	0.195
Episodes (t-1)			(0.21)	(0.30)			(0.23)	(0.33)
Lagged Growth				0.029				−0.033
Episodes (t-2)				(0.37)				(0.40)
Lagged Growth				0.259				0.233
Episodes (t-3)				(0.29)				(0.31)
p-value		0.413		0.251		0.712		0.615
(Lagged Variables = 0)								
Observations	4051	3837	4051	3837	4051	3837	4051	3837

Notes: Estimated by pooled logit. Standard errors are given in parenthesis.
+,*,** denote significance at the 10, 5 and 1 percent level. All estimations include a full set of time dummies. For an explanation of methodology, cf. Section 4.4.1.

Appendix 4.D: Sustained versus Unsustained Growth Accelerations After 1980

Table 4.D.3: Predicting Growth Accelerations - Sustained versus Unsustained After 1980

Dependent Variable is a Dummy for the Timing of Growth Accelerations		
	(1)	(2)
	sus.	unsus.
Economic Reforms	−0.037	0.051*
	(0.02)	(0.03)
Pos. Regime Changes	0.003	−0.035+
	(0.03)	(0.01)
Neg. Regime Changes	0.081+	
	(0.07)	
Pos. External Shocks	0.014	0.004
	(0.04)	(0.02)
Depreciation Events 1		
Over- to Overvalued		
Under- to Undervalued	0.054!	0.086*
	(0.04)	(0.04)
Over- to Undervalued		
Pseudo R^2	0.049	0.070
No. of Growth Accel.	11	14
Observations	649	940

Notes: Estimated by pooled logit. The coefficients are average marginal effects. Standard errors are given in parenthesis.
+,*,** denote significance at the 10, 5 and 1 percent level. ! denotes opposing conclusions regarding the significance of the AME and the estimated coefficient at the 10 percent level. For instance, ! means that the AME is not significant, but the estimated coefficient has a p-value lower than 0.1. *! indicates that the AME is significant the the 5 percent level, but the estimated coefficient is not significant at the 10 percent level. All estimations include a full set of time dummies.

Chapter 5

Conclusion

This thesis has argued that the key to understanding economic growth lies in understanding how and why countries switch between episodes of high and episodes of low growth. Although three different methods have been used to identify growth regimes and changes thereof, all methods lead to the same conclusion: growth transitions occur frequently and are not restricted to certain geographic locations, decades or levels of development. The identified growth regimes have been used to analyze three different aspects associated with growth regime changes. First, the proximate sources of growth transitions have been studied using a non-parametric growth accounting framework. Second, potential differences in growth fundamentals between rapidly growing economies and less successful ones have been analyzed by modeling economic growth as a Markov switching process and by deriving clusters of countries featuring distinct patterns of growth. Finally, the potential of real exchange rate depreciations to trigger growth accelerations has been evaluated.

The main insights of this thesis can be summarized as follows. First, growth regime changes mostly mirror changes in total factor productivity, which to a large extent represent changes in the efficiency of production. Factor accumulation plays a surprisingly small role in the initial years of a growth switch. Second, long periods of stable or fast growth require good institutions. However, a lack of good institutions does not automatically translate into dismal growth behavior. Geographic conditions and reasonably good policies can successfully mitigate the detrimental effects of bad institutions. Third, the triggers of growth accelerations remain a mystery. The success stories of East Asia and China on the back of undervalued currencies do not translate into a general link between real exchange rate depreciations and growth accelerations. Moreover, there are indications that once successful growth triggers have become less successful over time.

These insights tie in nicely with the existing literature. They confirm that igniting growth and sustaining it are two different endeavors (Rodrik, 2005). They also confirm that ”institutions rule” (Rodrik et al., 2004), but only in the long run. A growth acceleration can occur without large amounts of capital accumulation and/or technological progress and it does not require a set of high quality institutions. At the same time, sustained growth at steady or high rates will require all of this: capital accumulation, technological progress and high quality institutions. Unfortunately, this thesis has been no more successful than previous attempts to link specific policy tools to the initiation of growth accelerations (Hausmann et al., 2005). Real exchange rate depreciations do not regularly trigger an overwhelming growth response.

Despite these insights the actual policy implications of this thesis are limited.[1] At most, the results are encouraging in that creating an environment where the economy takes off does not require large-scale institutional or policy reforms. In particular, creating leeway for increases in productive efficiency may often be considerably easier than creating an environment conducive to capital accumulation and technological change. For instance, luring foreign capital into a country requires convincing foreign investors of reasonably secure property rights. Contrary to that, increasing the efficiency of domestic production often requires no more than getting access to a mobile phone.[2]

Yet, even this encouraging conclusion leaves policy makers in the dark of what precisely to do. One important, if not the main impediment to draw clear-cut policy implications is the necessity to take due account of local opportunities and constraints when designing growth strategies. Existing variables and indicators, however, are at best crude and neither capture local conditions in a sufficiently precise way nor do they reliably map context-specific institutional designs and policies into the non-context specific functions that the institutions or policies ensure (Chang, 2011; Hausmann et al., 2005; Lin, 2011; Rodrik, 2005).

If these difficulties are taken seriously and if their implications are fully acknowl-

[1] Unfortunately, this lack of policy implications characterizes most of the existing literature.

[2] There is an abundant literature on the benefits of modern telecommunication. An introduction is given in Aker and Mbiti (2010).

edged, one could argue that quantitative studies using *currently* available indicators for institutions and policies have ”passed the point of diminishing returns” with respect to policy relevance.[3] For the time being, a more promising strategy to uncover policy-relevant answers as to how countries can achieve growth turnarounds appears to be the use of comparative in-depth country studies organized around turning points in growth. For such a research agenda, the existing contributions on the timing of growth regime changes need to be reorganized in a systematic way in order to establish a subset of generally accepted turning points. At present, a multitude of identification strategies have resulted in too many turning points with limited overlap.[4] A subset of ”robust” turning points would represent a good point of departure for an analysis on what kind of advances typically occur in the vicinity of growth regime changes. The payoff of such country studies would be particularly large if the focus was shifted to countries that have thus far not been the center of attention.[5]

Systematic robustness analyses hold promise more generally. The association between explanatory variables and growth regime changes appears to be less robust than frequently acknowledged (chapter 4). The overall picture of the existing literature suggests that the time period the analysis refers to, the specific combination of explanatory variables, the underlying method used to identify growth transitions and the method of estimation all seem to matter. Therefore, a systematic robustness analysis of these aspects would be useful to gain more certainty about which of the existing explanations are particularly worthwhile to pursue. Methodologically, it would be interesting to examine whether and to what extent Bayesian model averaging procedures proposed in the context of growth regressions could be used to enhance our understanding in this respect, too.

The datasets used in this thesis ended before the onset of the global financial crisis in 2007/2008. In terms of growth transitions, the financial crisis will likely manifest itself in growth decelerations in most countries.[6] More importantly, the financial

[3]This is the wording that Pritchett (2000, p. 245) has used in his seminal essay with regard to growth regressions.

[4]The lack of consistency between identified breaks has also been noted by Kar et al. (2013), who, however, suggest a different remedy.

[5]For instance, as stated by Sen (2013) a lot is known about the growth miracle in China, whereas policies of African countries around growth accelerations have hardly ever been analyzed in detail.

[6]The details, of course, depend on the underlying identification methods for growth decelerations. However, a visual inspection of the country groups in the World Economic Outlook dataset (International Monetary Fund, 2014) suggests that a growth slowdown has

crisis corroborates the potential of in-depth country studies to generate new policy-relevant insights. It stands to reason that existing indicators on institutional quality, for example, did not pick up the large deficiencies in the organization of financial markets that have to be conceded in hindsight. An analysis of what went wrong in the run-up to the crisis and of what has enabled some countries to escape the crisis more quickly than others offers valuable lessens in order to understand what constitutes good institutions and policies for growth in general.

occurred in all regions of the world.

Bibliography

Abiad, A., E. Detragiache, and T. Tressel (2008). A New Database of Financial Reforms. *IMF Working Paper 08/266*.

Acemoglu, D. and D. Autor (2010). Skills, Tasks and Technologies: Implications for Employment and Earnings. *NBER Working Paper 16082*.

Acemoglu, D., S. Johnson, J. Robinson, and Y. Thaicharoen (2003). Institutional Causes, Macroeconomic Symptoms: Volatility, Crises and Growth. *Journal of Monetary Economics 50*, 49–123.

Acemoglu, D., S. Johnson, and J. A. Robinson (2001). The Colonial Origins of Comparative Development: An Empirical Investigation. *American Economic Review 91*, 1369–1401.

Acemoglu, D. and F. Zilibotti (1997). Was Prometheus Unbound by Chance? Risk, Diversification, and Growth. *Journal of Political Economy 105*, 709–751.

Aghion, P., P. Bacchetta, R. Rancière, and K. Rogoff (2009). Exchange Rate Volatility and Productivity Growth: The Role of Financial Development. *Journal of Monetary Economics 56*, 494–513.

Aghion, P. and S. Durlauf (2005). *Handbook of Economic Growth*. Amsterdam: Elsevier B.V.

Aghion, P. and P. Howitt (1992). A Model of Growth Through Creative Destruction. *Econometrica 60*, 323–351.

Aguirre, A. and C. Calderon (2005). Real Exchange Rate Misalignments and Economic Performance. *Central Bank of Chile Working Papers 315*.

Aizenman, J. and M. M. Spiegel (2010). Takeoffs. *Review of Development Economics 14*, 177–196.

Aker, J. C. and I. M. Mbiti (2010). Mobile Phones and Economic Development in Africa. *Journal of Economic Perspectives 24*, 207–232.

Alfo, M., G. Trovato, and R. J. Waldmann (2008). Testing for Country Heterogeneity in Growth Models Using a Finite Mixture Approach. *Journal of Applied Econometrics 23*, 487–514.

Alon, J., S. Sclaroff, G. Kollios, and V. Pavlovic (2003). Discovering Clusters in Motion Time-Series Data. *Computer Vision and Pattern Recognition. Proceedings. 2003 IEEE Computer Society Conference on 1*, 375–381.

Andrews, D. W. K. (1991). Heteroskedasticity and Autocorrelation Consistent Covariance Matrix Estimation. *Econometrica 59*, 817–858.

Andrews, D. W. K. and J. C. Monahan (1992). An Improved Heteroskedasticity and Autocorrelation Consistent Covariance Matrix Estimator. *Econometrica 60*, 953–966.

Arbache, J. S. and J. Page (2010). How Fragile is Africa's Recent Growth? *Journal of African Economies 19*, 1–24.

Ardiç, O. P. (2006). The Gap Between the Rich and the Poor: Patterns of Heterogeneity in the Cross-Country Data. *Economic Modelling 23*, 238–555.

Azariadis, C. and A. Drazen (1990). Threshold Externalities in Economic Development. *Quarterly Journal of Economics 105*, 501–526.

Azariadis, C. and J. Stachurski (2005). Poverty Traps. See Aghion and Durlauf (2005), pp. 295–384.

Baştürk, N., R. Paap, and D. van Dijk (2012). Structural Differences in Economic Growth: An Endogenous Clustering Approach. *Applied Economics 44*, 119–134.

Badunenko, O. (2013). Financial Development And The Sources of Growth and Convergence. *International Economic Review 54*, 629–663.

Badunenko, O., D. J. Henderson, and R. Houssa (2014). Significant Drivers of Growth in Africa. *Journal of Productivity Analysis 42*, 339–354.

Badunenko, O., D. J. Henderson, and R. R. Russell (2013). Polarization of the Worldwide Distribution of Productivity. *Journal of Productivity Analysis 40*, 153–171.

Badunenko, O., D. J. Henderson, and V. Zelenyuk (2008). Technological Change and Transition: Relative Contributions to Worldwide Growth During the 1990s. *Oxford Bulletin of Economics and Statistics 70*, 461–492.

Badunenko, O. and K. Tochkov (2010). Soaring Dragons, Roaring Tigers, Growling Bears. *Economics of Transition 18*, 539–570.

Bai, J. and P. Perron (1998). Estimating and Testing Linear Models with Multiple Structural Changes. *Econometrica 66*, 47–78.

Bai, J. and P. Perron (2003a). Computation and Analysis of Multiple Structural Change Models. *Journal of Applied Econometrics 18*, 1–22.

Bai, J. and P. Perron (2003b). Critical Values for Multiple Structural Change Tests. *Econometrics Journal 6*, 72–78.

Bai, J. and P. Perron (2006). Multiple Structural Change Models: A Simulation Analysis. See Corbae et al. (2006), pp. 212 – 240.

Barro, R. J. (1991). Economic Growth in a Cross Section of Countries. *Quarterly Journal of Economics 106*, 407–443.

Barro, R. J. and J.-W. Lee (1993). International Comparisons of Educational Attainment. *Journal of Monetary Economics 32*, 363–394.

Barro, R. J. and J.-W. Lee (2001). International Data on Educational Attainment: Updates and Implications. *Oxford Economic Papers 3*, 541–563.

Barro, R. J. and J. W. Lee (2013). A New Data Set of Educational Attainment in the World, 1950–2010. *Journal of Development Economics 104*, 184–198.

Barro, R. J. and X. Sala-i Martin (2004). *Economic Growth (2nd Edition)*. Cambridge, Massachusetts: MIT Press.

Becker, T. and P. Mauro (2006). Output Drops, and the Shocks that Matter. *IMF Working Paper 06/172*.

Ben-David, D. (1998). Convergence Clubs and Subsistence Economies. *Journal of Development Economics 55*, 155–171.

Ben-David, D. and D. H. Papell (1998). Slowdowns and Meltdowns: Postwar Growth Evidences From 74 Countries. *Review of Economics and Statistics 80*, 561–571.

Benhabib, J. and M. M. Spiegel (2005). Human Capital and Technology Diffusion. See Aghion and Durlauf (2005), pp. 935–966.

Bentolila, S. and G. Saint-Paul (2003). Explaining Movements in the Labor Share. *The B. E. Journal of Macroeconomics 3*, 1–31.

Béreau, S., A. L. Villavicencio, and V. Mignon (2012). Currency Misalignments and Growth: A New Look Using Nonlinear Panel Data Methods. *Applied Economics 44*, 3503–3511.

Berg, A. and Y. Miao (2010). The Real Exchange Rate and Growth Revisited: The Washington Consensus Strikes Back? *IMF Working Paper 10/58*.

Berg, A., J. D. Ostry, and J. Zettelmeyer (2012). What Makes Growth Sustained? *Journal of Development Economics 98*, 149–166.

Bernanke, B. S. and R. S. Gürkaynak (2001). Is Growth Exogenous? Taking Mankiw, Romer, and Weil Seriously. *NBER Macroeconomics Annual 16*, 11–72.

Berthelemy, J.-C. (2006). Convergence and Development Traps: How Did Emerging Economies Escape the Underdevelopment Trap? *Annual World Bank Conference on Developent Economics 2006*.

Biernacki, C., G. Celeux, and G. Govaert (2003). Choosing Starting Values for the EM Algorithm for Getting the Highest Likelihood in Multivariate Gaussian Mixture Models. *Computational Statistics & Data Analysis 41*, 561–575.

Bloom, D. E., D. Canning, and J. Sevilla (2003). Geography and Poverty Traps. *Journal of Economic Growth 8*, 335–378.

Bluedorn, J., R. Duttagupta, J. Guajardo, and N. Mwase (2014). What Underlies the Recent Growth Comeback in Developing Countries? *Journal of Policy Modeling 36*, 717–744.

Bos, J. W. B., C. Economidou, M. Koetter, and J. W. Kolari (2010). Do All Countries Grow Alike? *Journal of Development Economics 91*, 113–127.

Bosworth, B. P. and S. M. Collins (2003). The Empirics of Growth: An Update. *Brookings Papers on Economic Activity 0*, 113–206.

Breton, T. R. (2012). Penn World Table 7.0: Are the Data Seriously Flawed? *Economics Letters 117*, 208–210.

Brown, R. L., J. Durbin, and M. Evans (1975). Techniques for Testing the Constancy of Regression Relationships over Time. *Journal of the Royal Statistical Society, Series B 37*, 149–192.

Bussière, M., S. C. Saxena, and C. E. Tovar (2012). Chronicle of Currency Collapses: Re-Examining the Effects on Output. *Journal of International Money and Finance 31*, 680–708.

Butler, M. (2003). *Hidden Markov Model Clustering of Acoustic Data.* Online: http://www.inf.ed.ac.uk/publications/thesis/online/IM030057.pdf (15.04.2011).

Cadez, I., D. Heckermann, C. Meek, P. Smyth, and S. White (2003). Model-Based Clustering and Visualization of Navigation Patterns on a Web Site. *Data Mining and Knowledge Discovery 7*, 399–424.

Campbell, S. (2002). Specification Testing and Semiparametric Estimation of Regime Switching Models: An Examination of the US Short Term Interest Rates. *Brown University Working Paper 2002-26*.

Canning, D. (1998). A Database of World Stocks of Infrastructure, 1950–1995. *The World Bank Economic Review 12*, 529–547.

Canova, F. (2004). Testing For Convergence Clubs in Income Per Capita: A Predictive Density Approach. *International Economic Review 45*, 49–77.

Caselli, F. (2004). Accounting for Cross-Country Income Differences. *NBER Working Paper 10828*.

Caselli, F., G. Esquivel, and F. Lefort (1996). Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics. *Journal of Economic Growth 1*, 363–389.

Caves, D. W., L. R. Christensen, and W. E. Diewert (1982). The Economic Theory of Index Numbers and the Measurement of Input, Output and Productivity. *Econometrica 50*, 1393–1414.

Chang, H.-J. (2011). Institutions and Economic Development: Theory, Policy and History. *Journal of Institutional Economics 7*, 473–498.

Cheibub, J. A., J. Gandhi, and J. R. Vreeland (2010). Democracy and Dictatorship Revisited. *Public Choice 143*, 67–101.

Christopoulos, D. K. (2007). Explaining Country's Efficiency Performance. *Economic Modelling 24*, 224–235.

Coelli, T., D. S. P. Rao, and G. E. Battese (1998). *An Introduction to Efficiency and Productivity Analysis*. Boston: Kluwer Academic Publishers.

Cohen, D. and M. Soto (2001). Growth and Human Capital: Good Data, Good Results. *CERP Discussion Paper 3025*.

Corbae, D., S. Durlauf, and B. E. Hansen (2006). *Econometric Theory and Practice: Frontier of Analysis and Applied Research - Essays in Honor of Peter Phillips*. Cambridge: Cambridge University Press.

Cottani, J. A., D. F. Cavallo, and M. S. Khan (1990). Real Exchange Rate Behavior and Economic Performance in LDCs. *Economic Development and Cultural Change 39*, 61–76.

Couharde, C. and A. Sallenave (2013). How do Currency Misalignments' Threshold Affect Economic Growth? *Journal of Macroeconomics 36*, 106–120.

Crafts, N. F. R. (2003). Quantifying the Contribution of Technological Change to Economic Growth in Different Eras: A Review of Evidence. *London School of Economics Working Paper in Economic History 79/03*.

Cuestas, J. C. and D. Garratt (2011). Is Real GDP Per Capita a Stationary Process? Smooth Transitions, Nonlinear Trends and Unit Root Testing. *Empirical Economics 41*, 555–563.

Darné, O. (2009). The Uncertain Unit Root in Real GNP: ARe-Examination. *Journal of Macroeconomics 31*, 153–166.

de Mello, L., P. C. Padoan, and L. Rousová (2011). The Growth Effects of Current Account Reversals. *OECD Economics Department Working Papers No. 871*.

Delgado-Rodríguez, M. J. and I. Álvarez Ayuso (2008). Economic Growth and Convergence of EU Member States: An Empirical Investigation. *Review of Development Economics 12*, 486–497.

Dempster, A., N. Laird, and D. Rubin (1977). Maximum Likelihood from Incomplete Data via the EM Algorithm. *Journal of the Royal Statistical Society, Series B 39*, 1–38.

Desdoigts, A. (1999). Patterns of Economic Development and the Formation of Clubs. *Journal of Economic Growth 4*, 305–330.

Diebold, F. X., L. Joon-Haeng, and G. C. Weinbach (1994). Regime Switching with Time-Varying Transition Probabilities. pp. 283–302.

Diewert, W. (1980). Capital and the Theory of Productivity Measurement. *American Economic Review 70*, 260–267.

Dollar, D. (1992). Outward-Oriented Developing Economies Really Do Grow More Rapidly: Evidence from 95 LDCs, 1975 - 1985. *Economic Development and Cultural Change 40*, 523–544.

Dooley, M. P., D. Folkerts-Landau, and P. Garber (2003). An Essay on the Revived Bretton Woods System. *NBER Working Paper 9971*.

Dovern, J. and P. Nunnenkamp (2007). Aid and Growth Accelerations: An Alternative Approach to Assessing the Effectiveness of Aid. *Kyklos 60*, 359–383.

Dreher, A. (2006). Does Globalization Affect Growth? Evidence From a New Index of Globalization. *Applied Economics 38*, 1091–1110.

Dreher, A., N. Gaston, and P. Martens (2009). *Measuring Globalization - Gauging Ist Consquences*. New York: Springer.

Duffy, J. and C. Papageorgiou (2000). A Cross-Country Empirical Investigation of the Aggregate Production Function Specification. *Journal of Economic Growth 5*, 87–120.

Durlauf, S. N. and P. A. Johnson (1995). Multiple Regimes and Cross-Country Growth Behaviour. *Journal of Applied Econometrics 10*, 365–384.

Durlauf, S. N., P. A. Johnson, and J. R. W. Temple (2005). Growth Econometrics. See Aghion and Durlauf (2005), pp. 555–677.

Durlauf, S. N., A. Kourtellos, and C. M. Tan (2008). Are Any Growth Theories Robust? *The Economic Journal 118*, 329–346.

Easterly, W. (2011). Benevolent Autocrats. Preliminary Version of Working Paper. Available at `dri.as.nyu.edu/docs/IO/20085/DRIWP75.pdf` (07.10.2012).

Easterly, W., M. Kremer, L. Pritchett, and L. H. Summers (1993). Good Policy or Good Luck? Country Growth Performance and Temporary Shocks. *Journal of Monetary Economics 32*, 459–483.

Easterly, W. and R. Levine (2001). It's Not Factor Accumulation: Stylized Facts and Growth Models. *The World Bank Economic Review 15*, 177–219.

Edwards, S. (1986). Are Devaluations Contractionary? *Review of Economics and Statistics 68*, 501–508.

Edwards, S. (1993). Openness, Trade Liberalization, and Growth in Developing Countries. *Journal of Economic Literature 31*, 1358–1393.

Edwards, S. (2004). Thirty Years of Current Account Imbalances, Current Account Reversals and Sudden Stops. *NBER Working Paper No. 10276*.

Edwards, S. (2011). Exchange-Rate Policies in Emerging Countries: Eleven Empirical Regularities From Latin America and East Asia. *Open Economies Review 22*, 533–563.

Eichengreen, B. (2008). The Real Exchange Rate and Economic Growth. *Commission on Growth and Development Working Paper 4*.

Eichengreen, B., D. Park, and K. Shin (2012). When Fast-Growing Economies Slow Down: International Evidence and Implications for China. *Asian Economic Papers 11*, 42–87.

Enflo, K. and P. Hjertstrand (2009). Relative Sources of European Regional Productivity Convergence: A Bootstrap Frontier Approach. *Regional Studies 43*, 643–659.

Farrell, M. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society. Series A (General) 120*, 253–290.

Federal Research Division - Library of Congress (2015). The Country Studies Series. Official Website. Available at `http://lcweb2.loc.gov/frd/cs/about.html` (11.01.2015).

Felipe, J. and F. M. Fisher (2003). Aggregation in Production Functions: What Applied Economists Should Know. *Metroeconomica 54*, 208–262.

Feyrer, J. (2009). The US Productivity Slowdown, the Baby Boom, and Management Quality. *NBER Working Paper 15474*.

Frankel, J. A. (2005). Contractionary Currency Crashes in Developing Countries. *NBER Working Paper 11508*.

Frankel, J. A. and D. Romer (1999). Does Trade Cause Growth? *American Economic Review 89*, 379–399.

Färe, R., S. Grosskopf, M. Norris, and Z. Zhang (1994). Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries. *American Economic Review 84*, 66–83.

Frenkel, R. and M. Rapetti (2008). Five Years of Competitive and Stable Real Exchange Rate in Argentina, 2002–2007. *International Review of Applied Economics 22*, 215–226.

Freund, C. and M. D. Pierola (2012). Export Surges. *Journal of Development Economics 97*, 387–395.

Furceri, D. and A. Mourougane (2012). The Effect of Financial Crises on Potential Output: New Empirical Evidence from OECD Countries. *Journal of Macroeconomics 34*, 822–832.

Gallup, J. L., J. D. Sachs, and A. D. Mellinger (1998). Geography and Economic Development. *NBER Working Paper 6849*.

Gallup, J. L., J. D. Sachs, and A. D. Mellinger (1999). Geography and Economic Development. *International Regional Science Review 22*, 179–232.

Galor, O. and O. Moav (2004). From Physical to Human Capital Accumulation: Inequality and the Process of Development. *Review of Economic Studies 71*, 1001–1026.

Garcia, R. (1998). Asymptotic Null Distribution of the Likelihood Ratio Test in Markov Switching Models. *International Economic Review 39*, 763–788.

Ghura, D. and T. J. Grennes (1993). The Real Exchange Rate and Macroeconomic Performance in Sub-Saharan Africa. *Journal of Development Economics 42*, 155–174.

Giles, D. (2013). Econometrics Beat: Dave Giles' Blog - Robust Standard Errors for Nonlinear Models. Blog. Available at `http://davegiles.blogspot.de/2013/05/robust-standard-errors-for-nonlinear.html` (02.10.2013).

Glaeser, E. L., R. La Porta, F. Lopez-de Silanes, and A. Shleifer (2004). Do Institutions Cause Growth? *Journal of Economic Growth 9*, 271–303.

Glüzmann, P. A., E. Levy-Yeyati, and F. Sturzenegger (2012). Exchange Rate Undervaluation and Economic Growth: Diaz Alejandro (1965) Revisited. *Economics Letters 117*, 666–672.

Gollin, D. (2002). Getting Income Shares Right. *Journal of Political Economy 110*, 458–474.

Gore, C. (2007). Which Growth Theory is Good for the Poor? *The European Journal of Development Research 19*, 30–48.

Greene, W. (2010). Testing Hypotheses about Interaction Terms in Nonlinear Models. *Economics Letters 107*, 291–296.

Greene, W. H. (2003). *Econometric Analysis* (5th ed.). Upper Saddle River, New Jearsey: Pearson Education International.

Grosskopf, S. and S. Self (2006). Factor Accumulation or TFP? A Reassessment of Growth in Southeast Asia. *Pacific Economic Review 11*, 39–58.

Growiec, J. (2012). The World Technology Frontier: What Can We Learn from the US States? *Oxford Bulletin of Economics and Statistics 74*, 777–807.

Guidotti, P. E., F. Sturzenegger, and A. Villar (2004). On the Consequences of Sudden Stops. *Economía 4*, 171–214.

Guillaumont, P. and L. Wagner (2012). Aid and Growth Accelerations: Vulnerability Matters. *UNU-WIDER Working Paper 2012/31*.

Gupta, P., D. Mishra, and R. Sahay (2007). Behavior of Output During Currency Crises. *Journal of International Economics 72*, 428–450.

Hall, R. E. and C. I. Jones (1999). Why Do Some Countries Produce So Much More Output per Worker than Others? *Quarterly Journal of Economics 114*, 83–116.

Hamilton, J. D. (1994). *Time Series Analysis.* Princeton, New Jersey: Princeton University Press.

Hansen, B. E. (1992). The Likelihood Ratio Test under Non-Standard Conditions: Testing the Markov Switching Model of GNP. *Journal of Applied Econometrics 7*, S61–S82.

Hansen, B. E. (2000). Sample Splitting and Threshold Estimation. *Econometrica 68*, 575–603.

Hausmann, R., L. Pritchett, and D. Rodrik (2005). Growth Accelerations. *Journal of Economic Growth 10*, 303–329.

Hausmann, R., F. Rodriguez, and R. Wagner (2006). Growth Collapses. *CID Working Paper 136*.

Henderson, D. J. and R. R. Russell (2005). Human Capital and Convergence: A Production-Frontier Approach. *International Economic Review 46*, 1167–1205.

Henderson, D. J. and V. Zelenyuk (2007). Testing for (Efficiency) Catching-up. *Southern Economic Journal 73*, 1003–1019.

Henry, P. B. (2008). Comments and Discussion on "The Real Exchange Rate and Economic Growth". *Brookings Papers on Economic Activity 2*, 413–420.

Henry, P. B. and C. Miller (2009). Institutions versus Policies: A Tale of Two Islands. *American Economic Review Papers And Procedings 99*, 261–267.

Heston, A., R. Summers, and B. Aten (2006a). About PWT 6.2 - What is New in PWT 6.2? *Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania*.

Heston, A., R. Summers, and B. Aten (2006b). Penn World Table Version 6.2. *Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania*.

Heston, A., R. Summers, and B. Aten (2009). Penn World Table Version 6.3 Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania. *Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania*.

Heston, A., R. Summers, and B. Aten (2011). Penn World Table Version 7.0. *Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania*.

Heston, A., R. Summers, and B. Aten (2012). Penn World Table Version 7.1. *Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania*.

Hong, K. and A. Tornell (2005). Recovery From a Currency Crisis: Some Stylized Facts. *Journal of Development Economics 76*, 71–96.

Hulten, C. R. (1981). *Depreciation, Inflation & the Taxation of Income from Capital.* Washington, DC: Urban Institute.

Hutchison, M. M. and I. Noy (2006). Sudden Stops and the Mexican Wave: Currency Crises, Capital Flow Reversals and Output Loss in Emerging Markets. *Journal of Development Economics 79*, 225–248.

Imam, P. and G. Salinas (2008). Explaining Episodes of Growth Accelerations, Decelerations, and Collapses in Western Africa. *IMF Working Paper 08/287*.

International Monetary Fund (2008). Globalization: A Brief Overview. Issues Brief 02/08. Available at https://www.imf.org/external/np/exr/ib/2008/053008.htm (27.09.2014).

International Monetary Fund (2014). World Economic Outlook Database. Online Database. Available at http://www.imf.org/external/pubs/ft/weo/2014/01/weodata/index.aspx (13.09.2014).

Islam, N. (1995). Growth Empirics: A Panel Data Approach. *Quarterly Journal of Economics 110*, 1127–1170.

Jedidi, K., H. S. Japgal, and W. S. DeSarbo (1997). Finite-Mixture Structural Equation Models for Response-Based Segmentation and Unobserved Heterogenity. *Marketing Science 16*, 39–59.

Jerzmanowski, M. (2006). Empirics of Hills, Plateaus, Mountains and Plains: A Markov-Switching Approach to Growth. *Journal of Development Economics 81*, 357–385.

Jerzmanowski, M. (2011). Acceleration, Stagnation and Crisis: the Role of Macro Policies in Economic Growth. Working Paper, Clemson University. Available at http://ssrn.com/abstract=178891 (06.05.2014).

Johnson, S., W. Larson, C. Papageorgiou, and A. Subramanian (2012). Is Newer Better? Penn WorldTable Revisions and Their Impact on Growth Estimates. *Journal of Monetary Economics 60*, 255–274.

Jones, B. F. and B. A. Olken (2005). The Anatomy of Start-Stop Growth. *NBER Working Paper*.

Jones, B. F. and B. A. Olken (2008). The Anatomy of Start-Stop Growth. *Review of Economics and Statistics 90*, 582–587.

Jones, L. E. and R. Manuelli (1990). A Convex Model of Equilibrium Growth: Theory and Policy Implications. *Journal of Political Economy 98*, 1008–1038.

Jong-A-Pin, R. and J. de Haan (2011). Political Regime Change, Economic Reform and Growth Accelerations. *Public Choice 146*, 93–115.

Jorgenson, D. and Z. Griliches (1967). The Explanation of Productivity Change. *Review of Economic Studies 34*, 249–280.

Kali, R., J. Reyes, J. McGee, and S. Shirrell (2013). Growth Networks. *Journal of Development Economics 101*, 216–227.

Kappler, M., H. Reisen, M. Schularick, and E. Turkisch (2012). The Macroeconomic Effects of Large Exchange Rate Appreciations. *Open Economies Review 0*, 471–494.

Kar, S., L. Pritchett, S. Raihan, and K. Sen (2013). Looking For a Break: Identifying Transitions in Growth Regimes. *Journal of Macroeconomics 38*, 151–166.

Karlis, D. and E. Xekalaki (2003). Choosing Initial Values for the EM Algorithm for Finite Mixtures. *Computational Statistics & Data Analysis 41*, 577–590.

Kaufmann, D., A. Kraay, and M. Mastruzzi (2008). Governance Matters VII: Aggregate and Individual Governance Indicators 1996-2007. *World Bank Policy Reserach Working Paper*.

Kejriwal, M. and P. Perron (2010). A Sequential Procedure to Determine the Number of Breaks in Trend with an Integrated or Stationary Noise Component. *Journal of Time Series Analysis 31*, 305–328.

Kerekes, M. (2011). Analyzing Patterns of Economic Growth: A Production Frontier Approach. Working Paper. Available at `http://www.wiwiss.fu-berlin.`

de/fachbereich/vwl/corneo/mitarbeiter/Kerekes_Monika/index.html (27.09.2014).

Kerekes, M. (2012). Growth Miracles and Failures in a Markov Switching Classification Model of Growth. *Journal of Development Economics 98*, 167–177.

Kim, C.-J. (2004a). Markov-Switching Models with Endogenous Explanatory Variables. *Journal of Econometrics 122*, 127–136.

Kim, C.-J. (2004b). Markov-Switching Models with Endogenous Explanatory Variables II: A Two-Step MLE Procedure with Standard-Error Correction. Working Paper. Available at http://ssrn.com/abstract=516683 (06.06.2011).

Kim, C.-J., J. Piger, and R. Startz (2008). Estimation of Markov Regime-Switching Regression Models with Endogenous Switching. *Journal of Econometrics 143*, 263–273.

King, R. G. and R. Levine (1993a). Finance and Growth: Schumpeter Might be Right. *Quarterly Journal of Economics 108*, 717–737.

King, R. G. and R. Levine (1993b). Finance, Entrepreneurship, and Growth: Theory and Evidence. *Journal of Monetary Economics 32*, 513–542.

Knab, B. (2000). *Erweiterungen von Hidden-Markov-Modellen zur Analyse ökonomischer Zeitreihen.* http://kups.ub.uni-koeln.de/id/eprint/541 (15.04.2011).

Knack, S. and P. Keefer (1995). Institutions and Economic Performance: Cross-Country Tests Using Alternative Institutional Measures. *Economics And Politics 7*, 207–227.

Knack, S. and P. Keefer (1997). Does Social Capital Have an Economic Payoff? *Quarterly Journal of Economics 112*, 1251–1288.

Kneip, A., L. Simar, and P. W. Wilson (2008). Asymptotics And Consistent Bootstraps For Dea Estimators In Nonparametric Frontier Models. *Econometric Theory 24*, 1663–1697.

Komiya, R. and K. Yasui (1984). Japan's Macroeconomic Performance Since the First Oil Crisis: Review and Appraisal. *Carnegie-Rochester Conference Series on Public Policy 20*, 69–114.

Kormendi, R. C. and P. G. Meguire (1985). Macroeconomic Determinants of Growth: Cross-Country Evidence. *Journal of Monetary Economics 16*, 141–163.

Kourtellos, A. (2002). A Projection Pursuit Appraoch to Cross Country Growth Data. *Department of Economics, University of Cyprus Discussion Paper 2002–13*.

Krueger, A. B. (1999). Measuring Labor's Share. *American Economic Review Papers And Procedings 89*, 45–51.

Kumar, S. and R. R. Russel (2002). Technological Change, Technological Catch-Up, and Capital Deepening: Relative Contributions to Growth and Convergence. *American Economic Review 92*, 527–548.

Kumbhakar, S. C. and C. A. K. Lovell (2000). *Stochastic Frontier Analysis.* Cambridge: Cambridge University Press.

La Porta, R., F. Lopez-de Silanes, C. Pop-Eleches, and A. Shleifer (2004). Judicial Checks and Balances. *Journal of Political Economy 112*, 445–470.

Laeven, L. and F. Valencia (2008). Systemic Banking Crises: A New Database. *IMF Working Paper WP/08/224*.

Lavezzi, A. M. and M. Matteo (2010). An Empirical Analysis of Growth Regimes. Working Paper. Available at `http://www.unipa.it/~lavezzi/papers/growthClustering2009_11.pdf` (06.06.2011).

Levine, R. and D. Renelt (1992). A Sensitivity Analysis of Cross-Country Growth Regressions. *American Economic Review 82*, 942–963.

Levy-Yeyati, E. and F. Sturzenegger (2007). Fear of Appreciation. *World Bank Policy Research Working Paper 4387*.

Levy-Yeyati, E., F. Sturzenegger, and P. A. Gluzmann (2013). Fear of Appreciation. *Journal of Development Economics 101*, 233–247.

Li, C. and G. Biswas (2000). A Bayesian Approach to Temporal Data Clustering Using Hidden Markov Models. *Proceedings of the Seventeenth International Conference on Machine Learning, pp. 543-550*.

Lin, J. Y. (2011). New Structural Economics: A Framework for Rethinking Development. *The World Bank Research Observer 26*, 193–221.

Lin, J. Y. (2012). *New Structural Economics: A Framework for Rethinking Development and Policy*. Washington, DC: World Bank.

Loayza, N. V., R. Ranciere, L. Serven, and J. Ventura (2007). Macroeconomic Volatility and Welfare in Developing Countries: An Introduction. *The World Bank Economic Review 21*, 343–357.

Lucas, R. E. (1988). On the Mechanics of Economic Development. *Journal of Monetary Economics 22*, 3–42.

Lutz, W., A. Goujon, K. Samir, and W. Sanderson (2007). Reconstruction of Populations by Age, Sex and Level of Educational Attainment for 120 countries for 1970-2000. *Vienne Yearbook of Population Research 2007*, 193–235.

MacDonald, R. and F. Vieira (2010). A Panel Data Investigation of Real Exchange Rate Misalignment and Growth. *CESIFO WORKING PAPER NO. 3061*.

Mankiw, G. N., D. Romer, and D. N. Weil (1992). A Contribution to the Empirics of Economic Growth. *Quarterly Journal of Economics 107*, 407 – 437.

Marshall, M. G., K. Jaggers, and T. R. Gurr (2010). Polity IV Database. *Taken From: Polity IV Project: Political Regime Characteristics and Transitions, 1800-2010*.

Mbaye, S. (2013). Currency Undervaluation and Growth: Is There a Productivity Channel? *International Economics 133*, 8–28.

McLachlan, G. J. and T. Krishnan (1997). *The EM Algorithm and Extensions*. New York: John Wiley & Sons.

McMillan, M., D. Rodrik, and I. n. Verduzco-Gallo (2014). Globalization, Structural Change, and Productivity Growth, with an Update on Africa. *World Development 63*, 11–32.

Menard, S. (2001). *Applied Logistic Regression Analysis*. Thousand Oaks, CA: Sage: Sage University Paper Series on Quantitative Applications in Social Sciences, 07-106.

Montiel, P. J. and L. Serven (2008). Real Exchange Rates, Saving and Growth. *World Bank Policy Research Working Paper 4636*.

Morales, J. A. and J. D. Sachs (1988). Bolivia's Economic Crisis. *NBER Working Paper 2620*.

Murphy, K. M., A. Shleifer, and R. Vishny (1989). Income Distribution, Market Size and Industrialization. *Quarterly Journal of Economics 104*, 537–564.

Murray, C. J. and C. R. Nelson (2000). The Uncertain Trend in U.S. GDP. *Journal of Monetary Economics 46*, 79–95.

Nehru, V. and A. Dhareshwar (1993). A New Database on Physical Capital Stock: Sources, Methodology and Results. *Revista de Analisis Economico 8*, 37–59.

Nelson, C. R. and C. I. Plosser (1982). Trends and Random Walks in Macroeconomics Time Series. *Journal of Monetary Economics 10*, 139–162.

Nelson, R. R. (1956). A Theory of the Low-Level Equilibrium Trap in Underdeveloped Economies. *American Economic Review 46*, 894–908.

Nelson, R. R. (1973). Recent Exercises in Growth Accounting: New Understanding or Dead End? *American Economic Review 63*, 462–468.

Nelson, R. R. and E. S. Phelps (1966). Investment in Humans, Technological Diffusion and Economic Growth. *American Economic Review 56*, 69–75.

Nouira, R., P. Plane, and K. Sekkat (2011). Exchange Rate Undervaluation and Manufactured Exports: Deliberate Strategy? *Journal of Comparative Economics 39*, 584–601.

Nouira, R. and K. Sekkat (2012). Desperately Seeking the Positive Impact of Undervaluation on Growth. *Journal of Macroeconomics 34*, 537–552.

Owen, A. L., J. Videras, and L. Davis (2009). Do All Countries Follow the Same Growth Process? *Journal of Economic Growth 14*, 265–286.

Paap, R., P. H. Franses, and D. van Dijk (2005). Does Africa Grow Slower Than Asia, Latin America and the Middle East? Evidence From a New Data-Based Classification Method. *Journal of Development Economics 77*, 553–570.

Papageorgiou, C. (2002). Trade as a Threshold Variable for Multiple Regimes. *Economics Letters 77*, 85–91.

Pattillo, C., S. Gupta, and K. Carey (2005). Sustaining Growth Accelerations and Pro-Poor Growth in Africa. *IMF Working Paper 05/195*.

Perron, P. (1989). The Great Crash, the Oil-Price Shock, and the Unit Root Hypothesis. *Econometrica 57*, 1361–1401.

Polterovic, V. and V. Popov (2003). Accumulation of Foreign Exchange Reserves and Long Term Growth. *MPRA Working Paper No. 20069*.

Porter, M. E. (1990). *The Competitive Advantage of Nations.* New York: Free Press.

Prescott, E. C. (1998). Needed: A Theory of Total Factor Productivity. *International Economic Review 39*, 525–552.

Pritchett, L. (2000). Understanding Patterns of Economic Growth: Searching for Hills among Plateaus, Mountains, and Plains. *The World Bank Economic Review 14*, 221–250.

Pritchett, L. (2003). A Toy Collection, a Socialist Star and a Democratic Dud? See Rodrik (2003), pp. 123–151.

Qu, G. and K. Sylwester (2010). Undervaluation, Institutions, and Development. *Southern Illinois University Carbondale Working Paper 2010-04*.

Rapetti, M. (2012). Macroeconomic Policy Coordination in a Competitive Real Exchange Rate Strategy for Development. *Journal of Globalization and Development 3*, 1–31.

Rapetti, M., P. Skott, and A. Razmi (2012). The Real Exchange Rate and Economic Growth: Are Developing Countries Different? *International Review of Applied Economics 26*, 735–753.

Ray, S. C. (2004). *Data Envelopment Analysis - Theory and Techniques for Economics and Operations Research.* Cambridge: Cambridge University Press.

Razin, O. and S. M. Collins (1997). Real Exchange Rate Misalignments and Growth. *NBER Working Paper 6174*.

Razmi, A., M. Rapetti, and P. Skott (2012). The Real Exchange Rate and Economic Development. *Structural Change and Economic Dynamics 23*, 151–169.

Rebelo, S. (1991). Long-Run Policy Analysis and Long-Run Growth. *Journal of Political Economy 99*, 500–521.

Rodriguez, F. and D. Rodrik (2000). Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence. *NBER Macroeconomics Annual 15*, 261–338.

Rodrik, D. (1997). TFPG Controversies, Institutions, and Economic Performance in East Asia. *NBER Working Paper Series*.

Rodrik, D. (1999). Where Did All the Growth Go? External Shocks, Social Conflict and Growth Collapses. *Journal of Economic Growth 4*, 385–412.

Rodrik, D. (2003). *In Search of Prosperity: Analytic Narratives on Economic Growth*. Princeton University Press.

Rodrik, D. (2005). Growth Strategies. See Aghion and Durlauf (2005), pp. 967–1014.

Rodrik, D. (2008). The Real Exchange Rate and Economic Growth. *Brookings Papers on Economic Activity 2*, 365–412.

Rodrik, D. and A. Subramanian (2005). From "Hindu Growth" to Productivity Surge: The Mystery of the Indian Growth Transition. *IMF Staff Papers 52*, 193–228.

Rodrik, D., A. Subramanian, and F. Trebbi (2004). Institutions Rule: The Primacy of Institutions Over Geography and Integration in Economic Development. *Journal of Economic Growth 9*, 131–165.

Romer, P. M. (1990). Endogenous Technological Change. *Journal of Political Economy 98*, 71–102.

Sachs, J., J. W. McArthur, G. Schmidt-Traub, M. Kruk, C. Bahadur, M. Faye, and G. McCord (2004). Ending Africa's Poverty Trap. *Brookings Papers on Economic Activity 2004*(1), 117–240.

Sachs, J. D. (2003). Institutions Don't Rule: Direct Effects of Geography on Per Capita Income. *NBER Working Paper*.

Sachs, J. D., A. Warner, A. Åslung, and S. Fischer (1995). Economic Reform and the Process of Global Integration. *Brookings Papers on Economic Activity 1995*, 1–118.

Sahay, R. and R. Goyal (2006). Volatility and Growth in Latin America: An Episodic Approach. *IMF Working Paper 06/287*.

Sala-i-Martin, X., G. Doppelhofer, and R. I. Miller (2004). Determinants of Long-Term Growth: A Bayesian Averaging of Classical Estimates (BACE) Approach. *American Economic Review 94*, 813–835.

Sala-i-Martin, X. X. (1997). I Just Ran Two Million Regressions. *American Economic Review 87*, 178–183.

Salinas-Jimenez, M., I. Alvarez-Ayuso, and J. Delgado-Rogriguez (2006). Capital Accumulation and TFP Growth in the EU: A Production Frontier Approach. *Journal of Productivity Analysis 28*, 195–205.

Schröder, M. (2013). Should Developing Countries Undervalue Their Currencies? *Journal of Development Economics 105*, 140–151.

Schreyer, P. (2004). Chain Index Number Formulae in the National Accounts. *8th OECD-NBS Workshop on National Accounts*.

Sen, K. (2013). The Political Dynamics of Economic Growth. *World Development 47*, 71–86.

Simar, L. and P. W. Wilson (1998). Sensitivity Analysis of Efficiency Scores: How to Bootstrap in Nonparametric Frontier Models. *Management Science 44*, 49–61.

Simar, L. and P. W. Wilson (1999). Estimating and Bootstrapping Malmquist Indices. *European Journal of Operational Research 115*, 459–471.

Simar, L. and P. W. Wilson (2000). Statistical Inference in Nonparametric Frontier Models: The State of the Art. *Journal of Productivity Analysis 13*, 49–78.

Simar, L. and P. W. Wilson (2007). Estimation and Inference in Two-Stage, Semi-Parametric Models of Production Processes. *Journal of Econometrics 136*, 31–64.

Simar, L. and P. W. Wilson (2008). Statistical Inference in Nonparametric Frontier Models: Recent Developments and Perspectives. pp. 421–521.

Simar, L. and V. Zelenyuk (2007). Statistical Inference for Aggregates of Farrell-Type Efficiences. *Journal of Applied Econometrics 22*, 1367–1394.

Sirimaneetham, V. and J. R. W. Temple (2009). Macroeconomic Stability and the Distribution of Growth Rates. *The World Bank Economic Review 23*, 443–479.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics 70*, 65–94.

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *Review of Economics and Statistics 39*, 312–320.

Subramanian, A. (2010). New PPP-Based Estimates of Renminbi Undervaluation and Policy Implications. *Peterson Institute for International Economics Policy Brief 10-8*.

Summers, R. and A. Heston (1991). The Penn World Table (Mark 5) : An Expanded Set of International Comparisons, 1950 -1988. *Quarterly Journal of Economics 106*, 327–368.

Swan, T. W. (1956). Economic Growth and Capital Accumulation. *Economic Record 32*, 334–361.

Taylor, A. M. and M. P. Taylor (2004). The Purchasing Power Parity Debate. *Journal of Economic Perspectives 18*, 135–158.

Temple, J. (1999). The New Growth Evidence. *Journal of Economic Literature 37*, 112–156.

Thompson, M. (2008). Generating Economic Growth: An Analytical Survey. *The Open Economics Journal 1*, 25–36.

Timmer, M. P. and G. J. de Vries (2009). Structural Change and Growth Accelerations in Asia and Latin America: A New Sectoral Data Set. *Cliometrica 3*, 165–190.

UN Millennium Project (2005). Investing in Development: A Practical Plan to Achieve the Millennium Development Goals – Overview.

Wacziarg, R. and K. H. Welch (2008). Trade Liberalization and Growth: New Evidence. *The World Bank Economic Review 22*, 187–231.

Wichern, B. (2001). *Hidden-Markov-Modelle zur Analyse und Simulation von Finanzmarktreihen*. Köln: Hundt Druck GmbH,.

Williamson, J. (1990a). *Latin American Adjustment: How Much Has Happened?* Washington: Peterson Institute for International Economics.

Williamson, J. (1990b). What Washington Means by Policy Reform. See Williamson (1990a), pp. 5–20.

Wilson, P. W. (2008). FEAR: A Software Package for Frontier Efficiency Analysis with R. *Wilson, Paul W. (2008), "FEAR 1.0: A Software Package Socio-Economic Planning Sciences 42*, 247–254.

Wong, J. Y. Y. and K.-W. Li (2012). Performance of Economic and Political Factors in Sustainable Growth Accelerations. *City of University Hong Kong - Department of Economics and Finance Working Paper: 2012024*.

Woodford, M. (2008). Comments and Discussion on "The Real Exchange Rate and Economic Growt". *Brookings Papers on Economic Activity 2*, 420–437.

World Trade Organization (2011). The GATT Years: From Havana to Marrakesh. Official Website. Available at `http://www.wto.org/english/thewto_e/whatis_e/tif_e/fact4_e.htm` (31.05.2011).

Young, A. (1995). The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience. *Quarterly Journal of Economics 110*, 641–680.

Zivot, E. and D. W. K. Andrews (1992). Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis. *Journal of Business & Economic Statistics 10*, 251–270.

Executive Summary

Even though results from growth regressions are remarkably unstable, this tool has so far remained the workhorse of empirical growth research. However, a growing body of literature acknowledges that economic growth in most countries is highly volatile and interspersed with structural breaks. This instability has two major implications for analyzing economic growth: First, empirical strategies that focus on explaining average growth rates over more or less arbitrarily chosen time periods (e.g. by using ad-hoc time spans in panel data) are bound to meet their limits. Second, the key to understanding long-run economic growth is to understand growth transitions or growth regime changes, i.e. how and why countries move between episodes of high and episodes of low growth. This thesis focuses on the instability of growth rates and uses three different approaches in order to improve the understanding of growth regime changes in three self-contained essays.

The first essay entitled ”Analyzing Patterns of Economic Growth: A Nonparametric Production Frontier Approach” analyzes the proximate sources of growth linked to growth regime changes. To that end, statistically significant shifts in the average growth rates of income per capita are identified in a cross-section of countries; the thus defined changes of per-capita income growth rates are then submitted to a nonparametric growth accounting analysis. Compared to traditional growth accounting, the nonparametric variant not only requires less restrictive assumptions, but also allows the further decomposition of total factor productivity changes (the Solow residual in traditional growth accounting) into the contributions made by changes in the efficiency of production and technological changes. The essay reveals that growth regime changes go hand in hand with total factor productivity changes, which themselves are to a large extent the result of changes in the efficiency of production. Growth accelerations in low and middle income countries are dominated by improvements in the efficiency of production; in high income countries the improvements of total factor productivity represent to a significant extent technological developments. Changes in factor accumulation are of limited importance for positive growth turnarounds. This is different for growth decelerations. Slower factor accumulation explains a noticeably larger part of the observed growth slowdown. However, deteriorating efficiency levels remain the most important element of the explanation. Both features do not hinge on the level of development of the respective economies.

The second essay entitled "Growth Miracles and Failures in a Markov Switching Classification Model of Growth" interprets economic growth as a sequence of transitions between distinct growth regimes characterized by the respective average growth rates and volatilities. The first part of the analysis simultaneously determines the features of four growth regimes and three clusters of countries. Countries within each cluster are characterized by similar growth dynamics. The first cluster represents successful countries that experience lengthy periods of high or very high growth. The second cluster comprises moderately successful countries that undergo both periods of reasonable growth and periods of stagnation. The third cluster consists of failing countries that suffer from highly volatile growth rates with frequent episodes of crisis. In a second step the identified clusters are used to uncover differences in growth fundamentals that may explain the distinct patterns of growth. Not surprisingly, successful countries are characterized by favorable initial conditions, good policies and good institutions. However, the differences between the moderately successful and failing cluster are more interesting: it is neither initial conditions nor institutions that distinguish moderately successful from failing countries; what makes them different is policy. Moderately successful countries have invested more into infrastructure and human capital, they have embraced trade liberalization earlier and they have more successfully limited policy volatility. This is an encouraging finding for countries with weak institutions. Even though good institutions are clearly important, a lack of them does not automatically translate into dismal growth behavior.

The third essay entitled "Growth Accelerations and Real Exchange Rates - A Reassessment" deals with the question whether real exchange rate depreciations are systematically related to the onset of growth accelerations. This is frequently claimed in the literature, even though the empirical evidence is scarce. In this essay a binary choice model is used to analyze the link between episodes of fast growth and real depreciation events, i.e. episodes of modest, but sustained real depreciations. The empirical association between real exchange rate depreciations and the onset of growth accelerations turns out to be quite fragile. The fragility is a result of distinct and often offsetting effects of real depreciation events, which depend on the associated level of the real exchange rate and the time period under consideration. Prior to 1980 sustained real depreciations of overvalued currencies are positively linked to the beginning of growth accelerations; in more recent times this applies to sustained real depreciations of already undervalued currencies. It is not only the link between real depreciation events and growth accelerations that changes over time. The same is true for the association between growth accelerations and their ”traditional” determinants, which become less successful in predicting the onset of growth spurts over time.

Zusammenfassung

Trotz einer auffallend hohen Instabilität der mit Hilfe von Wachstumsregressionen generierten Ergebnisse, stellen Wachstumsregressionen nach wie vor die Standardmethode der empirischen Wachstumsforschung dar. Mittlerweile erkennt jedoch eine ständig anwachsende Literatur an, dass das Wirtschaftswachstum in the meisten Ländern von hoher Volatilität und Strukturbrüchen geprägt ist. Diese Instabilität hat zwei wichtige Implikationen für die Wachstumsanalyse: Erstens stoßen empirische Strategien, die versuchen, das durchschnittliche Wirtschaftswachstum über einen mehr oder weniger willkürlich gewählten Zeitraum zu erklären (z.B. durch eine ad-hoc Festlegung der Zeitspannen in Paneldaten), zwangsläufig an ihre Grenzen. Zweitens liegt der Schlüssel zum Verständnis des langfristigen Wirtschaftswachstums im Verständnis von Regimewechseln, d. h. dem Verständnis, wie und warum Länder zwischen Episoden hohen und niedrigen Wirtschaftswachstums wechseln. Diese Dissertation stellt die Instabilität von Wachstumsraten in den Fokus der Analyse. In drei eigenständigen Aufsätzen werden unterschiedliche Analyseansätze verwendet, die zu einem besseren Verständnis der beobachteten Regimewechsel beitragen sollen.

Im ersten Aufsatz mit dem Titel „Analyzing Patterns of Economic Growth: A Nonparametric Production Frontier Approach“ werden die Quellen des Wirtschaftswachstums ("proximate sources") im Zusammenhang mit Regimewechseln untersucht. Zu diesem Zweck werden statistisch signifikante Strukturbrüche der Wachstumsraten des Pro-Kopf-Einkommens in einem Länderquerschnitt identifiziert; anschließend werden die mit diesen Strukturbrüchen einhergehenden Änderungen der Pro-Kopf-Wachstumsraten mittels einer nicht-parametrischen Wachstumsbuchhaltung analysiert. Verglichen zur traditionellen Wachstumsbuchhaltung benötigt das nicht-parametrische Pendant nicht nur weniger restriktive Annahmen, sondern erlaubt darüber hinaus die weitere Zerlegung von Änderungen der totalen Faktorproduktivität (das Solow-Residuum bei der parametrischen Wachstumsbuchhaltung) in die jeweiligen Beiträge durch Änderungen der Produktionseffizienz und technologische Änderungen. Aus dem Aufsatz geht hervor, dass Regimewechsel mit Änderungen der totalen Faktorproduktivität einhergehen, die wiederum größtenteils aus Änderungen der Produktionseffizienz resultieren. Wachstumsbeschleunigungen in Ländern mit niedrigem und mittlerem Einkommen werden von Verbesserungen der Produktionseffizienz dominiert; in Ländern mit hohem Einkommen stellen die Verbesserungen der totalen Faktorproduktivität zu einem bedeutenden Teil technologische Entwicklungen dar. Änderungen in Bezug auf die Faktorakkumulation sind für positive Regimewechsel von begrenzter Bedeutung. Die ist bei Wachstumsentschleunigungen anders. Hier wird ein spürbar höherer Anteil des abnehmenden Wirtschaftswachstums durch verlangsamte Faktorakkumulation erklärt. Das wichtigste Element der Erklärung bleibt allerdings eine Verschlechterung der Produktionseffizienz. Beide Merkmale gelten unabhängig vom Entwicklungsstand der Volkswirtschaften.

Im zweiten Aufsatz mit dem Titel „Growth Miracles and Failures in a Markov Switching Classification Model of Growth“ wird das langfristige Wirtschaftswachstum als eine Abfolge von Übergängen zwischen verschiedenen Wachstumsregimen interpretiert, die sich durch unterschiedlich hohe durchschnittliche Wachstumsraten und Volatilitäten auszeichnen. Im ersten Teil der Analyse werden zeitgleich die Eigenschaften von vier Wachstumsregimen hergeleitet und drei Ländercluster gebildet. Länder innerhalb eines Clusters weisen eine ähnliche Wachstumsdynamik auf. Das erste Cluster repräsentiert erfolgreiche Länder, die sich durch lang anhaltende Perioden hohen oder sehr hohen Wirtschaftswachstums auszeichnen. Im zweiten Cluster finden sich mäßig erfolgreiche Länder, die sowohl ordentliche Wachstumsperioden als auch Stagnationsperioden erleben. Das dritte Cluster umfasst erfolglose Länder, die an hochgradig volatilen Wachstumsraten und häufig auftretenden krisenhaften Episoden leiden. In einem zweiten Schritt werden die identifizierten Cluster verwendet, um Unterschiede in den zugrunde liegenden fundamentalen Wachstumsfaktoren aufzudecken, die geeignet sein könnten, die unterschiedlichen Wachstumsmuster zu erklären. Wenig überraschend zeichnen sich erfolgreiche Länder durch gute allgemeine Ausgangsbedingungen, gute Politikentscheidungen und gute Institutionen aus. Interessanter sind jedoch die Unterschiede zwischen mäßig erfolgreichen und erfolglosen Ländern. Diese Ländergruppen unterscheiden sich vornehmlich nicht etwa hinsichtlich der Ausgangsbedingungen oder der institutionellen Rahmenbedingungen, vielmehr macht die Politik den entscheidenden Unterschied. So haben mäßig erfolgreiche Länder mehr Investitionen in Infrastruktur und Ausbildung getätigt, den Handel früher liberalisiert und politisch weniger volatil agiert. Dieses Ergebnis ist insbesondere für Länder mit schwachen Institutionen ermutigend. Auch wenn gute Institutionen fraglos wichtig sind, gibt es keinen Automatismus, demzufolge sich ein schwächeres institutionelles Umfeld zwangsläufig in desolaten Wachstumsraten niederschlagen muss.

Der dritte Aufsatz mit dem Titel „Growth Accelerations and Real Exchange Rates - A Reassessment“ analysiert, ob reale Währungsabwertungen systematisch mit dem Beginn von Wachstumsbeschleunigungen zusammenfallen. Dieser Zusammenhang wird in der Literatur häufig geltend gemacht, obwohl die empirische Evidenz rar ist. Im Aufsatz wird ein binäres Regressionsmodell verwendet, um das statistische Zusammenfallen von Hochwachstumsphasen und realen Abwertungsereignissen, also mäßigen, aber nachhaltigen realen Abwertungen einer Währung, zu erforschen. Der empirische Zusammenhang zwischen realen Abwertungen und dem Beginn von Wachstumsbeschleunigungen erweist sich als fragil. Die Fragilität resultiert aus unterschiedlichen und oftmals gegenläufigen Effekten von realen Abwertungsereignissen; ihre Auswirkungen hängen von dem mit ihnen einhergehenden Niveau des realen Wechselkurses und vom Beobachtungszeitraum ab. Vor 1980 gibt es einen positiven Zusammenhang zwischen nachhaltigen realen Abwertungen von überbewerteten Währungen und dem Beginn von Wachstumsbeschleunigungen; in jüngerer Zeit existiert dieser Zusammenhang bei nachhaltigen Abwertungen von bereits unterbewerteten Währungen. Auch der beobachtete Zusammenhang zwischen Wachstumsbeschleunigungen und ihren „traditionellen“ Determinanten ändert sich im Zeitablauf. Letztere sind im Zeitablauf immer weniger in der Lage, Episoden hohen Wirtschaftswachstums vorherzusagen.

Berlin, 26.06.2015

Erklärung gem. § 10 Abs. 3 der Promotionsordnung zum Dr. rer. pol. des Fachbereichs Wirtschaftswissenschaft der Freien Universität Berlin vom 13. Februar 2013

Hiermit erkläre ich, dass ich für die Dissertation folgende Hilfsmittel und Hilfen verwendet habe:

Stata SE 10 und Stata SE 12

Matlab 2007b

R Version 3.3.1

Zitierte Literatur

Auf dieser Grundlage habe ich die Arbeit selbständig verfasst.

Monika Kerekes