Charles University

Faculty of Social Sciences
Institute of Economic Studies

MASTER'S THESIS

The impact of human capital and population age structure on economic growth

Author: **Bc. Michal Topinka, M.Sc.**

Supervisor: **PhDr. Jaromír Baxa, Ph.D.**

Academic Year: **2017/2018**

Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

The author grants to Charles University permission to reproduce and to distribute copies of this thesis document in whole or in part.

Prague, July 31, 2018

Signature

References

TOPINKA, Michal. The impact of human capital and population age structure on economic growth. Prague, 2018. 61 pages. Master's thesis (Mgr.). Charles University, Faculty of Social Sciences, Institute of Economic Studies. Supervisor PhDr. Jaromír Baxa, Ph.D.

Length of the thesis: 96 594

Acknowledgments

My sincere gratitude goes to PhDr. Jaromír Baxa Ph.D. for his guidance, valuable suggestions and feedback. I would also like to thank my family and friends for their continued support.

Abstract

The demographic transition led to an added productivity commonly referred to as the demographic divided, which resulted in high rates of economic growth in most of the world. The general consensus is that the increased pace of economic growth was attained largely thanks to changes in population age structure. However, the literature contains evidence that the population structure does not have a significant impact on economic growth and that improvements in education attainment have in fact been responsible for the high rates of economic growth. These claims are in contradiction with most of the literature and can have important implications for future research and policy making. Since these claims have not been, to the best of our knowledge, verified, this thesis aims to replicate the original research using newer and more suitable data for a higher number of countries. In addition to the original research, analysis is also performed on various subsamples based on governance and cultural indicators. The level and the change in education attainment did not appear statistically significant in most of the regressions, so the claims could not be proved or disproved. However, important insights about the role of not only population structure and labor force participation in explaining economic growth were obtained.

Keywords demographic dividend, demographic transition, economic growth, human capital, population age structure

Author's e-mail `michal.topinka@gmail.com`
Supervisor's e-mail `jaromir.baxa@fsv.cuni.cz`

Thesis title in English

The impact of human capital and population age structure on economic growth

Abstrakt

Demografický přechod vedl ke zvýšené produktivitě obecně označované jako demografická dividenda, která vedla k vysoké míře ekonomického růstu ve většině světa. Obecným konsensem je, že tohoto zvýšeného tempa hospodářského růstu bylo dosaženo převážně díky změnám ve věkové struktuře populace. Nicméně literatura obsahuje důkaz, že struktura populace nemá významný dopad na ekonomický růst a že zlepšení v průměrném nejvyšším dosaženém vzdělání bylo ve skutečnosti zodpovědné za tyto vysoké ekonomické růsty. Tato tvrzení jsou v rozporu s většinou literatury a mohou mít významné důsledky pro budoucí výzkum a tvorbu politik. Vzhledem k tomu, že tato tvrzení nebyla podle našeho nejlepšího vědomí ověřena, cílem této diplomové práce je replikovat původní výzkum za využití novějších a vhodnějších dat pro vyšší počet zemí. Navíc oproti původnímu výzkumu je také provedena analýza na několika menších skupinách zemí rozdělených podle indikátorů kvality vlády a kultury. Úroveň a změna průměrného nejvyššího dosaženého vzdělání nebyla ve většině regresí statisticky významná, a proto tato tvrzení nemohou být potvrzena ani vyvrácena. Byly však získány důležité poznatky o úloze nejenom struktury obyvatelstva a podílu pracovní síly na vysvětlení ekonomického růstu.

Klíčová slova	demografická dividenda, demografický přechod, ekonomický růst, lidský kapitál, věková struktura populace

E-mail autora	michal.topinka@gmail.com
E-mail vedoucího práce	jaromir.baxa@fsv.cuni.cz

Český název práce

Vliv lidského kapitálu a věkové struktury populace na ekonomický růst

Contents

List of Tables

List of Figures

Acronyms

AE Accounting Effects

BACE Bayesian Averaging of Classical Estimates

BAMLE Bayesian Averaging of Maximum Likelihood Estimates

BMA Bayesian Model Averaging

CPIA Country Policy and Institutional Assessment

DPD Dynamic Panel Data

EU European Union

GDP Gross Domestic Product

GE Government Effectiveness

GMM Generalized Method of Moments

IIASA International Institute for Applied Systems Analysis

LTO Long-Term Orientation

MAS Masculinity

NUTS Nomenclature of Territorial Units for Statistics

OECD Organisation for Economic Co-operation and Development

OLS Ordinary Least Squares

PIP Posterior Inclusion Probability

PWT Penn World Table

RQ Regulatory Quality

TFP Total Factor Productivity

UNESCO United Nations Educational, Scientific and Cultural Organisation

WDI World Development Indicators

WGI Worldwide Governance Indicators

Master's Thesis Proposal

Author	Bc. Michal Topinka, M.Sc.
Supervisor	PhDr. Jaromír Baxa, Ph.D.
Proposed topic	The impact of changes in age structure of the population on long-term economic growth

Motivation Economists have for long been interested in the economic impacts of population ageing. The first articles discussing this concept date back to the late thirties of the last century. (Keynes, 1937; Hansen, 1939) The population aging is, however, not the only interesting demographic development. Since the beginning of the twenty first century, some economists have been intrigued by the changes in the structure of the population. The distribution of the population can change substantially as population grows, and since people have different economic habits at various stages of life, this demographic trend can have a significant effect on the world's economies. (Bloom, Canning & Sevilla, 2001)

The interest of this paper lies in the significance of the proportion of population in working age relative to total population, since, unlike the young and elderly, this group alone contributes to the economic growth of nations. It has been shown, for example by Bloom et al. (2001) or Honohan and Walsh (2002), that an increase in the proportion of population at work helped many countries achieve outstanding rates of economic growth. This phenomenon has become known as the demographic dividend.

The literature on the determinants of long-term economic growth is understandably very extensive. In this thesis, I will attempt to contribute to the literature revolving around the determination of statistical significance of many economic, demographic, political and institutional factors, which were suggested by theory and empirical studies as determinants of economic growth.

This body of economic literature dates to 1992, when economists Levine and Renelt performed a series of tests to assess the robustness of the conclusions of a vast literature on cross-country determinants of long-term GDP growth and concluded that majority of the results are not robust. Their results have been challenged by Sala-i-Martin, who in 1997 employed less severe tests with aim to 'assign some level of confidence to each of the variables that were previously found important in the literature.' His work has then been followed by Fernandez, Ley and Steel, who in 2001 proposed to deal with the issue of model uncertainty in cross-country growth regressions by employing Bayesian Model Averaging (henceforth BMA) approach. The previous two researches consisted in estimating large number of regressions (4 million by Sala-i-Martin and over two trillion by Fernandez et al.) with different combinations of regressors. Fernandez et al. used Markov Chain Monte Carlo (MCMC henceforth) method to solve the computational problem and their work has served as a baseline for the implementations of BMA cross-country growth regressions that followed. The BMA approach has since been extended also to dynamic panel data models, firstly introduced by León-González and Montolio in 2004 and extended mainly by Moral-Benito in 2010.

There are tens of variables used in these empirical works and most of the authors, including the ones mentioned above, use the original dataset of Sala-i-Martin from 1997. This dataset includes demographic variables such as the average age of the population, size of the labor force, population growth or the ratio of workers to population. The lastly-mentioned variable, which may seem identical to the new variable proposed below, captures only the employed workers, who contribute to the GDP growth and not the whole population group. To the best of my knowledge, the variables most closely related to the variable proposed at the bottom of this section which have been introduced in this body of literature are the separate inclusions of the proportion of population aged either less than fifteen, or more than sixty-five. They were introduced in the works of Doppelhofer, Miller and Sala-i-Martin (2003) and Moral-Benito (2010). The former authors use the proportion of population aged less than fifteen and do not find it particularly important. I believe that this definition of the variable is not the most appropriate in regards to the literature concerned with the importance of changes in age structure of the population outlined in the beginning of this proposal, since it excludes the elderly population, which not only does not contribute to the production of a country, but typically also has high medical costs and receives a pension. Moral-Benito uses both variables and thereby captures the population not in the working age in two separate variables. The comparison of these work to the existing literature Is difficult, because the authors propose new methods in both papers.

The more recent literature on these topics include propositions for new specifications of the above-mentioned methods (e.g. Leon-González, Montolio, 2015) or an updated work of Moral-Benito (2012), which I could not access. There are also many works with the aim similar to this thesis, which is the replication of the current research with the goal of testing for a newly proposed variable.

In this diploma thesis, I would therefore like to add the proportion of the population between ages fifteen and sixty-five relative to total population, regardless of their work status, to the set of explanatory variables typically tested for in this literature. My aim is to use the conclusions of Bloom et al. (2001) and others and try to prove them using the methods outlined above. I will perform both cross-country regressions following the work of Fernandez et al. (2001) and regressions using dynamic panel data models, mostly following the work of Moral-Benito (2010). Like most of the authors, I will not focus on any region of the world, but will try to use the available data on all countries.

Hypotheses

Hypothesis #1: Is the age structure of the population important for the explanation of long-term economic growth?

Hypothesis #2: Is the proportion of working age population robustly correlated with long-term GDP per capita growth?

Hypothesis #3: Is the conclusion identical for cross-country regressions and regressions using dynamic panel data models?

Hypothesis #4: Is it important to control for this variable in the future research in growth regressions?

Methodology For cross country regressions, I will follow the work of Fernandez et al. (2001) and their recommendations regarding the implementation of the BMA and choice of the prior distribution. I will use the original dataset of Sala-i-Martin, which I will update with the latest data available. I will update just the variables which were measured over the sample period, since some variables are measured only at the beginning to avoid endogeneity. I will obtain the dataset from Sala-i-Martin's website, where it is publicly available. For my new explanatory variable, I will use the data for population between the ages 15-64 from the World Bank. To avoid endogeneity, I will use the value for the beginning of the sample period. For the implementation of the BMA, I will use the R and the package 'BMS'.

For dynamic panel data models, I will collect yearly observations on time-varying variables from the list of important variables available in the literature discussed above. I will then average the data to five-year periods to reduce the problem of serial correlation and follow the methods described by Moral-Benito

(2010) For the estimations, I will use either R or Stata, which includes some useful packages for dynamic panel data modelling created by Moral-Benito.

Expected Contribution My aim in this thesis is to contribute to the extensive empirical literature on growth regressions by examining the significance of the share of working age population on long-term economic growth. The impact of increase in the proportion of this population group is well established in the literature, but has only partially been tested in the empirical growth context. The results indicate that the similarly defined variables are not very important, but I believe this could be caused by the different and perhaps improper definitions of the variations of this variable. I would therefore like to determine whether the previously proven impact of population at work can be proved using the BMA and whether it should be used in the future research. This is still a very active field and therefore my results and recommendations about the inclusion of this variable can influence the future research on this topic. Moreover, I believe it would be beneficial to use test for the inclusion of this variable using both cross-country regressions and dynamic panel data models, since the variations of this variable have only been introduced in the papers introducing new concepts. In case of positive results, this variable can be used in any future research, since it is publicly available for all the whole period used in current growth regressions.

Outline

1. Motivation: Current studies neglect the inclusion of the proportion of working age population among the explanatory variables in growth regressions. Publication bias has been shown to distort most areas of empirical economics, so there is a good chance it will be important here as well.

2. Literature Review: Summary of the empirical literature regarding the determinants of long-term economic growth.

3. Model and methods: Specification of the models and methods for estimation

4. Data and variables: Description of the data collecting process and brief outline of the selected variables

5. Estimation results: Discussion of results

6. Concluding remarks: Summary of findings and recommendations for future research.

Core bibliography

Bloom, D., Canning, D. and Sevilla, J. (2001). Economic Growth and the Demographic Transition. [online] NBER.

Doppelhofer, G., Miller, R. and Sala-i-Martin, X. (2003). Determinants of Long-Term Growth: A Bayesian Averaging of Classical Estimates (BACE) Approach. [online] Ingentaconnect.com.

Fernández, C., Ley, E. and Steel, M. (2001). Model uncertainty in cross-country growth regressions. [online] Wiley Online Library.

Honohan, P. and Walsh, B. (2002). Catching up with the Leaders: The Irish Hare on JSTOR. [online] Jstor.org.

Keynes, J. (1937). Some economic consequences of a declining population. [online]

León-González, R. and Montolio, D. (2004). Growth, convergence and public investment. A Bayesian model averaging approach: Applied Economics: Vol 36, No 17. [online] Tandfonline.com.

León-González, R. and Montolio, D. (2015). Endogeneity and panel data in growth regressions: A Bayesian model averaging approach. [online] Sciencedirect.com.

Levine, R. and Renelt, D. (1992). A Sensitivity Analysis of Cross-Country Growth Regressions on JSTOR. [online] Jstor.org.

Moral-Benito, E. (2010). Determinants of Economic Growth: A Bayesian Panel Data Approach — Review of Economics and Statistics — MIT Press Journals. [online] Mitpressjournals.org.

Sala-i-Martin, X. (1997a). I Just Ran Four Million Regressions. [online] NBER.

Sala-i-Martin, X. (1997b). I Just Ran Two Million Regressions on JSTOR. [online] Jstor.org.

Chapter 1

Introduction

The relationship between demography and economic growth is well established in the literature. Economist have been studying the impacts of demographic changes since the 30s of the 20th century, when Keynes (1937) studied the economic impacts of a declining population. The effect of population growth (decline) has since been well investigated and one can find evidence to support all of the three possible scenarios, namely that population aging harms, promotes, or that it doesn't affect economic growth, as documented by Bloom *et al.* (2003).

Since the beginning of the 21st century, economists have also been intrigued by the importance of changes in the age structure of population and its impacts on economic growth. As explained in Bloom *et al.* (2003), these changes are important because people's economic behavior varies at different stages of life and therefore as the age structure of the population changes, the aggregate economic performance can be seriously affected.

Countries tend to devote a large number of resources to both children and elderly, who both don't produce any economic output. That implies that if there is a high proportion of children and/or elderly, it slows down the economic growth of a particular country. In contrast, if a country has a high proportion of working-age population, who produce more than they consume, it can benefit from this added productivity.

All of the world's countries have either already completed, or are in the process of the *demographic transition*. This transition transforms a mostly rural agrarian society with high mortality and fertility rates to an urban society with low rates of mortality and fertility. (Lee & Mason 2006b) For much of the developing world, the transition accelerated after the end of Second

World War, when improvements in medicine, public health and sanitation reduced mortality, which led to higher life expectancies. This initially led to population increasing in numbers, but actually growing younger, because the improvements in medicine and sanitation had the largest impact on child mortalities. (Bloom *et al.* 2003)

The drop in mortality rates, which started the demographic transition, has been been followed by equally dramatic reductions in fertility rates. The decision of parents to have fewer children can be explained as their response to a realization that since fewer children die during childhood, they can give birth to a smaller number of children to have the desired number of offspring. (Bloom *et al.* 2003) Because there was a lag between the reduction in mortality and the reduction in fertility, a large number of babies was initially born. When this cohort of youngsters reached working ages, there has suddenly been a large group of population concentrated at working ages, whose additional productivity led to higher rates of economic growth.

This phenomenon had initially been called a *demographic dividend*, but now it is more appropriately called a *first demographic dividend*, because a *second demographic dividend* has also been identified. To explain the second demographic dividend, it is useful to firstly explain the trends in mortality and fertility rates, which led to contemporary trend of aging population in most of the world. As previously stated, the large cohort of babies who then turned into a large workforce is now approaching retirement age and since there is not enough babies being born to feed the elderly in the near future and the life expectancy is rising, people face longer retirements and therefore have more incentives to accumulate assets to secure a better future. Nowadays, when global distrust in organizations and governments is rising, according to Harrington (2017), the incentives are probably only going to grow larger. This leads to a rise in national income, regardless of whether the money is invested domestically or abroad. (Lee & Mason 2006b)

Whereas the first demographic dividend is transitory, the second demographic dividend can in fact be permanent. This is because even though the rapid asset accumulation that leads to second demographic dividend is transitory, it leads to an increase in per capita income and assets which stabilize at levels that are permanently higher. (Lee & Mason 2006a) It is also worth noting that the benefits from either of the dividends do not come automatically and necessary policies and high-quality institutions are needed to reap the benefits. (Bloom *et al.* 2003; Lee & Mason 2006b)

The outstanding rates of economic growth are thus attributed to the favorable demographic changes, which led to a temporary increase in the share of working age population. However, it has been identified that there are more ways through which demography influences economic growth. Apart from labor force and savings, it may also affect economic growth through education enrollment and human capital. (Prskawetz *et al.* 2007) As will be demonstrated in Chapter 2, the importance of human capital has been stressed by the recent literature.

There are also conflicting conclusions in the literature. While the conclusions of most of the literature, such as Bloom *et al.* (2003), are that the increase in the share of working age population has been largely responsible for the increase in the pace of economic growth in most of the world's countries, there is a one particular research by Cuaresma *et al.* (2014b), which claims that the changes in the population structure do not have a significant impact on economic growth and that it is in fact the changes in education attainment that have been responsible for the increases pace of economic growth.

As already said, the claims of Cuaresma *et al.* (2014b) are in a contradiction with most of the literature and, if proven right, can have a large impact on the policy making and future research. To the best of our knowledge, the assertions of Cuaresma *et al.* (2014b) have not been validated by other researchers and it is therefore very important to do so. At the time of this writing, there are newer and more appropriate data available and the goal of this thesis is thus to replicate the research of Cuaresma *et al.* (2014b) using these new and better data, which are also available for a higher number of countries, to either support or contradict the conclusions of Cuaresma *et al.* (2014b). Since the insights about the role of population structure and human capital, represented by education attainment, are very important for policy making and future research, it is essential that they are validated.

Apart from replicating the research of Cuaresma *et al.* (2014b), an additional subsampling based on data from Worldwide Governance Indicators and cultural dimensions compiled by Geert Hofstede is conducted. The regressions are then repeated on these smaller, but more homogeneous subsamples, in order to assess the provide a further sensitivity analysis and assess the robustness of the results, or to provide additional insights for a particular group of countries.

System generalized method of moments (henceforth GMM) are primarily be used for the estimation, as in Cuaresma *et al.* (2014b). However, the empirical implementation of this method of estimation differs across individual software packages and since Cuaresma *et al.* (2014b) does not report the software and libraries used for the estimation in their research, this thesis will provide this information in order for other researchers to be able to better validate the results obtained in this thesis. There is also a confusion about the dataset that was used in Cuaresma *et al.* (2014b), because some of the data used in this thesis is claimed to come from publicly available datasets, but for a one particular variable the data are not available for a 10 out of the 25 years used for the analysis in Cuaresma *et al.* (2014b). As already said, the data available for the research in this thesis are not only newer, but more suitable for this analysis thanks to new data sources and methods of measurement of the key variables, such as income per capita growth.

The education attainment variables were mostly found statistically insignificant in the research of this thesis and therefore the claims of Cuaresma *et al.* (2014b) cannot be proved or disproved. However, many important insight about the impact of labor force participation, share of working age population, education attainment, physical capital and several other variables on the income per capita growth were obtained. Additionally, the specific results for certain subsamples of countries provides insights about the appropriateness of certain policies and the importance of governance. These effects of the demographic variables found in this research demonstrates the importance of this area of research and the insights of this thesis provide a future researcher or a policy maker with valuable information.

This thesis is organized as follows. Chapter 2 contains an extensive literature review about the demographic transition, first and second demographic dividends, model averaging in the economic growth literature, and the relationship between demography, human capital and economic growth. Chapter 3 derives the model used for the analysis, describes the system GMM method and the conditions that need to be satisfied. Chapter 4 contains the description of the data used, including the data sources and explanation of the necessary data transformations. It also contains information about the data that will be used to create subsamples on which the regressions will be repeated, including an argumentation as to why the subsampling based on these particular indicators is relevant. Chapter 5 then presents the results and the related discussion. Chapter 6 then concludes.

Chapter 2

Literature Review

In order to summarize the state of the art research examining the importance of demography in explaining economic growth, I have reviewed papers in several areas of research. I have divided the literature in the following categories: (1) papers explaining what demographic dividend is, how it helped particular countries or regions of the world achieve high rates of economic growth, what policies are necessary, etc.; (2) second demographic dividend and how and to what extent it can help particular countries to offset the problems of aging populations; (3) more detailed case studies about particular countries or regions achieving high rates of economic growth, often complemented with various forecasts of future economic performance; (4) model averaging and its application to the growth literature; (5) a closer look at the relationship between demography, education, human capital and economic growth.

2.1 What are the demographic dividends?

The first category of papers are about demographic dividend in general and are mostly dedicated to policy makers to explain what the demographic dividend is and to outline the potential benefits and importance of policies that need to be in place in order to exploit this opportunity. These papers are not really empirical, in a sense that they do not conduct any sort of econometric analysis, but instead use simple charts or tables to illustrate various trends and rather focus on explaining why these trends occur and what does it mean for world's nations.

The most influential work is by Bloom *et al.* (2003). As already mentioned in Chapter 1, the authors firstly review the current findings about the effects of increase in population on economic growth, and then coin the term *demographic dividend*, which is the main focus of the paper. The focus of this paper is mainly on the first demographic dividend, which is in this paper simply referred to as the demographic dividend, but even though the authors did not invent the term second demographic dividend, they already outline this increased tendency to save in the later working ages and therefore establish grounds for the later origination of this term. The term second demographic dividend has been coined by Mason (2005) and has since been a subject of further research. Since the second demographic dividend is not of particular focus in this paper, I will further talk only about the first demographic dividend and in the next few paragraphs that are dedicated to Bloom *et al.* (2003) I will refer to the first demographic dividend as demographic dividend in line with the authors.

I already outlined in Chapter 1 how this phenomenon arises, so here I will just shortly summarize some of the case studies about most of the world's regions as well as the importance of needed policies. The paper first describes the experience of East Asia, where countries were able to exploit the opportunities presented by the demographic dividend the most. The East Asian economic transition was also the fastest, occurring over 50-75 year period. Bloom & Williamson (1998) demonstrated that the demographic dividend accounted for as much as one third of the very high growth rates experienced by the countries in this region. This phenomenon is commonly referred to as the East Asian 'economic miracle'. The East Asian countries must now, however, prepare for their aging population, as their large cohort of baby boomers ages.

The authors next explain the situation of Japan, which was at the time of writing perhaps one of the world's fastest aging countries and as of 2017 has, and in 2050 will still have (according to United Nations' estimates), the largest percentage of population over 60 years old. (United Nations DESA (2017)) The authors then describe the situation of most of the other world's regions in the same matter. The one region which stands out is Sub-Saharan Africa, which as of 2003 still hasn't experienced the typical demographic transition.

Lastly, Bloom *et al.* (2003) give an explanation of the importance of appropriate policy environment, so that the countries can enjoy the benefits of the demographic dividend. The conclusions about these policies are derived from the previously mentioned case studies. The authors explore policies related to public health and access to care, family planning and reproduction, education, labor market flexibility, openness to trade, adequate credit, and savings.

Improvements in public health are crucial during a demographic transition. It is the components of public health such as improved sanitation, vaccines, antibiotics, contraceptives, etc. that lead to reduced mortality and fertility which are the factors behind the changes in age structure of population, as explained before. Furthermore, health is also very important for economic performance and poverty alleviation. (findings by the World Heath Organization, cited in Bloom *et al.* (2003)). In this paper, five particular health policies needed to take advantage of the demographic dividend are outlined. The authors then explain the importance and advise on all of the other policy areas mentioned in the previous paragraph. I will not further describe them here since the specifics are not particularly important for this thesis, but the reader is encouraged to look in Bloom *et al.* (2003) if more information is needed.

There exists more literature explaining the demographic dividends, for example a short article by Lee & Mason (2006b) presents a nice explanation of both of the dividends together with some estimates of the specific sizes of these dividends taken from Mason (2005). However, I will not discuss this article here, because the work of Mason (2005) will be reviewed later and this article does not contain any information that is not, or will not be, explained in this chapter later on. The same holds for other similar articles found in the literature.

There also exist short reports that focus on a small number of countries, but the level of analysis is only superficial combined with general explanation of the demographic dividends and its impacts, needed policies, etc., majority of which can already be found in Bloom *et al.* (2003). These reports are for policy makers in those certain areas, but do not add a particular value to this thesis and as a result will not be discussed here. An example of such a report is Gribble & Bremner (2012), who focus on Thailand, Bolivia, Brazil and Ethiopia.

2.2 A closer look at the second demographic dividend

In this section I will mention two papers focusing on the second demographic dividend and its implications for the countries of focus. The first paper is by Lee & Mason (2006a) who focuses on the importance of reforms to appropriately capture and enhance the second demographic dividend and it can be viewed as an extension of the policy suggestions presented in Bloom *et al.* (2003) for the second demographic dividend.

The contribution of this paper is twofold. The first contribution is in calculating and/or estimating the specific sizes of the first demographic dividend for all of the world's major regions. The second and main contribution is in demonstrating that population aging will not necessarily lead to a slowdown in economic growth and in emphasizing the importance of an early reform stressing the importance of accumulation of pension assets instead of continued reliance on families.

The calculation and/or estimation of the first demographic dividend for the period 1960-2050 is done in two ways. The first approach uses growth models typically estimated in the literature and the second approach relies on growth accounting or direct calculation. To estimate the size of the second demographic dividend the authors use a modification of a simulation model from their earlier works (reference in the paper) with parameters based on Taiwan's economy and population. Consequently, the simulations are only performed for the Taiwanese economy for the period 1900-2050. The paper has several limitations, one of which being that the entire simulation only considered a case of a small open economy - Taiwan. Other limitations include sole focus on familial transfer system, accumulation of only physical capital and more.

The second paper in this category written by Mason & Kinugasa (2008) focuses on the East Asian economy and even though the authors cover both demographic dividends, the main focus is on the second demographic dividend. The paper aims to describe the differences in demographic transitions between the countries in this region and discusses the implications. It also aims to prove, or dispute, that the accelerated economic growth in this region can be traced to the two demographic dividends. The period of focus is 1960-2000 and the nature of this paper is empirical as they use an elaboration of the neoclassical growth model to frame the analysis, followed by the regression analyses using OLS and two-stage least squares to estimate the determinants of saving rates. Lastly, they use a counter-factual analysis to assess the importance of changes in adult survival and the youth dependency ratio.

The authors find that the incentives to save depend on expectations about the long-term trends in adult survival and not on short-term fluctuations in mortality. However, they didn't find a strong support for the case that the demographic factors had a strong role for economic growth. They are also uncertain about the contribution of fertility decline and increased longevity to the tremendous increase in saving rates in East Asia. The main message is the conclusion that the rate of economic growth will most definitely decline as the first demographic dividend passes. Moreover, countries which rely on transfer systems to support the needs of the elderly will not benefit from the second demographic dividend as opposed to the nations that encourage capital accumulation as a means of meeting retirement needs. In those countries, aging can serve as a fundamental force for creating a wealthier and more prosperous society.

2.3 Case studies about the demographic transition

There exist a large number of papers that take a closer look at demographic transition of particular countries or regions. These papers often aim to clarify the confusion around the extraordinary economic growth rates or to correct general misconception about what was the cause of these high growths.

The first paper I will give a summary of was one of the initial inspirations for my thesis. In this paper, Honohan & Walsh (2002) reveal the true drivers behind Ireland's tremendous growth rate experienced after mid-1980s that enabled the country to catch up with the world's most advanced economies. Before the release of this paper, Ireland's growth rates had been attributed to some sort of 'productivity miracle'. The two main tasks of this paper are analyzing the sources of output growth and understanding the transformation of the labor market. The authors also illustrate how inappropriate policies held Ireland back before the onset of the high growth after mid-1980s. They demonstrate that the most important feature of Ireland's exceptional growth has been an increase in the proportion of the working-age population. This was a result of the demographic trends and high reduction in the rate of unemployment, neither of which can be repeated. They also demonstrated that the credit for exploiting this demographic opportunity must be widely shared among multiple policy entities and institutions.

The authors do not use any econometric analysis, but rather provide and extensive discussion and explanations using various charts and summary tables to illustrate important trends. The specific aspects of Irish economy are not particularly important for this thesis and so these explanations will not be further described here. The main outcome and inspiration for this thesis was the realization of the formerly hidden importance of the demographic changes that took place all over the world and their implications for economic growth.

The next two papers are focused on China. China is a very interesting country from a demographic point of view and as for all the other East Asian countries, the demographic transition here was a very important catalyst for economic growth. However, China also faces difficulties as its population ages and the accounting benefit of the demographic transition fades.

The first article by Cai (2010) attempts to find connections between demographic transition and dual economy development. The paper points out to the diminishing demographic dividends and the arrival of *Lewis turning point*, which indicates the state when labor supply is no longer unlimited. It also illustrates the importance of faster economic growth and transition into a high-income economy, which is the only way how China can close the *aging before affluence gap*, which has arisen because the extraordinary economic growth happened too late and the income per capita in China is therefore still too low as its population is entering a new demographic stage, where a large part of the population is of high age.

The main contribution of this paper lies in reviewing the current theory and research coupled with reasoning based on data and experiences. The author uses a panel data regression to estimate the relationships between *total fertility rate* and economic growth. The findings favor the importance of demographic transition in Chinese economic development and support the arrival of the Lewis turning point. Moreover, the author informs that there still is a short-term potential to exploit the first demographic dividend (paper written in 2010) and notifies about the possibility to exploit the second demographic dividend. However, there is a great need for a new driving force to achieve a sustainable economic growth in the long run. As for the aging before affluence gap, based on prediction of foreign economists about the favorable prospects of Chinese development the gap is eventually expected to close, under the assumption of unchanged demographic transition.

The second paper focusing on China written by Feng (2011) examines the importance of Chinese state and highlights the few important features of Chinese economic future. The paper demonstrates that China is a demographic overachiever in terms of speed and magnitude and that it is not only the Chinese state that sets the country's demographic transition apart from other countries, but that the culture also plays a role. Consistently with the findings of the previous paper, it points to the coming shortage of labor supply. It explains that Chinese elderly will face loneliness mainly thanks to the one-child policy, which was ended in 2015 as a response to prevalent population aging. (Phillips (2015)) The final message is that after realizing the gains of demographic overachiever, China must now be prepared to face upcoming costs.

The last paper from the Asian region written by Song (2013) examines the effects of demographic changes on economic growth in thirteen Asian countries. It uses 5-year panel data for period 1965-2009 and estimates 3 different models of growth regression equations derived from the Solow-Swan model. The results indicate negative effects of growth in both total and young population on economic growth while showing positive effects of growth in the working-age population and the working-age population ratio. Therefore, it concludes that the fast economic growth in Asia can be attributed to the favorable demographic changes that took place in this region.

The European Union (henceforth EU) has also been a subject of research examining the importance and implications of demography to economic growth. I will sum up two papers here. The first papers is by Gaag & de Beer (2015) and examines whether the *Europe 2020* employment targets will be sufficient to compensate for the *demographic burden* and whether the impact of demography on economic growth differs between EU countries, and between urban and rural regions. The second paper is by Prskawetz *et al.* (2007) who review three empirical studies modeling economic growth in the

EU and its relation to changes in the demographic structure for the six decades preceding 2007. The authors also conducted an extensive literature review, which contains some very important insights.

Gaag & de Beer (2015) use annual country-level data on *NUTS2* level for the period 2000-2010. They decompose GDP into 5 components in order to see which factors contributed to the economic growth. They also estimate the future consequences of the demographic burden, in this paper defined as the situation when the demographic dividend turns negative as a result of the concurrent rise in fertility and life expectancy. In summary, the authors find that increasing employment rates to the Europe 2020 targets has the potential to present positive opportunities for economic growth, but not in all countries and only to a limited extent. They also conclude that the prospects for demographic burden are very similar for both urban and rural regions.

The report of Prskawetz *et al.* (2007) is very comprehensive and hence I will only summarize here the information from this paper that I find relevant for this thesis. These insights are mostly based from authors' own literature research and review, so the findings I present below are usually not of Prskawetz *et al.* (2007) themselves, but they are contained in their large literature overview, from which I picked out the most important findings pertinent to my thesis.

They state that demography can also affect individual worker's productivity through human capital formation, savings, investments, technological change, etc. This is a new insight not so far presented in the this chapter and that is that apart from the *accounting effect* of the demographic dividends, the changes may also set *behavioral effects* in motion as people's perceptions and behavior change, which leads to, for example, higher education enrollment and consequently to higher productivity per worker. This has been confirmed by findings demonstrating that the growth rate of the working-age population has a positive effect on the growth rate of output per worker. It has been found that human capital, measured by life expectancy and education, was in some cases strongly growth-inducing whereas financial and political components had more equivocal impacts.

Furthermore, high-quality institution matter for policies to take effects and for countries to reap the benefits of the demographic dividends. In particular, open economies, a flexible labor force and modern institutions are very effective. The authors also find that in most of the studies, independent of the method applied, the growth rate of the working-age population is one of the most robust determinant that is positively linked to the growth of output per worker. An additional insight from this paper is that a scenario of zero migration has a strong negative effect on income per capita for countries that currently have a positive net migration.

Their report indicates that demographic factors matter for economic growth at least as much as factors commonly found important in the literature, such as technological change, innovation, etc. Moreover, the authors' sensitivity tests show that demographic effects are extremely robust, independent of the economic variables included and the method applied. Consistent with the previous study, they state that a decline in GDP for EU is imminent and that it will be severer for countries with slow or even negative rates of workforce growth.

There exists multiple of other studies that can be easily fitted in this section, for example Bloom *et al.* (2007), where the authors test whether the effects of demography are different in Africa than in the rest of the world, or Gordon (2012), who focuses on the United States and identifies six headwinds that will drag the long-term growth down. However, these or other similar papers do not add much extra value for the purpose of my thesis, thus I will not review them here.

2.4 Model averaging in the growth literature

Since my thesis centers around economic growth, it makes sense to look into the general growth literature not necessarily focused on demographics. The literature on the determinants of economic growth is understandably very extensive. There has already been identified more than 140 variables suggested as the determinants of economic growth (Moral-Benito (2012)), including some demographic variables. The *Bayesian model averaging* (henceforth BMA) is probably the most widely used method and I will review some of the influential works implementing this method and its extensions. Since all of the papers use growth rate of GDP per capita as their dependent variable, I will not explicitly mention it when discussing each paper, unless the authors used a different variable.

The seminal paper of Fernández *et al.* (2001) was the first case where

BMA was implemented to assess the importance of various determinants of economic growth. This paper and its dataset, which in fact comes from Sala-I-Martin (1997), have since been used in a great amount of research. Fernández *et al.* (2001) estimated 2^{41} models and none of the demographic variables included was found to be important in explaining long-term GDP growth. The demographic variables included in these regressions include average age of the population, size of the labor force, ratio of employed workers to population and population growth. This famous dataset of Sala-I-Martin (1997) does not include a variable that would effectively capture any of the demographic dividends.

Ever since this seminal paper the literature around BMA revolves around authors implementing new approaches or adding new possible determinants of economic growth and testing for their importance. Also, the authors often experiment with using different prior distributions. I will summarize some additional influential papers and focus particularly on the importance of the demographic factors and variables related to human capital found in these works.

One of the papers employing a new approach is by Doppelhofer *et al.* (2003). They employ an approach called *Bayesian Averaging of Classical Estimates* (henceforth BACE), which constructs estimates as a weighted average of OLS estimates for every possible combination of included variables, to examine robustness of explanatory variables in cross-country regressions. They used data on 88 countries for the period 1960-1996 and out of 67 explanatory variables, 18 were found to be robustly partially correlated with long term GDP growth and three more were found to be marginally related. These 21 'important' variables include one demographic variable - life expectancy, and two variables related to education - primary school enrollment and fraction of population speaking foreign language, which can be thought of as some sort of proxy for adult education level.

Another influential paper is by Moral-Benito (2012) who extended BMA to panel data models with country-specific fixed effects with an aim to concurrently address model uncertainty and endogeneity issues. In total, he implemented three methods of estimation, namely BMA, BACE and *Bayesian averaging of maximum likelihood estimates* (henceforth BAMLE). Out of 34 explanatory variables he found three robust demographic factors, namely population growth, urban population and total population. Moreover, he also obtained confusing results about life expectancy, a variable which was found important in the previous paper. He found that this variable is associated with economic growth, but could not deduce in which direction because of the model uncertainty problem.

Another paper by Cuaresma *et al.* (2014a) implements 3 different model specifications to describe the growth process in the 255 EU regions at NUTS2 level in the period 1995-2005. They implement classic cross-section BMA, then they extend it with country fixed effects, and finally they combine it with a *spatial autoregressive* structure. Among the relevant findings for this thesis, their results suggest that human capital, measured as population share of workers with higher (tertiary) education, has a robust positive association with regional economic growth.

From the branch of this literature where authors try to think of new variables that were not previously used in BMA I will mention Hasan *et al.* (2016), who added several new financial variables into the classic cross-section BMA. They use an updated dataset of Fernández *et al.* (2001) and found that life expectancy variable has a *posterior inclusion probability* (henceforth PIP) of 1.00 when only one of the 5 new financial variables is included, as well as when all 5 are added for the whole period of analysis 1960-2011. The result about this variable does not have the same problem as in Moral-Benito (2012), and therefore it appears to be valid. Moreover, the ratio of employed workers has PIP of 1.00, but only the for the period 2000-2011 and the case when all 5 new financial indicators were added. The rest of the demographic variables was not found important in any of the model settings.

2.5 Relationship between demography, education, human capital and economic growth

In the sections about the demographic dividends I have reviewed some evidence that the demographic factors are important for explaining economic growth and that the demographic transition helped most of the world's regions achieve high rates of growth. There is also a body of literature that examines the interplay between demography, human capital and productivity. I have already mentioned earlier in this section that it has been established that demography can affect individual worker's productivity and in this section I will take a closer look at few papers that examine this interaction in a greater detail.

The first paper in this section is by Cuaresma *et al.* (2014b), who claims that the demographic dividend was in fact an education dividend and that after the effect of human capital dynamics is controlled for, no evidence exists that changes in age structure affect labor productivity. According to their findings, the effect of changes in age structure of the population on economic growth is a standard translation effect, which is very small. This diminished the importance of mainly the first demographic dividend and directly contradicts most of the results presented above.

The authors explain these differences to stem from 3 main reasons. First, they use better data on educational attainment. Second, they use dynamic panel *generalized method of moments* methods, which they claim to be the state of the art. These methods were not used in any of the papers I reviewed so far. Third, the key difference is said to lie in the way the education variable is treated. According to the authors, the shortcoming of most of the studies is that they either used the level or the change in educational attainment, which they claim need to be included together.

The variable life expectancy that was found significant in some previous studies was not found significant here. There is also few other differences in some of the variables included in their models, but further details are not important for this literature review. Even though authors state that this paper should only be a first step in a broader analysis of the effects of changes in age composition, they seem pretty confident about their results and point only to a few limitations, to which they present suggestions on how to extend their research further.

Feyrer (2007) examines the relation between changes in age structure and aggregate productivity. He uses a country-level panel data on two samples of 87 and 19 countries for the period 1960-1990 and implements standard methods such as *first differencing*, *fixed effects*, *ordinary least squares* (henceforth OLS), *instrumental variables*, and *reduced form for instrumental variables.*

He found that workforce demographics are strongly correlated with productivity and output and also observed big differences between individual 10-year age groups and their impact on productivity. He suggests that a large portion of the productivity gap between rich and poor countries can be explained by different demographic structures. He also points out that the demographic variables have a substantial time variation, which may be a reason why the demographic variables do not appear significant in the model averaging literature, where either averages or values at the beginning of the period are taken in order to avoid endogeneity. However, the author concludes by saying he that the evidence is not strong enough to establish a causal link between demographic change and productivity growth, but warns about the importance to further examine these effects and calls for additional research.

The importance of fertility changes has been examined for example by Lee & Mason (2010). They stress the importance of individual worker's productivity and focus on the quantity-quality trade-off. Even though the evidential base of this paper is weak and the results should be interpreted carefully, they express several interesting ideas worth future research. For example, during the lag between the reduction in (child) mortality and reduction in fertility, couples have more children and produce the baby boom generation which then creates the first demographic dividend. However, during the period when they have more children they can afford to invest less in each child which leads to lower investment in baby boomers and therefore weaker first demographic dividend. However, when the baby boomers enter the workforce and the national productivity rises, they can afford to not only accumulate more capital an create the second demographic dividend, but also to invest more in their children, of which now they have less, and this can therefore increase the future productivity per worker and can reduce the negative consequences of population aging.

In this section I will also include a work by Bloom *et al.* (2009), which aims to estimate the effect of fertility on female labor force participation. Even though it may seem like this paper doesn't belong into this category, I believe its findings are important for the above discussion about fertility and therefore I will also provide its summary here. The authors use 5-year panel data on 97 countries and period 1960-2000 and develop a theoretical model for female labor supply and fertility, where female labor supply is a function of wage rates of men and women, the infant mortality rate, the type of residence (urban versus rural), and the woman's fertility choice. In this paper, the authors use abortion legislation as an instrument for fertility.

The authors observe that removing legal restrictions on abortion significantly reduces fertility and that on average a birth reduces a woman's labor supply by almost 2 years during her reproductive life. Their results imply that behavioral change, in the form of increased female labor supply, contributes significantly to economic growth during the demographic transition when fertility declines.

2.6 Takeaway from the literature

To summarize the insights from the literature presented above, it seems that the demographic transition has definitely been important in one way or another. As the more recent literature suggests, it is important to examine the interplay between all of the factors that are either causing, or are influenced by demographic changes. From empirical point of view, the model averaging literature has difficulties in capturing the significance of demographic variables, but this is most likely caused by the improper measurement of these variables due to the nature of these estimations. Even though some authors seem to diminish the importance of the pure accounting effect of the first demographic dividend, the changes that gave rise to and accompanied this dividend led to, for example, changes in human capital formation or fertility decisions which are being found more and more important.

It is important for economists to further examine the interplay between all of the above mentioned factors, so they will be able to better advise governments about effective policies and institutions in order to offset the declines in economic growth which are expected as population ages. It is evident that more research is needed as there are still a number of contradictory results in the literature and the evidential base of a fair amount of research is too weak.

Chapter 3

Methodology

3.1 Model derivation

In this thesis, we will use the human capital augmented production function to derive the equation for the estimation, defined as the following:

$$Y_{it} = A_{it} K_{it}^{\alpha} H_{it}^{1-\alpha} \tag{3.1}$$

where Y_{it} denotes real GDP on the output side of the economy (as describe in the previous section), A_{it} is total factor productivity (henceforth TFP), K_{it} is capital stock, and L_{it} represents size of the labor force. Lastly, H_{it}, defined as $H_{it} = h_{it} L_{it}$, where h_{it} is human capital per worker, which is calculated as $h_{it} = e^{\phi(s)}$ as in e.g. Caselli (2015). The s stands for average years of schooling of population 15-64 years old.

According to *Human capital in PWT 9.0*, the human capital index $\phi(s)$ is computed as:

$$\phi(s) = \begin{cases} 0.134 \cdot s & \text{for } s \leq 4 \\ 0.134 \cdot 4 + 0.101(s-4) & \text{for } 4 < s \leq 8 \\ 0.134 \cdot 4 + 0.101 \cdot 4 + 0.068(s-8) & \text{for } s > 8 \end{cases} \tag{3.2}$$

Equation 3.1 in per-worker form looks like the following:

$$y_{it} = A_{it} k_{it}^{\alpha} h_{it}^{1-\alpha} \tag{3.3}$$

where $y_{it} = Y_{it}/L_{it}$ and $k_{it} = K_{it}/L_{it}$. For our analysis we will the previous equation in growth-rate form, computed as:

$$
\begin{aligned}
\Delta \ln y_{it} &= \ln y_{it+4} - \ln y_{it} \\
&= (\ln A_{it+4} - \ln A_{it}) + \alpha \cdot (\ln k_{it+4} - \ln k_{it}) \\
&\quad + (1-\alpha) \cdot (\ln h_{it+4} - \ln h_{it}) \\
&= \Delta \ln A_{it} + \alpha \Delta \ln k_{it} + (1-\alpha) \Delta \ln h_{it}
\end{aligned} \tag{3.4}
$$

where $t = \{1990, 1995, 2000, 2005, 2010\}$[1].

Most growth regression analyses do, however, use income in per-capita form, so we will write:

$$
y_{it} = \frac{Y_{it}}{L_{it}} = \frac{Y_{it}}{N_{it}} \frac{N_{it}}{L_{it}} = \tilde{y}_{it} \frac{N_{it}}{L_{it}} \tag{3.5}
$$

Equation 3.4 in per-capita for can therefore be written as:

$$
\begin{aligned}
\Delta \ln \tilde{y}_{it} &= \Delta \ln y_{it} + \Delta \ln L_{it} - \Delta \ln N_{it} \\
&= \Delta \ln A_{it} + \alpha \Delta \ln k_{it} + (1-\alpha) \Delta \ln h_{it} + \Delta \ln L_{it} - \Delta \ln N_{it}
\end{aligned} \tag{3.6}
$$

If changes in the labor force share do not affect productivity and only affect income through the accounting channel from Equation 3.5, then parameters associated with variables $\Delta \ln L_{it}$ and $\Delta \ln N_{it}$ from Equation 3.6 should have parameter values equal to 1 and -1, respectively.

In line with Cuaresma *et al.* (2014b), we will also assume that, because of income convergence dynamics and technology adoption, the growth rate of TFP is determined by the distance to global technology frontier. Additionally, the growth rate of TFP is also affected by the level of human capital stock, which acts as a catalyst of technology creation and adoption, as in Benhabib & Spiegel (1994) or Wei & Hao (2011). Consequently, the growth rate of TFP can be expressed as:

$$
\Delta \ln A_{it} = \delta + \rho s_{it-5} + \mu \ln y_{it-5} \tag{3.7}
$$

where δ represents a secular trend and μ is assumed to be negative because of conditional convergence dynamics.

[1] The values for t are the same for every subsequent equation in this thesis. Variables in growth rates, marked with Δ, are measured over the corresponding 5-year period and variables in levels are measured at the beginning of each 5-year period as in Cuaresma *et al.* (2014b).

Furthermore, we can incorporate labor force participation rate and the share of working-age population into Equation 3.7 using the following trick:

$$\begin{aligned}\ln y_{it} &= \ln \tilde{y}_{it} + \ln N_{it} - \ln L_{it} \\ &= \ln \tilde{y}_{it} + \ln N_{it} - \ln L_{it} + \ln W_{it} - \ln W_{it} \\ &= \ln \tilde{y}_{it} - \ln \frac{W_{it}}{N_{it}} - \ln \frac{L_{it}}{W_{it}}\end{aligned} \tag{3.8}$$

Combining equations 3.2, 3.6, 3.7, and 3.8 and using the fact that $h_{it} = e^{\phi(s)}$ we get the following:

$$\begin{aligned}\Delta \ln \tilde{y}_{it} = \delta + \rho s_{it-5} + \mu \ln \tilde{y}_{it-5} - \mu \ln \frac{L_{it-5}}{W_{it-5}} - \mu \ln \frac{W_{it-5}}{N_{it-5}} \\ + \alpha \Delta \ln k_{it} + \Delta \ln L_{it} - \Delta \ln N_{it} + (1-\alpha)\theta_s \Delta s_{it}\end{aligned} \tag{3.9}$$

with θ_s taking values 0.134, 0.101, or 0.068 depending on the level of education as can be obtained by first-differencing Equation 3.2. As already stated, the coefficients associated with $\Delta \ln L_{it}$ and $\Delta \ln N_{it}$ should equal to 1 and -1, respectively. Additionally, the parameter μ from Equation 3.7 appears in front of $\ln \tilde{y}_{it-5}$, $\ln \frac{L_{it-5}}{W_{it-5}}$, and $\ln \frac{W_{it-5}}{N_{it-5}}$, because of the derivation in Equation 3.8 plugged into Equation 3.7. Equation 3.9 is thus the final equation that will be used for estimation.

3.2 Method of estimation

All together we will be estimating 6 different specifications of Equation 3.9 with an additional subsampling, which will be described in the next section. The first two specifications, which will not include the lagged income per capita and therefore do not contain country-specific effects will be estimate by a classic pooled OLS regression. The rest of the equations to be estimated include lagged income per capita and thus country-specific effects will be estimate by the so called *system* generalized method of moments (henceforth system GMM).

It has been documented by Blundell & Bond (1998) and Alonso-Borrego & Arellano (1999), standard first-differenced GMM estimators tends to have large finite sample bias because of weak instruments when the sample size is comparatively large and the number of periods is small. This is the case in our analysis, as will be explained in the next chapter.

Arellano & Bover (1995) propose the use of lagged first differences as instruments for equations in levels, in addition to lagged levels used as instruments for equations in first differences for econometric specifications, which include the lagged level of the dependent variable. Blundell & Bond (1999) then apply this approach to estimation of Cobb-Douglas production function.

To illustrate which conditions needs to be satisfied, let us consider the specification estimated in this thesis:

$$\begin{gathered}\Delta \ln \tilde{y}_{it} = \mu \ln \tilde{y}_{it-5} + \boldsymbol{X\beta}_{it} + \Delta\gamma_t + \Delta v_{it} + \Delta m_{it} \qquad (3.10)\\ v_{it} = \rho v_{it-5} + e_{it}, \qquad |\rho| < 1\\ m_{it}, e_{it} \sim MA(0)\end{gathered}$$

where $\Delta\gamma_t$ is the first-differenced year-specific effect, Δv_{it} is first-differenced, possibly autoregressive productivity shock, and Δm_{it} are first-differenced serially uncorrelated measurement errors. There is no unobserved country-specific effect in this equation, because the equation has already been first-differenced (see eq. 3.5). However, there are country-specific effects present, because the equation contains lagged income per capita. Our method of estimation does, however, assume the presence of these effects.

There are two sets of moment conditions which need to be satisfied for us to implement the system GMM. Let's further define $w_{it} = \Delta v_{it} + \Delta m_{it}$. Then, the first set of moment conditions allowing the use of appropriately lagged levels of variables as instrument for the first-differenced equation is the following:

$$E(x_{it-s}\Delta w_{it}) = 0 \qquad (3.11)$$

for [2] $s \geq 10$ when $w_{it} \sim MA(0)$, which holds true when there are no measurement errors, and $s \geq 15$ when $w_{it} \sim MA(1)$. The x_{it} in Equation 3.11 is an arbitrary independent variable from our model.

If we further assume that $E(\Delta\tilde{y}_{it+5}\eta_i^*) = 0$ and $E(\Delta x_{it}\eta_i^*) = 0$, with x_{it} again being an arbitrary independent variable from our model, we can define the second set of moment conditions:

$$E(\Delta x_{it-s}(\eta_i^* + w_{it})) = 0 \qquad (3.12)$$

[2] $s = \{5, 10, 15, 20\}$ for all s in this section.

for $s = 5$ when $w_{it} \sim MA(0)$, $s = 10$ when $w_{it} \sim MA(1)$, and x_{it} being any of the independent variables from Equation 3.9. This second set of moments conditions allows for the usage of appropriately lagged first differences of the variables in our model as instruments for the equations in levels. According to Blundell & Bond (1999), the combination of both sets of these moment conditions gives us the system GMM estimator used in this thesis. The explanatory variables in the system GMM regressions are instrumented using lagged levels dated t-2 and earlier and lagged first differences dated t-2, as in Blundell & Bond (1999). Blundell & Bond (1999) used lagged levels dated t-3 and earlier, because the validity of instruments dated t-2 was rejected. However, in our case, only the validity of instruments dated t-1 was rejected using the AR tests.

For the empirical implementation, we will use `R` and `RStudio` software. For the pooled OLS and system GMM regressions, we will use `plm` and `pgmm` functions, described in Croissant *et al.* (2017).

According to Croissant *et al.* (2017), `pgmm` aims to adapt GMM estimators available in the DPD (dynamic panel data) library for GAUSS by Blundell & Bond (1998) (see Arellano & Bond (1998)), DPD library for Ox (see Doornik (2015)), and `xtabond2` library for Stata (see Roodman (2006)). Doornik *et al.* (2012) pointed out mistakes in the original DPD library for GAUSS used in Blundell & Bond (1998) and proposed a new package, the DPD for Ox. The results obtained by replicating the fourth column of Table 1 in Doornik *et al.* (2012) using the `pgmm` function are not identical to the values obtained using the DPD for Ox, but all of the coefficients have the same sign and a similar magnitude, so the `pgmm` function for `R` was used in this thesis, because `R` was used for the rest of the coding in this thesis. The software used in Cuaresma *et al.* (2014b) is not reported by the authors.

Chapter 4

Data

For our analysis, we have compiled a dataset of 165 countries for the period 1990-2014, from which we created five 5-year panels. The four main sources of our data are World Bank's World Development Indicators (henceforth WDI), Penn World Table 9.0 (henceforth PWT 9.0), and education data provided by Cohen & Leker (2014) and Barro & Lee (2013). Older versions of WDI and PWT we are also in Cuaresma *et al.* (2014b), but their education data were obtained from International Institute for Applied Systems Analysis (henceforth IIASA) and described in Lutz *et al.* (2007) and Kc *et al.* (2010). The details about the sources of data for each of our variables, along with necessary argumentation are provided in Section 4.1.

We will also create various, more homogeneous, subsamples of our dataset and perform the same regressions to see whether there are any differences. We generate these subsamples using data from the Worldwide Governance Indicators (henceforth WGI), described in Kaufmann *et al.* (2010) and cultural data from Hofstede *et al.* (2010), which are publicly available at Hofstede (2015). More details on subsampling is provided in Section 4.2.

4.1 Data for regressions

4.1.1 World Development Indicators (WDI)

World Bank (2017a) claims the World Development Indicators present the most current and accurate collection of global development indicators, available annually for most of the world's countries. From this dataset, we took data on total labor force, total working-age population, and total population. Also, WDI population data by 5-year age groups were used to compute mean years of schooling of working-age population needed for our estimation, details of which are described in Subsection 4.2.1. The one strange feature of the analysis of Cuaresma *et al.* (2014b) is that they claim use data for the period 1980-2005, but the labor force data from WDI, which they claim to be using, are only available since 1990, as evident from World Bank (2018).

4.1.2 Penn World Table 9.0 (PWT)

From this data source we used data on two variables, namely real GDP and capital stock. Also, we used the same methodology and data sources to compute the human capital variable that is in PWT 9.0, but since the variable in this dataset is based on mean years of schooling of population older than 25 years old and we needed education the average years of schooling of the working-age population aged 15-64, we had to reconstruct this variable.

The first variable taken from this dataset, the real GDP, is defined differently than the one used in Cuaresma *et al.* (2014b). According to Feenstra *et al.* (2015), the PWTs prior to version 8.0 contain real GDP data on the expenditure side of the economy, intended to measure standards of living rather than output of the economy. Ever since PWT 8.0, we have, however, at our disposal the real GDP data on the output side of the economy, which is better suited to measure the productive capacity of a particular country and is pertinent to studies of the determinants of GDP, as claimed in Feenstra *et al.* (2015). In order to be clear, we use the variable named $RGDP^o$ as labeled in Feenstra *et al.* (2015), which is intended to measure the productive capacity both across countries and years.

A thorough reader could also notice that Cuaresma *et al.* (2014b) reports the usage of GDP per capita obtained from PWT 6.3, whereas we took only the total value of GDP. According to the Appendix to PWT 6.1, the population data used to compute the per-capita WDI were taken from WDI and there are no reporter differences in the documentation to PWT 6.2, or PWT 6.3 that would indicate that the source of population data changed. Therefore, the Equation 3.5 is not violated both here and in Cuaresma *et al.* (2014b).

As describe in Feenstra *et al.* (2015), the calculation of capital stock is further improved since PWT version 8.0 with more accurate data. Nevertheless, the results will still be comparable to Cuaresma *et al.* (2014b), since both capital stock variables were computed using perpetual inventory method based on investment by asset, so there should no major differences, just an improvement in accuracy.

As written in Feenstra *et al.* (2015), the PWT 9.0 also introduces, for the first time, a measure of relative TFP across countries. This measure will, however, not be used because it would completely change Equation 3.9 and our study would therefore not be comparable to Cuaresma *et al.* (2014b).

Another important feature of PWT 9.0 is the new human capital variable based on data from Cohen & Leker (2014) and Barro & Lee (2013). As already outlined, the data needed to be reconstructed in order to obtain the education data of working-age population. The data sources and methodology is, however, identical to the initial human capital data provided by PWT 9.0 and the only difference is in the target population. In the forthcoming description of this data source, we will refer to them simply as 'human capital data from PWT'. Also, we will interchangeably refer to these data as human capital data and education data, because it will be easier to contrast them to other sources of data on schooling, and because the human capital index is computed directly from education data with no other input and it is the features of the education data that make the index superior to other data sources, not the method of the construction of the index itself, which is almost identical to the one in Cuaresma *et al.* (2014b)[1].

First of all, the features of the new human capital data from PWT will be outlined, followed by a brief description of the way we reconstructed this index based on original source data for PWT 9.0. The education data from PWT 9.0 are constructed from two highly used sources of education data, based on the number of citations. These sources are Barro & Lee (2013) and Cohen & Leker (2014), whose data set was constructed using the methodology from Cohen & Soto (2007). A unique feature of the PWT approach is that they constructed the human capital index by combining the education data from these two sources. They did this by comparing the data from both datasets to another widely used data sources by De la Fuente & Doménech (2006) and UNESCO. Since these datasets cover relatively short period, whenever the education data for comparison were not available, the

[1]Cuaresma *et al.* (2014b) assumes the returns to education to be constant, whereas in our case it depend on the level of education attainment.

growth rates in years of schooling were compared to enrollment data from UNESCO. In this was suspicious growth rates from either Barro & Lee (2013) or Cohen & Leker (2014) were detected.

We also argue that the human capital data from PWT 9.0 are superior to the data provided by IIASA, which were used in Cuaresma *et al.* (2014b). First of all, the data in IIASA are based on education data only until the year 2000, after which it has only been extrapolated using population projections. Second of all, the datasets, which were used as sources for IIASA were and older version of Barro & Lee (2013) dataset, dataset by Cohen & Soto (2007) and the data by De la Fuente & Doménech (2006). The older version of Barro & Lee (2013) had several shortcomings, most of which have, however, been addressed in the newest version as claimed in Barro & Lee (2013), and the other two sources were not chosen by the creators of PWT 9.0, because they period they cover is too short. Consequently, both Barro & Lee (2013) and Cohen & Leker (2014) data sources used for the construction of the human capital data in PWT 9.0 are superior to those provided by IIASA. In addition, both Barro & Lee (2013) and Cohen & Leker (2014) cover longer period for more countries.

The original human capital data from PWT 9.0 were not used in our estimation, because, as already mention before, they are based on mean years of schooling of population older than 25 years, and we need these data for working-age population aged 15-64 in order for our study to be comparable to Cuaresma *et al.* (2014b). Fortunately, both Barro & Lee (2013) and Cohen & Leker (2014) data, as well as the methodology used to compute the human capital index in PWT 9.0, are publicly available, which enabled us to reconstruct the human capital variable for our target group.

Both Barro & Lee (2013) and Cohen & Leker (2014) data contain mean years of schooling by 5-year age groups. We used population by 5-year age groups from WDI to calculate the average years of schooling of population aged 15-64. Even though Barro & Lee (2013) data include population data by 5-year age groups, they are only available for the countries covered in Barro & Lee (2013) and not in Cohen & Leker (2014), which do not include population data. Therefore, we used population data from WDI, which are available for all countries covered by either Barro & Lee (2013) or Cohen & Leker (2014). Barro & Lee (2013) data are available every 5 years, but Cohen & Leker (2014) data are available only on a decadal basis, so we linearly interpolated between the 10-year observations, as was done for the construction of human capital data in PWT 9.0 as described in Human capital in PWT 9.0. The human capital data from PWT are available for 144 countries and we have the rest of our data available for 143 of those countries. Therefore, for regressions without either of the education variables from Equation 3.9 we have data on 165 countries at our disposal and for the regressions including either of these education variables we have data on 143 countries.

4.2 Subsampling

4.2.1 Income groups and OECD membership

Similar to Cuaresma *et al.* (2014b), we will also divide the countries according to their income group and OECD membership in order to estimate the effect of a one standard deviation in our independent variables on yearly per-capita income growth. We categorize the countries in our sample according to their income classification and OECD membership in 2002, which is approximately the middle of our sample period. We categorize the countries according to World Bank (2002) and OECD (2016). The categorization is presented in Table 4.1.

Table 4.1: Income Groups and OECD categorization for 165 countries (in 2002)

	Income Group			
	LI	LMI	UMI	HI
OECD	0	0	7	23
Non-OECD	58	42	22	13
Total	58	42	29	36

Note: The values in the table indicate number of countries in the particular group.

4.2.2 Worldwide Governance Indicators

For our subsampling exercise, we will primarily use data from WGI, because they are available for majority of the countries. We believe that subsampling based on governance can provided us with further insights as it can potentially lead to different results. This is because as we know e.g. from Bloom *et al.* (2003), proper governance and policy environment are important for the realization of the first demographic dividend, so it can be that countries with a more poor governance are not able to effectively realize the benefits of the first demographic dividend, which could possibly render our demographic dividend variable, the share of working-age population, less important and may perhaps give more value to the education variables in our model. As we know from e.g. Lee & Mason (2006a), policy environment is also important for the exploitation of the second demographic dividend, but since we are not focusing on the second demographic dividend in this thesis, we will further in this section talk only about the first demographic dividend.

We will conduct our final regression on smaller subsamples based on two WGI indicators, namely *government effectiveness*[2] and *regulatory quality*[3]. The scores range from −2.5 (weak) to 2.5 (strong). We will use data from 2002, which is our mid-sample period, and also, for a sensitivity check, from 1996 as it is the closest available year to the beginning of our sample period. As can be seen from Figure 4.1, the values are pretty evenly distributed. The categorization of the countries based on the two aforementioned WGI indicators is presented in Table 4.2. The countries are categorized as either having a strong governance score (greater than zero), or a weak governance score (equal to or less than zero).

Another set of indicators of an appropriate policy environment is called Country Policy and Institutional Assessment from World Bank. The data on these indicators are, however, only available for about 35% of the countries in our sample. Moreover, the Country Policy and Institutional Assessment already serve as an input for the calculation of WGI, according to Kaufmann *et al.* (2010).

[2] "Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies." (World Bank n.d.a)

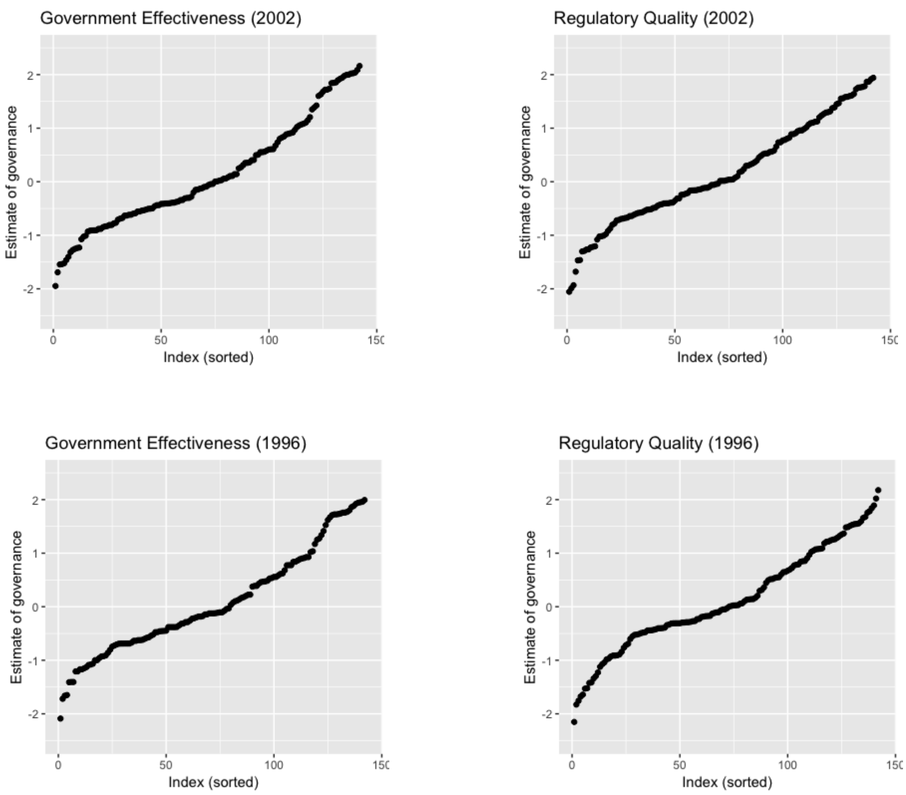
[3] "Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development." (World Bank n.d.b)

Table 4.2: WGI categorization (142 countries)

	Score ranges	
Variable	(-2.5, 0]	(0, 2.5]
2002		
Government Effectiveness	74	68
Regulatory Quality	70	72
1996		
Government Effectiveness	79	63
Regulatory Quality	72	70

Note: The values in the table indicate number of countries with a score in the particular range.

Figure 4.1: Distribution of the Government Effectiveness and Regulatory Quality scores (142 countries)



4.2.3 Hofstede's cultural dimensions

The second and last set of indicators are the dimension of national culture compiled by Geert Hofstede, described e.g. in Hofstede (2011). Two out of six cultural indicators have been chose for the subsampling. First dimension is *Long-term orientation* (LTO. Hofstede Insights (n.d.) claims that nations with a high score tend invest more into education as a way to prepare for the future. The second score is *Masculinity* (MAS). According to Hofstede Insights (n.d.), masculine societies are more competitive and focus on achievement and material rewards for success. As stated in Hofstede Insights (n.d.), countries with a low long-term orientation score are rather short-term oriented and countries with a low masculinity score are said to be rather feminine. We believe that countries grouped by these two scores can have different growth rates and levels of mean years of schooling and labor force participation and the subsampling can therefore influence the regression results.

The long-term orientation scores range between 0 and 100 and the masculinity scores range between 0 and 110, with only a one country having a score higher than 100. These data are the base data for Hofstede *et al.* (2010). Year 2010 is close to the end of our sample, but unfortunately earlier data are not available. Additionally, the data are only available for 59% and 47% of the countries used for our final regression for long-term orientation and masculinity, respectively. The values are again distributed quite evenly, as visible from Figure 4.2. The cutoff value for the subsampling based on both of these scores is again set to the middle of the possible values, i.e. 50[4]. The categorization of countries based on these two scores is presented in Table 4.3.

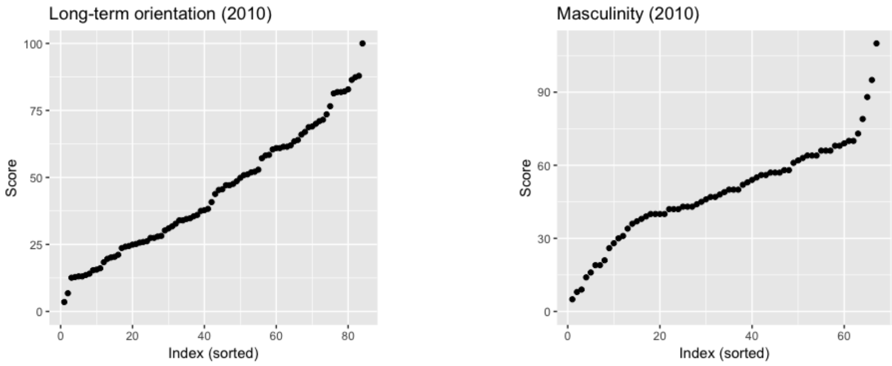
Table 4.3: Categorization based on the long-term orientation and masculinity scores (84 and 67 countries, respectively) in 2010

	Score ranges	
Variable	(0,50]	(50,100]
Long-term orientation	50	34
Masculinity	37	30

Note: The values in the table indicate number of countries with a score in the particular range.

[4] The country with a masculinity value of 110 is treated as having a 100.

Figure 4.2: Distribution of the Long-term orientation and Masculinity scores (84 and 67 countries, respectively)



Chapter 5

Results

5.1 Full sample

The results of all of the six specifications are presented in Table 5.1. The first two models, which do not include lagged income per capita and therefore do not include country fixed effects[1], are estimated by pooled OLS. Robust standard errors are reported for all of the estimates. The chosen type is "HC3" based on recommendations by Long & Ervin (2000). These errors are clustered by individual countries, because there can be specific measurement errors due to different ways of measurement, since the input for most of the data comes from national surveys.

The regressions which do not contain the growth rate or the change in the mean years of schooling are conducted on the full sample of 165 countries. Including either of the two education variables reduces the number of countries in the total sample to 143. The are data available for five 5-year periods for each of the countries, except for a one country, which only has four periods available. This country is, however, included in the regressions, since the missing observation does not present any problem. The specific sizes of the effects reported in this section are ceteris paribus effects.

The results also contain tests for accounting affects (AE). The AE tests test for the two restrictions imposed in column 6 of Table 5.1. The null hypothesis of AE: growth rates is that the parameters associated with $\Delta \ln L_{it}$ and $\Delta \ln N_{it}$ equal to 1 and -1, respectively, and AE: levels tests for the μ parameter from Equation 3.9, i.e. all three coefficients have the same mag-

[1] The variables are in growth rates and thus the country fixed effects have been differenced away. (see Equation 3.4)

nitude and their respective signs. AE: both then combines these restrictions together. Rejection of the null hypothesis means the estimated parameters do not satisfy these restrictions.

We can see that consistently the most significant variable is the capital stock. The effect of capital stock is much larger in the pooled OLS regressions compared to system GMM. When only the capital stock is included in the regression, the estimated effect of a 1% increase in the 5-year growth rate of capital stock leads to an 0.47% increase in the GDP per capita 5-year growth rate.

Adding the size of the labor force and total population changes the coefficient of capital stock very slightly. Even though the coefficients of the two newly added variables do not equal 1 and -1, the test for accounting effects has not been able to reject the null hypothesis that the coefficients equal these values. The variable indicating the size of the labor force is significant and a 1% increase in 5-year growth rate of the labor force leads to an 0.49% increase in the GDP per capita 5-year growth rate. The coefficient is the growth rate of total population is not statistically significant, but its magnitude is negative as would be expected. These two newly added variables do not, however, explain almost no additional variation in the dependent variable, as indicated by the very small change in R^2 from 24.7% to 28%.

The first system GMM regression, model 3, is a specification without any education (human capital) variable and with no imposed restrictions. We can see that the capital stock is still statistically significant, but about half the size compared to the pooled OLS regressions. The coefficients on labor force and total population are closer to 1 and -1, implying that changes in the labor force share do not have productivity effects. The AE: growth rates also does not reject the null hypothesis. The negative parameter of the lagged income per capita is a sign of income convergence, indicating that countries with lower income levels tend to grow faster. The results of this regression also indicate that changes in the share of working age population have a direct effect on economic growth. The lagged level of labor force participation is not statistically significant in this or any of the regressions without the imposed restrictions.

Adding the growth and lagged level of mean years of schooling does not significantly change the results and none of these education variables appear significant in any of the specifications. For models 3-5, with no imposed restrictions, capital stock is always positive and statistically significant, with coefficients ranging from 0.244 to 0.271. Changes in the size of labor force have positive effects, but the coefficient is significant only in model 3. In model 3, a 1% increase in the growth rate of labor force is estimated to increase the growth rate of GDP per capita by 0.97%. Changes in the total size of population have negative effects, again loosing significance after adding the education variables. In model 3, a 1% increase in the growth rate of total population is estimated to decrease the growth rate of income per capita by 1.13%.

All of the parameters associated with with $\Delta \ln L_{it}$ and $\Delta \ln N_{it}$ in equations 3-5 are fairly close to 1 and -1, respectively, and none of tests for accounting effects have been able to reject the null hypothesis stating that the parameters equal these values, which indicates that the changes in the labor force share do not have direct income effects, but only accounting effects through the derivation in Equation 3.5. This is a satisfactory result as it confirms that the transformation of the human capital augmented production function from income per worker to income per capita does not have inadvertent effects.

The coefficients on the lagged income per capita remains negative and statistically significant in models 4-5, with the coefficients slightly decreasing in size after adding the first and second education variables. The labor force participation variable surprisingly has negative coefficients in equations 3-5, but the variable is not statistically significant in any of these regressions. The addition of the education variables in models 4 and 5 also decreases the size of the parameters associated with the share of working age population and its statistical significance. After adding both of the education variables, the size of the effect of the working age population share on the dependent variable decreases by almost 40% and its statisticall significant decreases from a 1% level to a 10% level.

The null hypotheses stating that the coefficients of $\ln \tilde{y}_{it-5}$, $\ln \frac{L_{it-5}}{W_{it-5}}$, and $\ln \frac{W_{it-5}}{N_{it-5}}$, should be equal in size with the first one having an opposite sign (see Equation 3.7 and 3.8), are all rejected, so the results of regressions 3-5 do not satisfy our model derivation.

Model 6 contains two imposed restrictions. The first is setting the parameters of $\Delta \ln L_{it}$ and $\Delta \ln N_{it}$ equal to 1 and -1, respectively, and the second is to force the variables of $\ln \tilde{y}_{it-5}$, $\ln \frac{L_{it-5}}{W_{it-5}}$, and $\ln \frac{W_{it-5}}{N_{it-5}}$ to be equal to μ, $-\mu$, and $-\mu$, respectively. (see Equation 3.7 and 3.8) The size of the μ coefficient is then estimated in the regression. The first restriction was set even though the accounting tests for growth rates have not been able to reject the null hypothesis, because the exact sizes of the coefficients, 1 and -1, are important for the comparison of the coefficients of the other explanatory variables with the ones estimated by Cuaresma *et al.* (2014b). The tests for accounting effects need not be performed in model 6, since all of the restrictions are forced.

The parameter associated with the lagged income per capita is about half the size in model 6 compared to model 5. The labor force participation now appears statistically significant in the model, but with a coefficient of a very low magnitude. The value of the parameter of the working age population share decreased almost twenty times and the variable now appears to have a minimal impact on the per capita income growth. Again, none of the education variables are statistically significant and the sizes of the coefficients are close to zero. The negative effect of the growth rate of mean years of schooling is a surprising result, but since the variable is not statistically significant, no reliable conclusion can be made. The conclusion about s_{it-5} also cannot be made due to its statisticall insignificance. The estimate effect of the growth rate in physical capital in model 6 is the largest of all the models estimated by system GMM. a 1% increase in its growth rate should increase the growth rate of income per capita by 0.33%.

In model 6, the lagged income per capita, labor force participation and share of working age population are only statistically significant at a 10% level. The estimated coefficients should therefore be interpreted with caution. It is, however, important to remember that robust standard errors are reported and hence the level of statistical significance could still be viewed as acceptable, which is why the variables statistically significant at 10% level are marked.

The validity of the instruments was not rejected by the Hansen-Sargan test for all of the system GMM specifications. As already mentioned in Chapter 3, the validity of instruments dated t-2 was confirmed by the AR(2) test. The regressors are jointly significant, as confirmed by the Wald test, and the time dummy variables were significant only in model 6, so they were removed from all other system GMM regressions.

The results of the full sample regressions presented in Table 5.1 do not prove the importance of the education variables as in Cuaresma *et al.* (2014b), although the importance of education attainment can neither be disproved due to the statistical insignificance of these variables. Moreover, even though the demographic dividend effects associated with the increase in the share of working age population are confirmed in regression 3-5, after imposing the restrictions the effect is only marginal.

The differences between the results of Cuaresma *et al.* (2014b) and the results presented in this thesis can stem from multiple factors. First, the data for several variables used in this thesis are different. The dependent variable in this thesis is GDP per capita on the output side of economy, which is more appropriate given that we are interested in the productivity effects, whereas in Cuaresma *et al.* (2014b) used GDP measured on the expenditure side[2]. Moreover, the authors use population data from PWT 6.3 to construct GDP per capita, but then use total population data from WDI to construct variable N. This is a violation of Equation 3.5, because the data for the two Ns are different. Probably the most important difference is the usage of different human capital data. In this thesis, data from PWT 9.0 were used[3]. The calculation of the capital stock is also improved in PWT 9.0.

The period of analysis is also different. Interestingly, Cuaresma *et al.* (2014b) claim to use data from 1980-2005 and also state to use data on labor force from WDI. However, WDI only contains data on labor force from 1990. Additionally, the aforementioned authors excluded oil exporting countries, whereas in this thesis they were kept. A possible intuition for excluding the oil exporting countries is that their population figures do not include temporary workers, but GDP counts their production. ("What is new in PWT 6.2?", n.d.) The oil exporters were, however, included in this thesis, because most of the highest oil exporters are populous countries, according to Energy Information Administration (2002), so we do not believe a certain number of temporary workers would skew the results significantly, so by excluding these countries we could loose valuable information. The differences in the reported coefficients may also stem from the usage of different software for the system GMM regressions, but, as already mentioned, the software used in Cuaresma *et al.* (2014b) is unknown.

[2] Cuaresma *et al.* (2014b) used data from PWT 6.3 which only contained GDP on the expenditure side.

[3] As described in Chapter 4, the human capital data have been reconstructed for the population aged 15-64.

Since different regressors have different variation, a more realistic effects of the explanatory variables on the dependent variable can be assessed by examining the effects of a one standard deviation change in the independent variables on the yearly per capita income. Table 5.2 presents the estimated effects using the within-country standard deviation on the full sample of 143 countries used for the estimation of models with the education variables and the coefficients from model 6. The countries are further divided by income groups and OECD membership.

Apart from the explanatory variables reported in Table 5.1, Table 5.2 also includes the lagged level of the labor force over total population. The effect of this variable can be calculated using the same coefficient as the labor force participation and the share of working age population[4]. The growth rate of this variable is already included in model 6 of Table 5.1 and can be assessed by combining $\Delta \ln L_{it}$ and $\Delta \ln N_{it}$[5] with its respective coefficients 1 and -1. Additionally, the growth rate of the labor force participation and working age population share can be added as well by adding and subtracting $\Delta \ln W_{it}$ into Equation 3.9 and estimating the equation with the imposed restrictions, as in model 6 of Table 5.1, because simultaneously adding and subtracting an arbitrary term does not change the regression results.

In the full sample and all of the subsamples of Table 5.2, we can see that the physical capital, or capital stock, has the highest corresponding effect on the yearly per capita income. The changes in growth rates of the share of the labor force in total population, labor force participation rate and the share of working age population all have significant effects on the rate of income growth, whereas their lagged values have only minimal effects. The effects of the education variables are also really small, but since none of the variables were statistically significant, conclusions about these education effects should not be made based on these results.

In the full sample as well as in all of the subsamples, the size of the labor force over the total population has a larger effect on the income growth than the share of working age population. This makes sense since the workers need to be employed to contribute to a particular country's economic growth.

Low income countries appear to have benefited the most from the changes in the physical capital stock, whereas the effect was the lowest in the high

[4] $\ln \frac{L_{it-5}}{W_{it-5}} + \ln \frac{W_{it-5}}{N_{it-5}} = \ln \frac{L_{it-5}}{N_{it-5}}$

[5] $\Delta \ln L_{it} - \Delta \ln N_{it} = \Delta \ln \frac{L_{it}}{N_{it}}$

income countries, OECD members in particular. Changes in the share of the working age population appear to have had the largest impact in non-OECD and lower middle income countries, whereas the effect was the smallest in upper middle income and high income OECD members. This can be due to the fact these groups of countries were at different stages of the demographic transition during the period of the analysis.

The effect of the change in labor force participation is the largest in lower middle income countries closely followed by upper middle income countries and the lowest in low income countries. Changes in labor force participation have consistently larger effects on the per capita income growth than changes in the share of the working age population across all subsample groups. This points to the fact that demographic transition alone does not guarantee high rates of economic growth, but that a country has to be able to accommodate these workers using suitable policies in order to reap the benefits. This has been repeatedly stressed in literature, for example in Bloom *et al.* (2003). As already mentioned, the effects of the lagged levels of labor force over total population, labor force participation and working age population share are minimal and comparable across different subsamples.

In the next section, the regression of model 6 from Table 5.1 is repeated on various subsamples, as described in Section 4.2 in order to see whether grouping countries into more homogeneous sets leads to different results.

Table 5.1: Regression results – all countries, 1990-2014

	pooled OLS		system GMM			
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln k_{it}$	0.467*** [0.044]	0.476*** [0.043]	0.244*** [0.067]	0.259*** [0.062]	0.271*** [0.064]	0.327*** [0.073]
$\Delta \ln L_{it}$		0.490* [0.216]	0.967* [0.437]	0.749 [0.477]	0.784 [0.498]	1 [imposed]
$\Delta \ln N_{it}$		-0.383 [0.333]	−1.130* [0.506]	−0.873 [0.542]	−0.995† [0.585]	−1 [imposed]
$\ln \tilde{y}_{it-5}$			−0.093*** [0.024]	−0.063** [0.019]	−0.055* [0.022]	−0.028† [0.016]
$\ln(\frac{L_{it-5}}{W_{it-5}})$			−0.119 [0.166]	−0.162 [0.152]	−0.228 [0.143]	0.028† [0.016]
$\ln(\frac{W_{it-5}}{N_{it-5}})$			0.874** [0.277]	0.604* [0.242]	0.544† [0.297]	0.028† [0.016]
Δs_{it}				−0.020 [0.034]	−0.030 [0.033]	−0.020 [0.029]
s_{it-5}					−0.002 [0.005]	0.005 [0.007]
Intercept	-0.120*** [0.024]	-0.135*** [0.028]				−0.127 [0.121]
y1995	0.154*** [0.029]	0.152*** [0.030]				
y2000	0.173*** [0.030]	0.168*** [0.031]				0.028 [0.021]
y2005	0.116*** [0.031]	0.110*** [0.032]				−0.014 [0.027]
y2010	0.157*** [0.027]	0.157*** [0.028]				0.040† [0.023]
AE: growth rates	—	0.151	0.282	0.217	0.053	—
AE: levels	—	—	0.000	0.000	0.000	—
AE: both	—	—	0.000	0.000	0.000	—
Hansen-Sargan(χ^2)	—	—	0.681	0.959	0.964	0.986
AR(1) (normal distr.)	—	—	0.000	0.001	0.001	0.001
AR(2) (normal distr.)	—	—	0.834	0.663	0.682	0.939
Wald(χ^2) [all coef.]	—	—	0.000	0.000	0.000	0.000
Wald(χ^2) [time dum.]	—	—	—	—	—	0.018
n	165	165	165	143	143	143
T	4-5	4-5	4-5	4-5	4-5	4-5
N	824	824	824	714	714	714
R^2	0.274	0.280	—	—	—	—

Significance codes: '***' 0.001 '**' 0.01 '*' 0.05 '†' 0.1. Robust standard errors of type "HC3" are in brackets. The values next to all of the tests in the table are p-values. The parameter n stands for the number of countries, T is the number of time periods, and N is the total number of observations (one country only has four observations).

Table 5.2: Sizes of the effects of a one standard deviation change in the explanatory variables on yearly income growth based on the output of model 6 from Table 5.1

Income group and OECD membership (both in 2002)	Variable	Within-Country SD	Effect on yearly per capita income growth
Full Sample ($n = 143$)	$\Delta \ln k_{it}$	17.17%	1.12%
	$\Delta \ln(\frac{L_{it}}{N_{it}})$	2.59%	0.52%
	$\Delta \ln(\frac{L_{it}}{W_{it}})$	2.24%	0.45%
	$\Delta \ln(\frac{W_{it}}{N_{it}})$	1.43%	0.29%
	$\ln(\frac{L_{it-5}}{N_{it-5}})$	5.03%	0.03%
	$\ln(\frac{L_{it-5}}{W_{it-5}})$	3.23%	0.02%
	$\ln(\frac{W_{it-5}}{N_{it-5}})$	3.66%	0.02%
	Δs_{it}	19.24%	−0.08%
	s_{it-5}	75.33%	0.07%
High Income: OECD ($n = 23$)	$\Delta \ln k_{it}$	11.35%	0.74%
	$\Delta \ln(\frac{L_{it}}{N_{it}})$	2.33%	0.47%
	$\Delta \ln(\frac{L_{it}}{W_{it}})$	2.09%	0.42%
	$\Delta \ln(\frac{W_{it}}{N_{it}})$	1.15%	0.23%
	$\ln(\frac{L_{it-5}}{N_{it-5}})$	3.71%	0.02%
	$\ln(\frac{L_{it-5}}{W_{it-5}})$	3.61%	0.02%
	$\ln(\frac{W_{it-5}}{N_{it-5}})$	1.37%	0.01%
	Δs_{it}	22.77%	−0.09%
	s_{it-5}	67.02%	0.06%
High Income: Non-OECD ($n = 12$)	$\Delta \ln k_{it}$	13.90%	0.91%
	$\Delta \ln(\frac{L_{it}}{N_{it}})$	3.19%	0.64%
	$\Delta \ln(\frac{L_{it}}{W_{it}})$	2.46%	0.49%
	$\Delta \ln(\frac{W_{it}}{N_{it}})$	1.81%	0.36%
	$\ln(\frac{L_{it-5}}{N_{it-5}})$	6.66%	0.04%
	$\ln(\frac{L_{it-5}}{W_{it-5}})$	3.12%	0.02%
	$\ln(\frac{W_{it-5}}{N_{it-5}})$	4.00%	0.02%
	Δs_{it}	25.52%	−0.10%
	s_{it-5}	80.49%	0.07%

Table 5.2: Sizes of the effects of a one standard deviation change in the explanatory variables on yearly income growth based on the output of model 6 from Table 5.1 (cont.)

Income group and OECD membership (both in 2002)	Variable	Within-country SD	Effect on yearly per capita income growth
Low Income ($n = 49$)	$\Delta \ln k_{it}$	20.66%	1.35%
	$\Delta \ln(\frac{L_{it}}{N_{it}})$	2.07%	0.41%
	$\Delta \ln(\frac{L_{it}}{W_{it}})$	1.69%	0.34%
	$\Delta \ln(\frac{W_{it}}{N_{it}})$	1.38%	0.28%
	$\ln(\frac{L_{it-5}}{N_{it-5}})$	3.80%	0.02%
	$\ln(\frac{L_{it-5}}{W_{it-5}})$	2.65%	0.02%
	$\ln(\frac{W_{it-5}}{N_{it-5}})$	3.46%	0.02%
	Δs_{it}	14.86%	−0.06%
	s_{it-5}	65.69%	0.06%
Lower-middle Income ($n = 35$)	$\Delta \ln k_{it}$	17.79%	1.16%
	$\Delta \ln(\frac{L_{it}}{N_{it}})$	3.17%	0.63%
	$\Delta \ln(\frac{L_{it}}{W_{it}})$	2.76%	0.55%
	$\Delta \ln(\frac{W_{it}}{N_{it}})$	1.67%	0.33%
	$\ln(\frac{L_{it-5}}{N_{it-5}})$	6.65%	0.04%
	$\ln(\frac{L_{it-5}}{W_{it-5}})$	3.90%	0.02%
	$\ln(\frac{W_{it-5}}{N_{it-5}})$	5.06%	0.03%
	Δs_{it}	23.44%	−0.09%
	s_{it-5}	84.54%	0.08%
Upper-middle Income ($n = 24$)	$\Delta \ln k_{it}$	16.34%	1.07%
	$\Delta \ln(\frac{L_{it}}{N_{it}})$	2.75%	0.55%
	$\Delta \ln(\frac{L_{it}}{W_{it}})$	2.64%	0.53%
	$\Delta \ln(\frac{W_{it}}{N_{it}})$	1.26%	0.25%
	$\ln(\frac{L_{it-5}}{N_{it-5}})$	5.64%	0.03%
	$\ln(\frac{L_{it-5}}{W_{it-5}})$	3.14%	0.02%
	$\ln(\frac{W_{it-5}}{N_{it-5}})$	4.04%	0.02%
	Δs_{it}	15.55%	−0.06%
	s_{it-5}	86.98%	0.08%

5.2 Subsamples

5.2.1 World Governance Indicators

The results of the WGI subsample regressions are presented in Table 5.3. The estimated equation is the model 6 from Table 5.1, which is the full specification of Equation 3.9 with both of the imposed restrictions.

The growth of physical capital has a larger effect on per capita income in countries where the government effectiveness and regulatory quality are perceived as poor and the sizes of the effects in these two subsamples are almost identical. This can possibly be explained as the result of the inability of these countries to reap benefits from education and favorable demographic changes. The lagged income per capita and the lagged levels of labor force participation and working age population share are statistically significant only in the subsample of countries with a high perceived regulatory quality, where the coefficients are of a higher magnitude than on the full sample.

The education variables are statistically insignificant on all subsamples, except for the subsample of countries with a poor perceived government effectiveness. The change in the growth rate of mean years of schooling again has a surprising negative effect on the dependent variable. The effect is, however, rather small, since a one standard deviation increase in the growth rate of this explanatory variable decreases the growth rate of the income per capita by 0.22%. The lagged level of the mean years of schooling has a positive effect and an increase by a one standard deviation increases the growth rate of the income per capita by 0.13%. Therefore, the effects of both of the education variables are very small. The discussion about the acceptability of the 10% significance level from the previous sections applies here as well. The results of the specification tests are the same as in the full sample. None of the tests for accounting effects are again needed, because all of the require restrictions were imposed.

Subsampling based on the 1996 is included in Table A.2 (in Appendix A). The results are very similar to the results in Table 5.3, except that the lagged income per capita, labor force participation rate and share of working age population are not statistically significant in any of the subsample specifications. The lagged level of education is now statistically significant at the subsample of countries with a low regulatory quality. The effect is positive, but again rather small since a one standard deviation change in this explanatory variable causes the growth rate of the income per capita to increase by 0.16%. According to the test for serial correlation in model 5 of Table A.2, the AR(1) is not present and the lagged instruments dated t-1 could have theoretically been used for the variable that do not appear lagged in the regression. However, this is not consistent with the original system GMM methodology proposed in Blundell & Bond (1998), and it was therefore not done.

The subsampling according to the government effectiveness and regulatory quality score from WGI did not provide us with significantly different results and rather led to a loss of statistical significance, with the exception of the education variables in countries with a poor perceived government effectiveness. However, in this particular regression, the lagged income per capita and all of the demographic variables of interest lost its statisticall significance, so the comparison of the sizes of the respective effects on the dependent variable would not be reliable.

Table 5.3: Regression results – WGI subsamples (2002), 1990-2014

	Full sample	GE>0	GE≤0	RQ>0	RQ≤0
	(1)	(2)	(3)	(4)	(5)
$\Delta \ln k_{it}$	0.327*** [0.073]	0.278** [0.099]	0.416*** [0.057]	0.240* [0.107]	0.414*** [0.058]
$\Delta \ln L_{it}$	1 [imposed]	1 [imposed]	1 [imposed]	1 [imposed]	1 [imposed]
$\Delta \ln N_{it}$	−1 [imposed]	−1 [imposed]	−1 [imposed]	−1 [imposed]	−1 [imposed]
$\ln \tilde{y}_{it-5}$	−0.028† [0.016]	−0.002 [0.016]	−0.003 [0.006]	−0.036* [0.016]	−0.002 [0.006]
$\ln(\frac{L_{it-5}}{W_{it-5}})$	0.028† [0.016]	0.002 [0.016]	0.003 [0.006]	0.036* [0.016]	0.002 [0.006]
$\ln(\frac{W_{it-5}}{N_{it-5}})$	0.028† [0.016]	0.002 [0.016]	0.003 [0.006]	0.036* [0.016]	0.002 [0.006]
Δs_{it}	−0.020 [0.029]	−0.017 [0.027]	−0.071† [0.037]	−0.034 [0.031]	−0.052 [0.042]
s_{it-5}	0.005 [0.007]	−0.004 [0.004]	0.009† [0.005]	0.002 [0.004]	0.008 [0.006]
Intercept	−0.127 [0.121]	0.082 [0.085]		−0.079 [0.088]	
y1995					
y2000	0.028 [0.021]	−0.027 [0.025]		−0.011 [0.025]	
y2005	−0.014 [0.027]	−0.090* [0.025]		−0.057 [0.036]	
y2010	0.040† [0.023]	−0.005 [0.023]		0.017 [0.022]	
Hansen-Sargan(χ^2)	0.986	1.000	1.000	1.000	1.000
AR(1) (normal distr.)	0.001	0.002	0.041	0.001	0.043
AR(2) (normal distr.)	0.939	0.666	0.716	0.913	0.670
Wald(χ^2) [all coef.]	0.000	0.000	0.000	0.000	0.000
Wald(χ^2) [time dum.]	0.018	0.000	—	0.000	—
n	143	68	74	72	70
T	4-5	4-5	5	4-5	5
N	714	339	370	359	350

Significance codes: '***' 0.001 '**' 0.01 '*' 0.05 '†' 0.1. Robust standard errors of type "HC3" are in brackets. The values next to all of the tests in the table are p-values. The parameter n stands for the number of countries, T is the number of time periods, and N is the total number of observations (one country only has four observations).

5.2.2 Hofstede's cultural dimensions

The results of the subsample regressions based on the long-term orientation and masculinity indicators from Hofstede *et al.* (2010) are presented in Table 5.4. The estimated equation is the model 6 from Table 5.1, which is the full specification of Equation 3.9 with both of the imposed restrictions.

The physical capital variable is very statistically significant as in all of the previous cases. A small exception is model 5, where the significant level is 5%, which is still acceptable. The effect of the growth of physical capital is higher in short-term oriented countries, compared to countries with a long-term orientation. a 1% change in the growth of physical capital is estimated to increase the growth of the income per capita by 0.41% for rather short-term oriented countries and 0.30% for rather long-term oriented countries. The effect of physical capital on the dependent variable is also higher in more masculine countries. The sizes of the coefficients are 0.348 and 0.210 for rather masculine and rather feminine countries, respectively.

The results of all of the specification tests in Table 5.4 are acceptable, except for the AR(2) serial correlation in model 5. This autocorrelation makes the lagged instrument dated t-2 invalid, so they were removed.

The effects of the lagged income per capita, labor force participation rate and the share of working age population are much larger in models 2 and 5 than on the full sample regressions and the variables are also very statistically significant. The lagged level of mean years of schooling in model 2 is also very statistically significant and its effect is positive.

Table 5.5 presents the size of a one standard deviation change in each of the explanatory variables in model 2 on the dependent variable. The effect of the lagged level of mean years of schooling is now comparable to the effect of the change in labor force over total population and the change in labor force participation. It is also higher than the effect of a change in the share of working age population and much higher than the effect of the lagged levels of the three previously mentioned variables. A one standard deviation change in the lagged level of education attainment is estimate to increase the per capita income growth by 0.55%, which is certainly not a negligible effect. Even though the coefficients of the lagged income per capita, labor force participation rate and share of working age population are higher for more long-term oriented countries than on the full sample, the sizes of the effects are still fairly small.

Model 2 of Table 5.4 is hence the only regression where a direct effect of mean years of schooling, and thus human capital, on the growth rate of income per capita was proven. Increasing the education attainment in long-term oriented countries, which already focus on education, as written in Hofstede Insights (n.d.), is therefore likely to increase the pace of their economic growth. This conclusion provides an evidence that, other factors being equal, a long-term oriented policy and investment into education is beneficial for economic growth.

Table 5.4: Regression results – Hofstede subsamples (2010), 1990-2014

	Full sample	LTO>50	LTO≤50	MAS>50	MAS≤50
	(1)	(2)	(3)	(4)	(5)
$\Delta \ln k_{it}$	0.327***	0.303***	0.414***	0.348***	0.210*
	[0.073]	(0.070)	(0.070)	(0.079)	(0.106)
$\Delta \ln L_{it}$	1	1	1	1	1
	[imposed]	[imposed]	[imposed]	[imposed]	[imposed]
$\Delta \ln N_{it}$	−1	−1	−1	−1	−1
	[imposed]	[imposed]	[imposed]	[imposed]	[imposed]
$\ln \tilde{y}_{it-5}$	$-0.028^{\dagger}$	−0.104***	−0.011	−0.008	−0.057**
	[0.016]	(0.018)	(0.007)	(0.007)	(0.021)
$\ln(\frac{L_{it-5}}{W_{it-5}})$	$0.028^{\dagger}$	0.104***	0.011	0.008	0.057**
	[0.016]	(0.018)	(0.007)	(0.007)	(0.021)
$\ln(\frac{W_{it-5}}{N_{it-5}})$	$0.028^{\dagger}$	0.104***	0.011	0.008	0.057**
	[0.016]	(0.018)	(0.007)	(0.007)	(0.021)
Δs_{it}	−0.020	0.021	−0.007	−0.045	−0.029
	[0.029]	(0.046)	(0.049)	(0.050)	(0.029)
s_{it-5}	0.005	0.034**	−0.002	0.001	0.011
	[0.007]	(0.011)	(0.004)	(0.002)	(0.008)
Intercept	−0.127	−0.665***			$-0.229^{\dagger}$
	[0.121]	[0.197]			[0.139]
y1995					
y2000	0.028	0.012			−0.019
	[0.021]	[0.041]			[0.038]
y2005	−0.014	−0.042			−0.011
	[0.027]	[0.050]			[0.049]
y2010	$0.040^{\dagger}$	0.034			0.029
	[0.023]	[0.037]			[0.034]
Hansen-Sargan(χ^2)	0.986	1.000	1.000	1.000	1.000
AR(1) (normal distr.)	0.001	0.137	0.015	0.063	0.004
AR(2) (normal distr.)	0.939	0.212	0.313	0.479	0.039
Wald(χ^2) [all coef.]	0.000	0.000	0.000	0.000	0.000
Wald(χ^2) [time dum.]	0.018	0.000	—	—	0.015
n	143	34	50	30	37
T	4-5	5	5	5	5
N	714	170	250	150	185

Significance codes: '***' 0.001 '**' 0.01 '*' 0.05 '†' 0.1. Robust standard errors of type "HC3" are in brackets. The values next to all of the tests in the table are p-values. The parameter n stands for the number of countries, T is the number of time periods, and N is the total number of observations (one country only has four observations).

Table 5.5: Sizes of the effects of a one standard deviation change in the explanatory variables on yearly income growth based on the output of model 2 from Table 5.4

Income group and OECD membership (both in 2002)	Variable	Within-Country SD	Effect on yearly per capita income growth
LTO>50 ($n = 34$)	$\Delta \ln k_{it}$	15.49%	0.94%
	$\Delta \ln(\frac{L_{it}}{N_{it}})$	2.65%	0.53%
	$\Delta \ln(\frac{L_{it}}{W_{it}})$	2.79%	0.56%
	$\Delta \ln(\frac{W_{it}}{N_{it}})$	1.41%	0.28%
	$\ln(\frac{L_{it-5}}{N_{it-5}})$	3.53%	0.07%
	$\ln(\frac{L_{it-5}}{W_{it-5}})$	3.48%	0.07%
	$\ln(\frac{W_{it-5}}{N_{it-5}})$	2.60%	0.05%
	Δs_{it}	24.56%	0.10%
	s_{it-5}	81.08%	0.55%

Chapter 6

Conclusion

This thesis focuses mainly on the importance of human capital and the share of working age population, defined as population aged 15 to 64 divided by total population, in explaining economic growth. It has been documented, for example by Bloom *et al.* (2003), that the demographic transition from high mortality and high fertility to low mortality and low fertility presents a unique opportunity to achieve high rates of economic growth. Bloom *et al.* (2003) also demonstrated that most of the world's regions have been or are likely to be able to take advantage of this opportunity and generate the so called demographic dividend. For example, Bloom & Williamson (1998) showed that as much as a one third of the economic growth in East Asia was due to favorable demographic changes. However, Cuaresma *et al.* (2014b) claim that the demographic dividend was actually achieved mostly thanks to the increase in an educational attainment, rather than by the pure increase in the share of working age population. This thesis therefore attempts to validate the claims of Cuaresma *et al.* (2014b) using a newer and, in our opinion, better data on human capital, income per capita and physical capital stock.

The model estimated in this thesis (Equation 3.9) has income per capita growth as a dependent variable. However, the model was built from a standard human capital-augmented production function with income per worker as a dependent variable. This production function was then transformed using several derivations, as described in Section 3.1. Several specifications of (Equation 3.9) were estimated including only certain variables. Models without the lagged dependent variable were estimated using pooled OLS, and the rest of the models was estimated using system GMM (see Blundell

& Bond (1999)). Finally, several restrictions were imposed in the full specification of Equation 3.9 in order for certain variables not to have additional direct effects on the income growth and for certain parts of the derivation to be valid.

The estimation was done an a full sample of 165 and 143 countries for the regressions with and without any of the education variables, respectively. Additionally, the full specification of Equation 3.9 with all of the required restrictions imposed was estimated on various subsamples based on data from Worldwide Governance Indicators (see Kaufmann *et al.* (2010)) and cultural data from Hofstede *et al.* (2010).

On the full sample of countries, the results prove a positive causal relationship between the share of working age population and labor force participation rate on the income per capita growth, albeit the effects are rather small and the level of statisticall significance is only 10%. None of the education variables were found statistical significant in any of the specifications on the full sample of countries. The growth in physical capital has been found to have a positive and largest impact on the per capita income growth in all of the specifications, both on the full sample and all subsamples. All of the estimated regressions, both on the full sample and all the subsamples, showed signs of income convergence, albeit the effect was not always statistically significant. In addition to the estimated coefficients, Chapter 5 presents the estimated effects of a one standard deviation change in the explanatory variables on yearly per capita income growth.

The effects of the share of working age population and labor force participation rate are larger and more statistically significant in the subsample of countries with a high perceived regulatory quality, based on the classification from 2002. On the subsample of countries with a lower perceived government effectiveness, also based on the classification from 2002, the change in the mean years of schooling and its lagged level are statistically significant at 10% level. Surprisingly, a positive change in the mean years of schooling has a negative effect on the per capita income growth. The estimated effects of a one standard deviation changes are, however, rather small.

The lagged level of the labor force participation and the share of the working age population were found to have the highest impact on the per capita income growth in the subsample of countries with a high long-term orientation. Additionally, the lagged level of mean years of schooling was also found to have a positive impact on the dependent variable of interest. Moreover, all of these effects were very statistically significant. The effect of a one standard deviation change in the lagged level of mean years of schooling was found to have a much larger impact on the per capita income growth than the lagged levels of the share of working age population and labor force participation for the subsample of long-term oriented countries. In the subsample of countries with a low masculinity score, the effect of the lagged levels of labor force participation rate and share of the working age population was also greater and more statistically significant than on the full sample of countries.

The observations based on the results are the following. First, direct effect of the share of working age population on the income growth was proven. Second, the labor force participation has a larger impact on the per capita income growth than the population structure itself. This is consistent with the claims of Bloom *et al.* (2003) that a country has to be able to take advantage of the favorable demographic changes through the employment of adequate policies. If a country does not manage to provide the large pool of workers with employment, these workers will not be able to produce any demographic dividend.

Third, the claims of Cuaresma *et al.* (2014b) about the impact of education being greater than that of the demographic composition was proved only partially and only for a one small subsample of countries. The partial confirmation means that only the impact of the lagged level of education attainment was proven, not the impact of its growth rate. The size of the effect of the lagged mean years of schooling is also lower than in Cuaresma *et al.* (2014b). Contrary to the findings of Cuaresma *et al.* (2014b), the effect of the lagged mean years of schooling in this one case where the variable was very statistically significant was lower than that of the growth rate of labor force over total population, labor force participation rate and share of working age population, whereas in Cuaresma *et al.* (2014b) only the growth of the mean years of schooling and the physical capital had a larger impact on the yearly per capita income growth.

It is worth noting that the system GMM method was originally designed for datasets with a large number of countries (or firms), as stated in Blundell & Bond (1998). However, all of the specification tests yielded satisfactory results and robust standard errors are reported, so the reported results should be reliable.

In conclusion, we have proved that demographic structure indeed has an impact on economic growth, although it is very small. Unfortunately, the results do not allow us to convincingly confirm or reject the claims of Cuaresma *et al.* (2014b). We are confident that the data used in this thesis are more suitable for the analysis for reasons described in Chapter 5 and we therefore recommend the findings of Cuaresma *et al.* (2014b) to be further retested in future research.

The key contributions of this thesis are the replication of a research by Cuaresma *et al.* (2014b) with rather striking, but possibly very important, conclusions, which contradict findings in most of the literature, and a comprehensive literature review summarizing the state of the art literature about the demographic transition, first and second demographic dividends, model averaging in the economic growth literature, and the relationship between demography, human capital and economic growth. Even though we cannot accept or reject the claims of Cuaresma *et al.* (2014b), the fact that similar results were not observed when using a better data and the same methodology already raises a red flag and points to the importance of additional sensitivity analyses.

The main recommendation for future research is therefore to further examine the importance of human capital and population structure in explaining economic growth to determine the real factors behind the demographic dividends experienced in most of the world. Since we believe the data used in this thesis are the best available, researchers should focus on examining the relationships in question using different equations than the one used in this thesis and also possibly a different methodology than system GMM. This area of research is very important, because even though most of the world's countries have already experienced demographic transition, there are other demographic challenges, such as population aging, for which the insights from this body of literature are essential. Furthermore, the benefits of education need to be ascertained, so policy makers can use these insights when deciding, for example, on the amount of resources invested into their educational systems.

Bibliography

(2008): "Data Appendix for a Space-Time System of National Accounts: Penn World Table 6.1 (PWT 6.1)." Available at: `https://www.rug.nl/ggdc/docs/appendix_pwt_61.pdf`.

(2016): "Human capital in PWT 9.0." Available at: `https://www.rug.nl/ggdc/docs/human_capital_in_pwt_90.pdf`.

(n.d.a): "Penn World Table version 9.0." Available at: `https://www.rug.nl/ggdc/productivity/pwt/`.

(n.d.b): "What is new in PWT 6.2?" Available at: `https://www.rug.nl/ggdc/docs/what_is_new_in_pwt6_august312006.pdf`.

Alonso-Borrego, C. & M. Arellano (1999): "Symmetrically normalized instrumental-variable estimation using panel data." *Journal of Business & Economic Statistics* **17(1)**: pp. 36–49.

Arellano, M. & S. Bond (1998): "DPD for Gauss." Available at: `https://www.ifs.org.uk/publications/3255`.

Arellano, M. & O. Bover (1995): "Another look at the instrumental variable estimation of error-components models." *Journal of Econometrics* **68(1)**: pp. 29–51.

Barro, R. J. & J. W. Lee (2013): "A new data set of educational attainment in the world, 1950–2010." *Journal of Development Economics* **104**: pp. 184 – 198.

Benhabib, J. & M. M. Spiegel (1994): "The role of human capital in economic development evidence from aggregate cross-country data." *Journal of Monetary Economics* **34(2)**: pp. 143–173.

Bloom, D. E., D. Canning, G. Fink, & J. Finlay (2007): "Realizing the demographic dividend: Is africa any different?" *African Economic Research Consortium (AERC)* .

Bloom, D. E., D. Canning, G. Fink, & J. E. Finlay (2009): "Fertility, female labor force participation, and the demographic dividend." *Journal of Economic Growth* **14(2)**: pp. 79–101.

Bloom, D. E., D. Canning, & J. Sevilla (2003): *The demographic dividend: A new perspective on the economic consequences of population change*. RAND.

Bloom, D. E. & J. G. Williamson (1998): "Demographic transitions and economic miracles in emerging asia." *The World Bank Economic Review* **12(3)**: pp. 419–455.

Blundell, R. & S. Bond (1998): "Initial conditions and moment restrictions in dynamic panel data models." *Journal of Econometrics* **87(1)**: pp. 115–143.

Blundell, R. & S. Bond (1999): "Gmm estimation with persistent panel data: an application to production functions." *IFS Working Papers W99/04, Institute for Fiscal Studies* .

Cai, F. (2010): "Demographic transition, demographic dividend, and lewis turning point in china." *China Economic Journal* .

Caselli, F. (2015): "Accounting for cross-country income differences." *CEP Discussion Paper No 667* .

Cohen, D. & L. Leker (2014): "Health and Education: Another Look with the Proper Data." .

Cohen, D. & M. Soto (2007): "Growth and human capital: good data, good results." *Journal of economic growth* **12(1)**: pp. 51–76.

Croissant, Y. (n.d.): "pgmm: Generalized Method Of Moments (GMM) Estimation For Panel Data." Available at: `https://www.rdocumentation.org/packages/plm/versions/1.6-5/topics/pgmm`.

Croissant, Y., G. Millo, K. Tappe, O. Toomet, C. Kleiber, A. Zeileis, A. Henningsen, L. Andronic, & N. Schoenfelder

(2017): “Package ‘plm’.” Available at: `https://cran.r-project.org/web/packages/plm/plm.pdf`.

Cuaresma, J. C., G. Doppelhofer, & M. Feldkircher (2014a): “The determinants of economic growth in european regions.” *Regional Studies* **48(1)**: pp. 44–67.

Cuaresma, J. C., W. Lutz, & W. Sanderson (2014b): “Is the demographic dividend an education dividend?” *Demography* **51(1)**: pp. 299–315.

Doornik, J. (2015): “Ox - An Object-Oriented Matrix Language.” Available at: `http://www.doornik.com/ox/`.

Doornik, J. A., M. Arellano, & S. Bond (2012): “Panel data estimation using dpd for ox.” *Nuffield College, Oxford* .

Doppelhofer, G., R. I. Miller, & X. S. i Martin (2003): “Determinants of long-term growth: A bayesian averaging of classical estimates (bace) approach.” .

Energy Information Administration (2002): “Total Petroleum and Other Liquids Production 2002.” Available at: `https://www.eia.gov/beta/international/rankings/#?prodact=53-1&cy=2002`.

Feenstra, R. C., R. Inklaar, & M. P. Timmer (2015): “The Next Generation of the Penn World Table.” *American Economic Review* **105(10)**: pp. 3150–3182, available for download at `www.ggdc.net/pwt`.

Feng, W. (2011): “The future of a demographic overachiever: Long-term implications of the demographic transition in china.” *Population and Development Review* **37(s1)**: pp. 173–190.

Fernández, C., E. Ley, & M. F. J. Steel (2001): “Model uncertainty in cross-country growth regressions.” *Journal of Applied Econometrics* **16(5)**: pp. 563–576.

Feyrer, J. (2007): “Demographics and productivity.” *Review of Economics and Statistics* **89(1)**: pp. 100–109.

De la Fuente, A. & R. Doménech (2006): “Human capital in growth regressions: how much difference does data quality make?” *Journal of the European Economic Association* **4(1)**: pp. 1–36.

Gaag, N. V. D. & J. de Beer (2015): "From demographic dividend to demographic burden: The impact of population ageing on economic growth in europe." *Tijdschrift voor economische en sociale geografie* **106(1)**: pp. 94–109.

Gordon, R. J. (2012): "Is u.s. economic growth over? faltering innovation confronts the six headwinds." *Working Paper 18315*, National Bureau of Economic Research.

Gribble, J. N. & J. Bremner (2012): "Achieving a demographic dividend." *Population Reference Bureau* **67(2)**.

Harrington, M. (2017): "Survey: People's trust has declined in business, media, government, and ngos."

Hasan, I., R. Horvath, & J. Mares (2016): "What type of finance matters for growth? bayesian model averaging evidence." *The World Bank Economic Review* p. lhw029.

Hofstede, G. (2011): "Dimensionalizing cultures: The hofstede model in context." *Online readings in psychology and culture* **2(1)**: p. 8.

Hofstede, G. (2015): "Dimension data matrix." Available at: `https://geerthofstede.com/research-and-vsm/dimension-data-matrix/`.

Hofstede, G., G. V. Hofstede, & M. Minkov (2010): *Cultures and Organizations: Software of the Mind, Third Edition.* McGraw-Hill Education.

Hofstede Insights (n.d.): "National Culture." Available at: `https://www.hofstede-insights.com/models/national-culture/`.

Honohan, P. & B. Walsh (2002): "Catching up with the leaders: The irish hare." *Brookings Papers on Economic Activity* **2002(1)**: pp. 1–57.

Kaufmann, D., A. Kraay, & M. Mastruzzi (2010): "The worldwide governance indicators methodology and analytical issues." *Policy Research Working Paper 5430* .

Kc, S., B. Barakat, A. Goujon, V. Skirbekk, W. Sanderson, & W. Lutz (2010): "Projection of populations by level of educational attainment, age, and sex for 120 countries for 2005-2050." *Demographic research* **22**: pp. 383–472.

KEYNES, J. M. (1937): "Some economic consequences of a declining population." *The Eugenics Review* **29(1)**: pp. 13–17.

LEE, R. & A. MASON (2006a): "Reform and support systems for the elderly in developing countries: Capturing the second demographic dividend." *Genus* **62(2)**.

LEE, R. & A. MASON (2006b): "What is the demographic dividend?"

LEE, R. & A. MASON (2010): "Fertility,human capital, and economic growth over the demographic transition." *European Journal of Population* **26(2)**: pp. 159–182.

LONG, J. S. & L. H. ERVIN (2000): "Using heteroscedasticity consistent standard errors in the linear regression model." *The American Statistician* **54(3)**: pp. 217–224.

LUTZ, W., A. GOUJON, S. KC, & W. SANDERSON (2007): "Reconstruction of populations by age, sex and level of educational attainment for 120 countries for 1970-2000." *Vienna yearbook of population research* pp. 193–235.

MASON, A. (2005): "Demographic transition and demographic dividends in developed and developing countries." *UN DESA* .

MASON, A. & T. KINUGASA (2008): "East asian economic development: Two demographic dividends." *Journal of Asian Economics* **19**.

MORAL-BENITO, E. (2012): "Determinants of economic growth: A bayesian panel data approach." *Review of Economics and Statistics* **94(2)**: pp. 566–579.

OECD (2016): "List of OECD Member countries - Ratification of the Convention on the OECD." Available at: `http://www.oecd.org/about/membersandpartners/list-oecd-member-countries.htm`.

PHILLIPS, T. (2015): "China ends one-child policy after 35 years." Available at: `https://www.theguardian.com/world/2015/oct/29/china-abandons-one-child-policy`.

PRSKAWETZ, A., T. FENT, & W. BARTHEL (2007): *The Relationship Between Demographic Change and Economic Growth in the EU*. Institut für Demographie, Vienna Institute of Demography.

R Core Team (2018): *R: A Language and Environment for Statistical Computing. Version 3.5.0.* R Foundation for Statistical Computing, Vienna, Austria.

Roodman, D. (2006): "How to do xtabond2: an introduction to 'difference'and 'system." In "GMM in STATA', Center for Global Development Working Paper No. 103," Citeseer.

RStudio Team (2016): *RStudio: Integrated Development Environment for R. Version 1.1.447.* RStudio, Inc., Boston, MA.

Sala-I-Martin, X. X. (1997): "I just ran two million regressions." *The American Economic Review* **87(2)**: pp. 178–183.

Song, S. (2013): "Demographic changes and economic growth: Empirical evidence from asia." *Illinois Wesleyan University* .

United Nations DESA (2017): "World population ageing 2017: Highlights." *Technical report*, United Nations.

Wei, Z. & R. Hao (2011): "The role of human capital in china's total factor productivity growth: A cross-province analysis." *The Developing Economies* **49(1)**: pp. 1–35.

World Bank (2002): "World development indicators 2002 (English)." *Technical report*, World Development Indicators. Washington, DC : World Bank. Available at: http://documents.worldbank.org/curated/en/475281468159895302/World-development-indicators-2002.

World Bank (2017a): "World Development Indicators." Available at: https://data.worldbank.org/products/wdi.

World Bank (2017b): *World Development Indicators 2017.* Washington, DC: World Bank. License: Creative Commons Attribution CC BY 3.0 IGO.

World Bank (2018): "Labor force, total." Available at: https://data.worldbank.org/indicator/SL.TLF.TOTL.IN.

World Bank (n.d.a): "Government Effectiveness." Available at: http://info.worldbank.org/governance/WGI/ge.pdf.

World Bank (n.d.b): "Regulatory Quality." Available at: http://info.worldbank.org/governance/WGI/rq.pdf.

Appendix A

Supplementary Tables

Table A.1: List of the 165 countries used

Albania	Algeria	Angola	Argentina	Armenia
Australia	Austria	*Azerbaijan*	*Bahamas, The*	Bahrain
Bangladesh	Barbados	*Belarus*	Belgium	Belize
Benin	*Bhutan*	Bolivia	*Bosnia and Herzegovina*	Botswana
Brazil	Brunei Darussalam	Bulgaria	Burkina Faso	Burundi
Cabo Verde	Cambodia	Cameroon	Canada	Central African Republic
Chad	Chile	China	Colombia	*Comoros*
Congo, Dem. Rep.	Congo, Rep.	Costa Rica	Cote d'Ivoire	Croatia
Cyprus	Czech Republic	Denmark	*Djibouti*	Dominican Republic
Ecuador	Egypt, Arab Rep.	El Salvador	*Equatorial Guinea*	Estonia
Ethiopia	Fiji	Finland	France	Gabon
Gambia, The	*Georgia*	Germany	Ghana	Greece
Guatemala	*Guinea*	*Guinea-Bissau*	Haiti	Honduras
Hong Kong SAR, China	Hungary	Iceland	India	Indonesia
Iran, Islamic Rep.	Iraq	Ireland	Israel	Italy
Jamaica	Japan	Jordan	Kazakhstan	Kenya
Korea, Rep.	Kuwait	Kyrgyz Republic	Lao PDR	Latvia
Lebanon	Lesotho	Liberia	Lithuania	Luxembourg
Macao SAR, China	Madagascar	Malawi	Malaysia	Maldives
Mali	Malta	Mauritania	Mauritius	Mexico
Moldova	Mongolia	*Montenegro*	Morocco	Mozambique
Myanmar	Namibia	Nepal	Netherlands	New Zealand
Nicaragua	Niger	Nigeria	Norway	*Oman*
Pakistan	Panama	Paraguay	Peru	Philippines
Poland	Portugal	Qatar	Romania	Russian Federation
Rwanda	*Sao Tome and Principe*	Saudi Arabia	Senegal	Serbia
Sierra Leone	Singapore	Slovak Republic	Slovenia	South Africa
Spain	Sri Lanka	*St. Lucia*	*St. Vincent and the Grenadines*	Sudan (former)
Suriname	Swaziland	Sweden	Switzerland	Syrian Arab Republic
Tajikistan	Tanzania	Thailand	Togo	Trinidad and Tobago
Tunisia	Turkey	*Turkmenistan*	Uganda	Ukraine
United Arab Emirates	United Kingdom	United States	Uruguay	*Uzbekistan*
Venezuela, RB	Vietnam	Yemen, Rep.	Zambia	Zimbabwe

Note: The italicized countries are the ones used only for regressions without any of the education variables.

Table A.2: Regression results – WGI subsamples (1996), 1990-2014

	Full sample	GE>0	GE≤0	RQ>0	RQ≤0
	(1)	(2)	(3)	(4)	(5)
$\Delta \ln k_{it}$	0.327*** [0.073)	0.254** [0.093]	0.419*** [0.055]	0.271** [0.102]	0.401*** [0.056]
$\Delta \ln L_{it}$	1 [imposed]	1 [imposed]	1 [imposed]	1 [imposed]	1 [imposed]
$\Delta \ln N_{it}$	−1 [imposed]	−1 [imposed]	−1 [imposed]	−1 [imposed]	−1 [imposed]
$\ln \tilde{y}_{it-5}$	−0.028† [0.016]	−0.004 [0.015]	−0.002 [0.006]	−0.021 [0.014]	0.001 [0.007]
$\ln(\frac{L_{it-5}}{W_{it-5}})$	0.028† [0.016]	0.004 [0.015]	0.002 [0.006]	0.021 [0.014]	−0.001 [0.007]
$\ln(\frac{W_{it-5}}{N_{it-5}})$	0.028† [0.016]	0.004 [0.015]	0.002 [0.006]	0.021 [0.014]	−0.001 [0.007]
Δs_{it}	−0.020 [0.029]	−0.017 [0.029]	−0.063 [0.039]	−0.044 [0.030]	−0.039 [0.040]
s_{it-5}	0.005 [0.007]	−0.003 [0.005]	0.009 [0.005]	0.003 [0.005]	0.011† [0.006]
Intercept	−0.127 [0.121]	0.079 [0.089]		−0.039 [0.089]	
y1995					
y2000	0.028 [0.021]	−0.037 [0.025]		−0.017 [0.025]	
y2005	−0.014 [0.027]	−0.098** [0.032]		−0.069† [0.037]	
y2010	0.040† [0.023]	−0.010 [0.023]		0.012 [0.024]	
Hansen-Sargan(χ^2)	0.986	1.000	1.000	1.000	1.000
AR(1) (normal distr.)	0.001	0.002	0.028	0.001	0.053
AR(2) (normal distr.)	0.939	0.444	0.684	0.721	0.782
Wald(χ^2) [all coef.]	0.000	0.008	0.000	0.000	0.000
Wald(χ^2) [time dum.]	0.018	0.000	—	0.000	—
n	143	63	79	70	72
T	4-5	4-5	5	4-5	5
N	714	314	395	349	360

Significance codes: '***' 0.001 '**' 0.01 '*' 0.05 '†' 0.1. Robust standard errors of type "HC3" are in brackets. The values next to all of the tests in the table are p-values. The parameter n stands for the number of countries, T is the number of time periods, and N is the total number of observations (one country only has four observations).